Journal of Enterprise Information Management

Retail supply chain service levels: the role of inventory storage

Asif Salam Farhad Panahifar P.J. Byrne

Retail supply chain service levels: the role of inventory storage

Asif Salam
Faculty of Economics and Business Administration, King Abdulaziz University, Jeddah, Saudi Arabia
Farhad Panahifar
Design and Manufacturing Technology Department, University of Limerick, Limerick, Ireland and Information Technology Department, Management and Accounting Faculty, Shahid Beheshti University, Tehran, Iran, and
P.J. Byrne
Business School, Dublin City University, Dublin, Ireland

Received 25 January 2015
Revised 31 August 2015
14 February 2016
Accepted 24 February 2016

Abstract

Purpose – In today's competitive retail industry the most critical success factor is customer service which is indicated by product availability. It is argued that in the retail industry, product availability is an important measure of quality. The single most vital decision that every retailer needs to make is, how to maximize service level while keeping minimum inventory level. The purpose of this paper is to explain and demonstrate the relationship between inventory level and customer service level.

Design/methodology/approach – This study examines an inventory system utilizing a simulation model based on company data obtained from a retail fast-moving-consumer goods chain operating in Thailand.

Findings – The results suggest that the achievement of a responsive service level is dependent on managing an efficient supply chain in addition to logistics cost reductions. The findings also reveal the effect the inventory level has on the service level. From the findings of this study, demand variability and service level have been found to have the most significant influence on the inventory level. From the findings, it can also be shown that real and accurate information is very important for service supply chains.

Practical implications – The paper promotes the importance of having an appropriate inventory management policy for a retail chain which should be driven by retail companies in order to better balance inventory and service levels.

Originality/value – The relationship between the inventory level and customer service level lead to different outcomes at different combinations of inventory and service levels. Significant relationships were found between inventory and service levels.

Keywords Thailand, Case study, Fast-moving-consumer goods, Inventory level, Retail supply chain, Service level

Paper type Research paper

1. Introduction

In any highly competitive environment inventory and service levels are always a concern for any inventory management system and a major competitive factor. Poor service levels can result in the loss of customers and sales, whereas on the other hand excessive inventory results in unnecessary costs due to carrying large inventories (Hübner *et al.*, 2013). To date, the importance of service level management has been widely studied in a number of different research areas, such as: multimedia service providers – Teixeira *et al.* (2012); service strategies in manufacturing – Löfberg *et al.* (2010) and service level agreements – Beaumont (2006). Hübner *et al.* (2013) studied the effect of competition on a retailing firm's incentive to provide quality. In the retailing

Journal of Enterprise Information Management
Vol. 29 No. 6, 2016
pp. 887-902
© Emerald Group Publishing Limited
1741-0398
DOI 10.1108/JEIM-01-2015-0008

industry, product availability is generally regarded as an important indicator of quality. Product availability (fill rate) has been identified as one of the most important factor when the retail chain deals with consumer products (Cardos and García-Sabater, 2006). The problem of insufficient product availability in retail has also been identified as a typical example of low quality (Fleisch and Thiesse, 2007). To avoid such issues and in order to maintain desired service levels, firms have tended toward large stores of inventory which ultimately lead to extra cost. Although inventory service levels have been widely discussed in the extant literature, the relationship between inventory levels and service levels in a retail supply chain context is still under represented. In recent times, relatively few papers have studied the important relationship that exists between the inventory level and service level and the underlying challenges in addressing this trade-off (Sterman and Dogan, 2015; Wang *et al.*, 2015; Eltantawy *et al.*, 2015; Alftan *et al.*, 2015; Chuang and Oliva, 2015; Gurgur, 2013; Cattani *et al.*, 2011; Chou *et al.*, 2003).

The motivation for this study is thus to address this gap using a simulation model based on company data obtained from a major retail chain operating in Thailand, with a view to closely examining the tension between chains inventory and service levels. In a typical retail supply chain inventory management is considered to be an operational decision within the remit of an operations manager while customer service tends to be considered a marketing decision under the control of a marketing manager. To this end, the research question in this study attempts to understand the specific relationship between inventory level and service level and evaluates the existing tension between the two:

RQ1. Should the business minimize inventory to maximize profit or minimize cost?

On the other hand:

RQ2. Should the business maximize inventory availability (at a high operational cost) to attain maximum or highest customer service levels?

To address this tension this paper proposes that an integration of the two functional decisions is required, e.g., combined inventory and service level decision making based on overall organizational objectives.

Based on this, the remainder of the paper is organized as follows. Section 2 consists of an overview of inventory models and their application, followed by the methodological approach taken which focuses on simulation model in Section 3. Section 4 presents the research findings and extends to discussion. Finally, research implications and future research are discussed in Sections 5 and 6, respectively.

2. Literature review

The role of inventory management is to ensure that stocks of raw material or other supplies; i.e., work-in-progress and finished goods, are kept at levels that provide maximum service levels at minimum costs (Sterman and Dogan, 2015; Wang *et al.*, 2015). Sterman and Dogan (2015) further argued that once suppliers fail to fill orders, delivery delays get longer and customer service becomes poorer. A periodic review system is generally applied to understand and manage the retail replenishment system. Systems are designed to place orders of varying size at regular intervals so as to raise the stock level to a specified value (Waters, 1999). For example, supermarket shelves may be refilled periodically based on an inventory review every evening to replace whatever has been sold during the day. This kind of inventory management system is better suited to low value items of high and regular demand which contribute to low inventory management cost. However, Alftan *et al.* (2015) argue that despite advances in decision support systems in grocery supply chains, retail store replenishment management face many challenges. In particularly demand variations management tends to be a challenge right across the grocery industry.

A steady stream of studies on the importance of demand management and on the provision of strong linkage between demand and supply has been reported in the literature (Chuang and Oliva, 2015; Kosior and Strong, 2006; Holmström *et al.*, 2010). However, most retailers and distributors struggle to have the right stock-keeping unit (SKU) at the right place, in the right quantity, and at the right time to meet the demands of their customers (Christopher and Ryals, 2014) with others such as Xu *et al.* (2016), examining how to recover from getting these decisions wrong such as having stockouts and in turn how to retain customers in these circumstances. In response to increasingly shortening product-life-cycles, higher customer expectation, intense price competition and fierce global competition between retail chains, i.e., discount stores, supermarkets or convenient stores; it is imperative to understand the optimum service level needed to satisfy consumers (Elsayed, 2015). In a related study, Hunneman *et al.* (2015) found that there was a strong effect between the retail service level and customer satisfaction. A higher service level through fulfilling customer demands comes at the cost of carrying idle or slow moving inventory. A higher inventory results in increased investment in inventory and results in an opportunity cost (Jammernegg and Reiner, 2007). Retailers need to attempt to maintain optimal inventory levels, while fulfilling customer demand with the best service level possible. Inventory replenishment planning is a critical activity for items that are repeatedly ordered. The inventory plans should be based on forecasts and consider how inventory should be replenished to satisfy forecasted demand by focusing on a fast, optimal calculation and evaluation of inventory replenishment policies.

Finished goods carried by retailers can also be used as a means of improving customer service levels. Improving the service level should generate value in a supply chain as highlighted by Biehl (2005) and Faisal *et al.* (2007). Eltantawy *et al.* (2015) found that coordination in supply management is a leading approach for reducing inventory, reducing safety stock at the buyer's facility, improving forecasts while also lowering product delivery lead-times. If the inventory is balanced, safety stock will enable the manufacturer to offer higher levels of product availability with less chance of stock outs (Cheng and Lee, 2001). But the inventories should be held at the optimum level as additional stock acts as a buffer between variable and uncertain supply in addition to variable and uncertain demand.

2.1 Model development for decision support systems

Li and Wang (2015) asserted that through an innovative decision support system; i.e., using sensor network to predict the remaining shelf-life of perishable foods' pricing decision can be made instantly that will impact the overall supply chain profitability. The factor in DRP might be the following:

(1) Base-stock system, a base-stock system is where an organization maintains a base, or minimum, stock of a certain product.

(2) Reorder point system; the inventory policy of the outlet is to maintain a certain level, which is considered as full stock. When the inventory level falls to some low level, the inventory is replenished (Levi and Kaminsky, 2003).

The roots of good inventory management lie in knowing the customers and understanding their requirements. The optimum level of stock must be defined in order to minimize logistics cost. When an accurate daily replenishment's forecast is implemented, the inventory management can be organized better.

From the review of previous studies, the key role of inventory and demand management in retail industry has been widely heighted. However, the relationship between inventory levels and service levels in retail supply chains is still in its infancy. This paper is thus aimed at addressing this gap using a simulation model based on industry data obtained from a major retail chain, with a view to closely examining the tension between chains inventory and service levels.

3. Research methodology

3.1 Industry background

Thailand remains one of the fastest growing food retail markets in Asia and hosts the region's highest number of grocery transnational corporations (Isaacs, 2009). The majority of Thailand's food spend is through retail channels, with a smaller proportion through food-service channels. Different store formats dominate the Thai retail landscape, e.g., hypermarkets, supermarkets and convenience stores with many of these owned by large multinational firms. These multinational firms are well positioned to offer entry points for foreign exporters wishing to penetrate the Thai market. In 2013, there were 26.5 million tourists generating international tourism receipts of US$46 billion (World Bank, 2015). Thailand's retail sector has changed substantially in recent years. The sector was once dominated by thousands of small, local shops, but more recently this has changed through the emergence of a large number of shopping malls with the rapid rise in the number of modern retail outlets, including a significant presence of foreign invested hypermarkets.

Multinational firms from right across the consumer goods industry are increasingly targeting Asia. The sales volume of the retail industry in the Asia-Pacific region is forecasted to grow by 6 percent in 2013 and will maintain this upward momentum through to 2016 with an estimated market value of US$11.8 trillion, while that of North America and Western Europe is US$4.4 trillion and US$3.1 trillion, respectively (PWC, 2013). Similar to most Asian economies, Thailand's retail industry is highly fragmented. Traditional retailing still prevails and is dominated by local players. Apart from the challenges associated with navigating through regulatory hurdles in addition to adapting to cultural differences and consumer preferences, retail and consumer companies also increasingly have to cope with the influx of new competitors entering into the Thai retail landscape (Retailing in Thailand, 2015).

3.2 Modeling approach

In this research an Excel-based simulation was used for the analysis of the relationship between inventory and service level. The variables included in the simulation are those that have the greatest potential to affect inventory levels. Hence, the study have combined the safety stock model and the forecasting model, and then grouped them into a newly suggested order model as below:

$$\text{Suggested order} = (\text{Forecast} + \text{Safety stock} - \text{In Transit} - \text{Stock level})$$

$$\text{Suggested order} = \Big[\Big(\text{Moving average of} \overline{S} x \left(\text{Leadtime} + \overline{R}\right)\Big) + k\sqrt{\overline{R}\left(\sigma_s^2\right) + \overline{S}^2\left(\sigma_R^2\right)} - \text{In Transit stock} - \text{Stock level}\Big]$$

where $\overline{S}$ is the average daily sales (average demand per period),$\overline{R}$ the average replenishment cycle (average lead-time), *k* the service level factor[1], leadtime[2].

Safety stock model:

$$\sigma_c = \text{k} \ \sqrt{\overline{R}\left(\sigma_s^2\right) + \overline{S}^2\left(\sigma_R^2\right)}$$

where sc is the safety stock quantity, $\overline{R}$ the average replenishment cycle, ss the standard deviation of daily sales, $\overline{S}$the average daily sales, sr the standard deviation of the replenishment cycle, *k* the service level factor.

The amount of safety stock necessary to satisfy a given level of demand can be determined by statistical techniques. It is necessary to consider the joint impact of demand and the replenishment cycle variability. Once the data are gathered, it is possible to determine the safety stock requirement (Tyagi and Das, 1998). The service level factor is a dimension of the safety factor relating to safety stock as a measure of customer service. The factor is defined by the normal distribution. Most previous studies do not consider the *K* factor (service level) in their models (Herron, 1997; Graves and Willems, 1998). In reality, however, every retailer sets a service level factor with many setting it at more than 95 percent in order to meet customer demand. Therefore, the calculation model should include the *K* factor (service level) following a defined target for retailer policy.

3.3 Description of the model

Analysis in this research is based on products from a dry distribution center (DC) and not products in a fresh distribution center (FDC). The rationale for this selection is that products in FDCs are perishable products such as frozen products and vegetables. Therefore, fresh products need on-time delivery to stores. Cross-docking is used to replenish FDCs, with limited inventory management being applied for use at FDCs, as there is no inventory held at the FDC.

This study has been carried out using historical (secondary) data to test the impact of inventory levels on service levels. A list of 1,200 SKU data for one year (28 days/month (7days/week) × 12 months = 336 days) was collected, which resulted in 1,200 (336) = 403,200 observations. In this study, the sampling unit includes all categories of dry products that are available for one year (336 days). The company's historical data, which is the raw information for running the simulation, is composed of:

1. dispatching information from the DC to retail stores;
2. received product information from suppliers to the DC;
3. lead time of each supplier; and
4. inventory on hand for each product.

The present study is a case study providing detailed accounts of experiments undertaken at a large grocery retail chain based in Thailand. To anonymize the firm, a pseudonym, "Thai supermarket" is being used. Data for one complete year was obtained from the company's database to perform the simulation analysis. The Thai supermarket has 17,000 active SKUs in its "dry distribution center" imported from abroad as well as from local suppliers within Thailand. There were approximately 12,000 SKUs, which were active continuously across the year. This study was designed to use 1,200 SKUs for the purpose of simulation and analysis. In this study, the sampling units include all of the different top level categories of dry products in the Thai supermarket. The categories are: A = adult hygiene, B = baby care, C = cleaning, D = cooking, E = dry grocery, F = hair care, G = general merchandise, H = packaged food, I = snack and beverage, J = skin care, K = facial care, L = oral care and M = houseware.

The information was collected from January to December in order to calculate the safety stock for the following year, as presented earlier in the formulation. Then the information for the following six months (January-June) was used for simulating the suggested order model in order to evaluate the efficacy of the ordering approach in terms of inventory efficiency and to evaluate the presence of any service level changes. A multiple regression analysis was performed for simulation model testing. The study was conducted by applying the inventory model and comparing with the actual performance over a period of one year.

4. Research findings and discussions

The simulation analysis in this research case study involves a total 1,200 SKUs from 13 categories of products. Based on the analysis of existing data, the average of inventory level (number of days on hand) for each category is: A = 4.876, B = 4.246, C = 5.685, D = 4.639, E = 7.025, F = 7.572, G = 5.166, H = 6.514, I = 4.406, J = 5.856, K = 6.704, L = 6.055, M = 5.941. It can be seen that the inventory level of each category in terms of number of days on hand varies from four to seven days. This suggests that the stock on hand at the DC is not stable. The volume of stock rapidly changes because the stores order a non-standard quantity of products every day. It means that the buffer stocks were dispatched to the stores to replenish the stock and the new stocks are delivered every day to support store's demand.

The average replenishment cycle for each category is: A = 1.926, B = 1.410, C = 1.994, D = 2.219, E = 2.390, F = 2.39, G = 1.563, H = 2.302, I = 2.200, J = 2.301, K = 2.219, L = 1.853, M = 2.197. The average replenishment cycle represents the lead-time for receiving products from the time of order until receipt of the products from the suppliers in days. The average replenishment cycle for each category varies and is influenced by the lead-time from each supplier.

The service level of each category is shown in terms of percentages. The service level of each category is: A = 0.966 (96.6 percent), B = 0.988 (98.8 percent), C = 0.982 (98.2 percent), D = 0.984 (98.4 percent), E = 0.992 (99.2 percent), F = 0.967 (96.7 percent), G = 0.984 (98.4 percent), H = 0.974 (97.4 percent), I = 0.945 (94.5 percent), J = 0.977 (97.7 percent), K = 0.978 (97.8 percent), L = 0.972 (97.2 percent), M = 0.977 (97.7 percent). From this result, it can be interpreted that the inventory model suggests an improvement of service level from the earlier period. It can also be seen that the warehouse can supply product to the store with a high service level almost every time. Service implies the performance of the replenishment system at the retail outlets.

A stepwise regression method has been designed and used in this research to analyze the empirical model. The regression model is as follows:

$$\begin{aligned}\text{Inventory Level } (Y) = {} & \alpha + \beta_1 \times \text{Average Sales} + \beta_2 \\ & \times \text{Average Replenishment cycle} + \beta_3 \\ & \times \text{Std. Lead-time} + \beta_4 \times \text{New Service level} + \beta_5 \\ & \times \text{Std. Sales} + \beta_6 \times K \text{ Factor}\end{aligned}$$

The confidence interval or significance level for the purpose of this study has been set to 95 percent. This implies an error allowance in the data of 5 percent due to "noise factors"; i.e., shrinkage in a grocery store.

Model 1 (Table I), includes only the average sales and accounts for 83.6 percent of the variance. The inclusion of the average replenishment cycle into model 2 (Table I) accounts for an additional 1.1 percent of the variance being explained (R^2 change = 0.011). Each of the other variables are then added to each iteration of the model as presented in Table I (Model 1-6). Finally, the adjusted R^2 value shows that the final model represents 0.869 of the variance, which shows that the total amount of variance accounted for by the regression model is 86.9 percent.

With stepwise selection, each variable is entered in sequence and its value assessed. If adding the variable contributes to the model then it is retained, with all other variables in the model being re-tested to see if they are still contributing to the success of the model. If they no longer contribute significantly they are removed. Thus, this method should ensure that the process ends up with the smallest possible set of predictor variables included in the model (Brace *et al.*, 2013). In this study, model 3 has the smallest set of predictor variables and the adjusted R^2 is 0.854, or 85.40 percent variance accounted for by the model instead of 86.9 percent with three additional variables in the model 6. Hence, in the current study model 3 has been selected.

Table II reports the ANOVA findings, which assesses the overall significance of the model. The *F*-test is used to test the significance of the regression model. The findings suggests, all six models 1-6 are significant (sig. = 0.00, $p < 0.01$), with very slight improvement of one over another. Hence, to consider the best model with fewer predictors model 3 has been chosen for analysis.

Table III suggests that, all of the predictors can explain the inventory level significantly. This means changes in any of these predictors will affect the inventory levels significantly. Also, there are no problems of multicollinearity with the model. That is, the VIF (collinearity index) suggests that there is no existence of multicollinearity (association between the explanatory variables) between predictor variables. As suggested by Bagozzi (1994), a maximum VIF greater than 10 is thought to signal harmful collinearity.

					Change statistics					
Model	R	R^2	Adjusted R^2	SE of the estimate	R^2 change	F-change	df1	df2	Sig. F-change	Durbin-Watson
1	0.914	0.836	0.836	396.1364	0.836	6,101.122	1	1,198	0.000	
2	0.920	0.847	0.847	382.4345	0.011	88.382	2	1,197	0.000	
3	0.924	0.854	0.854	373.3784	0.007	59.769	3	1,196	0.000	
4	0.928	0.862	0.862	363.5826	0.008	66.315	4	1,195	0.000	
5	0.932	0.868	0.868	355.2384	0.006	57.798	5	1,194	0.000	
6	0.933	0.870	0.869	353.4831	0.001	12.888	6	1,193	0.000	1.562

Notes: Dependent variable: inventory level: [a]predictors: (constant), average sales; [b]predictors: (constant), average sales, average replenishment cycle; [c]predictors: (constant), average sales, average replenishment cycle, new service level; [d]predictors: (constant), average sales, average replenishment cycle, new service level, STD Lead-time; [e]predictors: (constant), average sales, average replenishment cycle, new service level, STD Lead-time, STD Sales; [f]predictors: (constant), average sales, average replenishment cycle, new service level, STD Lead-time, STD sales, *K* factor

Table I.
Model summary

	Sum of squares	df	Mean square	F	Sig.
Model 1					
Regression	957,412,982.845	1	957,412,982.845	6,101.122	0.000
Residual	187,995,055.773	1,198	156,924.087		
Total	1,145,408,038.618	1,199			
Model 2					
Regression	970,339,420.658	2	485,169,710.329	3,317.260	0.000
Residual	175,068,617.959	1,197	146,256.155		
Total	1,145,408,038.618	1,199			
Model 3					
Regression	978,671,962.229	3	326,223,987.410	2,340.009	0.000
Residual	166,736,076.389	1,196	139,411.435		
Total	1,145,408,038.618	1,199			
Model 4					
Regression	987,438,267.011	4	246,859,566.753	1,867.428	0.000
Residual	157,969,771.606	1,195	132,192.277		
Total	1,145,408,038.618	1,199			
Model 5					
Regression	994,732,012.519	5	198,946,402.504	1,576.508	0.000
Residual	150,676,026.099	1,194	126,194.327		
Total	1,145,408,038.618	1,199			
Model 6					
Regression	996,342,352.792	6	166,057,058.799	1,328.985	0.000
Residual	149,065,685.826	1,193	124,950.281		
Total	1,145,408,038.618	1,199			

Table II. Analysis of variances (ANOVA)

Model	Unstandardized coefficients		Standardized coefficients			Collinearity statistics	
	B	SE	β	t	Sig.	Tolerance	VIF
Constant	813.228	174.476		4.661	0.000		
Average sales	4.180	0.050	0.919	83.069	0.000	0.997	1.003
Average replenishment cycle	255.231	25.956	0.109	9.833	0.000	0.999	1.001
New service level	−1,295.966	171.274	−0.084	−7.567	0.000	0.996	1.004

Notes: Dependent variable: inventory level

Table III. The coefficients of dependent and independent variables

Average sales shows that it is a significant predictor of the inventory level ($t = +83.096$: $p < 0.01$). The greater the average sales, the greater the opportunity to control the inventory level and hence reduce safety stock. Due to higher predictability of the average sales the greater will be the forecasting accuracy which will result in a greater control over the inventory. From Table III, the β value of average sales is large ($\beta = 0.919$) which indicates that a unit change in average sales has a large effect on the inventory level and the service level.

The average replenishment cycle has a positive effect on unit savings of inventory. The variance of demand during a lead-time is greater when the lead-time period is longer.

During a shorter lead-time it is not necessary to keep high safety stock levels. The replenishment stock can replenish the products in a short time ($t = +9.833$: $p < 0.01$). The major factor affecting the inventory level is the demand variability. So, lead-time is directly related to the inventory level.

The β value of an average replenishment cycle is quite low ($\beta = 0.109$) and the lead-time has a moderate effect on each variable. To replenish stocks, the product replenishment must be ordered before stock out with the delivery lead-time being taken into account. Therefore, stock in the DC must support customer demand until the next shipment from suppliers has been received.

The customer service level indicates the highest utilization of available inventory ($t = -7.567$: $p < 0.01$). From Table III, the β value = –0.084. This variable has an inverse relationship with the inventory level. This implies, the greater the service level the lower will be the inventory level. This finding confirms the prior theoretical assumption. Therefore, a higher level of customer service will contribute to a greater savings in inventory.

From the result of testing 1,200 items, it can be seen that the improvement of using the inventory model is in two parts. One is to compare the result with the retail industry standard. From Table IV, this is the service level results from the supermarket retailers in Thailand. In the second quarter, the service level is only 92 percent (Table IV). While, the service level result of the inventory simulation model had shown a major improvement, i.e. 98 percent (see Table V). It can be seen that the service level result of the inventory model is higher when compared to the average industry service level.

Table IV presents a comparison between the service levels of the Thai supermarket with the average retail industry service level in Thailand for the period from January to June. The result has shown a major improvement, 98 percent (see Table V), while the current service level is 91 percent. There is an improvement of 7 percent, which can be considered to be a substantial improvement. This implies that, the Thai supermarket has better efficiency in terms of its shelf space utilization. This also ensures a 98 percent possibility that customers will not walk out of the store without the goods that they want to buy.

Besides the improvement in service level, the supply chain must be concerned about reducing the carrying cost in the DC. Therefore, the inventory model can reduce inventory in terms of value. From Table V, the warehouse carrying cost is currently 35,127 Baht per day. Using the proposed inventory model, the carrying cost has been reduced by 13,115 Baht per day from the current inventory value. On average,

Dry grocery product	Y1 Q2 (%)	Y1 Q3 (%)	Y1 Q4 (%)	Y2 Q1 (%)	Y2 Q2 (%)
Thai retail industry service level	80	87	90	92	92
Thai supermarket	93	94	93	94	94

Note: Comparative analysis of service level of Thai supermarket and Thai retail industry

Table IV. Service level results

1,200 items	Service level			Inventory (value)			Inventory (unit)		Inventory (day on hand)	
	Current	New	Improvement	Current	New	Improvement	Current	New	Current	New
Total	91%	98%	7%	35,127	22,013	59.58%	1,003	557	13	6

Table V. Result of simulation testing the inventory value configurations examined in the simulation were improved by 59.58 percent. Hence, it is justified that the inventory savings associates itself with the reduction of inventory and is worth pursuing.

Table VI, presents the improvement of service level by product category. It can be seen that all categories have shown improvement in their service levels.

Table VII shows, that major improvement took place with 907 SKU items, which represented 76 percent of total SKUs. There are 293 items, which could not improve the service level. The major reason for non-improving items is due to unexpected demand, which were caused mainly by promotional activities. This result can show that good forecasting of promotions is also very important for replenishment. This suggests the buffer stock for promotion should replenish before starting the promotion period.

5. Research implications

5.1 Implications for theory

This paper makes a contribution to the theory of supply chain management by investigating the relationship between inventory and service levels. Based on the

Category	Old service level (%)	New service level (%)	Improvement (%)
A	93.64	96.61	2.97
B	93.54	98.78	5.24
C	93.60	98.17	4.57
D	96.74	98.40	1.66
E	91.62	99.22	7.60
F	82.98	96.74	13.75
G	91.51	98.44	6.93
H	89.61	97.44	7.83
I	83.35	94.46	11.10
J	91.59	97.69	6.10
K	90.34	97.78	7.43
L	89.31	97.18	7.87
M	90.78	97.66	6.88
Grand total	90.89	97.60	6.71

Table VI.
The category service level improvement of 1,200 items

% Improve	Count	% Level
⩽−1	293	24
0-10	60	5
11-20	55	5
21-30	87	7
30-40	95	8
41-50	41	3
51-60	76	6
61-70	56	5
71-80	61	5
81-90	40	3
90-99	47	4
⩾100	289	24
Total	1,200	100

Table VII.
Frequency distribution on percentage savings

analysis of the historical data in the analyzed case it has been found that the service level is largely a function of the inventory level. This confirms our theoretical prediction and the research question that, there is a significant relationship between inventory and service levels. In other words, to maintain an optimum service level the "Thai Supermarket" must use their decision support-based continuous replenishment system. Alternately, to minimize the cost of transportation the grocery chain needs to order in large quantities on a periodic basis. The findings in this research are based on the analysis of only "dry products" inventory as the demand pattern for dry and fresh products are significantly different, i.e., some of the products are daily or regularly purchased and others are periodically (Fisher, 1997). Moreover, the grocery chain needs to develop an inventory management decision system based on its' positioning in the market. Through a collaborative and updated information sharing initiative between the retailer and suppliers an efficient service level agreement can be reached (Shockley and Fetter, 2015) which will lead to a win-win solution for both partners in this supply chain. Hence, based on the purchase patterns future research should develop specific retail industry models to investigate the relationship between inventories (i.e. dry, fresh or cold) and service level across product categories.

5.2 Implications for practice

To minimize the tension between inventory and customer service levels supply chain managers must consider the appropriate level of safety stock to be maintained. Maintaining additional inventory will increase product availability but with an increase in inventory holding cost and must take into account company policy. The practical implications of current study are as follows.

First, decisions about the optimal inventory level in order to minimize logistics costs, e.g., holding cost, ordering and receiving cost is a crucial task for the entire supply chain. It is generally recognized that the design of an appropriate inventory management policy for a retail chain should better balance the inventory and service levels.

Second, the findings also reveal that the inventory level can have a significant effect on the service level. From the findings of this study, demand variability and service level are the most important variables explaining the inventory level. Excessive levels of inventory were built up due to unpredictable demand. An average replenishment cycle or lead-time is of moderate importance. This suggests that a reasonably good forecast can produce major savings in inventory investment. Finally, to understand this relationship between the inventory level and service level the following matrix may be used.

Table VIII suggests that, there are different outcomes based on different combinations of inventory and service levels. Operations based on quadrant A will deliver the best

	Inventory level	
Service level	High	Low
High	*A* Fulfill customer demand Carrying significant inventory	*B* Optimum level Achieve service level with balanced inventory
Low	*C* Excess inventory and carrying non-performing inventory	*D* Shortage and stock-out

Table VIII. The relationships of service level and inventory level service level where the retailer will be carrying significant inventory which also includes slow moving and non-performing inventory. Quadrant B involves not a satisfactory service level but with optimum inventory; according to B the retailer is set up to satisfy the majority of the customers but possibly not all customers. Operating in quadrant C involves carrying inventory without catering for customer demand and without classifying between low performing and high performing inventory. Finally, quadrant D is not a good option for any retailer as the customer will experience stock outs on a regular basis albeit while holding very low levels of stock.

Realistically, quadrant A and B is the most feasible alternative to choose from. But again the trade-off decision as to operate with excessive inventory to maximize service level or optimize inventory and minimize service level is a strategic one.

Third, in Table VIII to choose the best of the options in quadrant A and B, supply chain members need to collaborate on real time information sharing and visibility across their supply chain. This will enable them to make efficient decisions based on their strategic goal. Therefore, information sharing between suppliers and retailers is a critical success factor for the retail supply chain. The real time data can enable suppliers and retailers to have a win-win solution. Retailers receiving goods from manufacturers carry them as inventory to meet customer demand. As items are sold, the retailer orders new items to replenish the inventory. Many retailers hope to have a high service level in order to meet customer demand, but, they also do not know, "what is the optimum level." Hence, in the retail industry it is crucial to identify the optimal inventory in order to satisfy the desired service level. The high service level with low inventory is the ideal for supply chain members helping them to minimize logistics cost. The value of the periodic demand forecast is typically calculated by assuming that it follows on a normal probability distribution.

6. Conclusion and future research direction

It is clear in this study that the use of simulation was able to provide better insights into resolving the conflict between inventory and service level. It led to reducing the inventory holding cost and making the managerial decision making process more efficient and effective. It aided in streamlining the transactions with the suppliers and customers and ultimately cut down the non-value adding inventory from the supply chain. Inventory is a problem that spans two functional areas: operations and marketing. Operation's goal is to minimize cost and maximize profit but marketing's goal is to enhance customer service. Hence, it requires integration of two functional decisions to serve the organizational objective. This research opens up insights on challenges in managing a retail supply chain in one of Asia's most dynamic markets, Thailand. Asia is a very attractive business market for companies from all over the world due to its large consumer base and significant tourist market. Doing business in Asia also has its own challenges. The Asian market is fragmented into many cultures and languages which present supply chain challenges such as the need to incorporate individualized product labeling, etc. Understanding these hidden challenges is a key to success in this fast growing continent.

From the findings of this study, it can be shown that real and accurate information is very important for the service supply chain. Information is the key to success of a supply chain because it enables management to make better decisions. A primary goal of inventory management is to achieve an optimum balance between inventory level and customer service level. It may not work well if both parties, e.g., retailers and suppliers lack information and communication. Sharing information such as demand, sales orders and inventory status using collaborative information sharing approaches such as collaborative planning, forecasting and replenishment (Panahifar *et al.*, 2015a, b) can help companies to reduce inventory costs and improve decision making along the entire supply chain. Consequently, customer service level can be improved. As an extension of this research, it could be possible to include an evaluation of the relationship between inventory and service levels under improved information sharing practices in the same industrial context.

In this study Table VIII is designed to present the trade-offs between inventory and service levels. But still two major challenging areas remain unexplored which could be used by researchers for future study. First, the concept of fresh foods or perishable items for daily consumption, such as: dairy products, vegetables, fruits, as these product types need to reorder before stocks are exhausted. The challenge here is to explore how the matrix can be adapted to apply in this scenario. Second, service industries such as banking, insurance, etc., are different in nature because their market offerings are intangible and hard to quantify. Again this is a potentially fruitful market for evaluation and model fit testing.

The model has been developed based on a very dynamic consumer-oriented market with the company selected being a resilient player within the industry utilizing data for a one year period. The application of Table VIII could also be tested on mid-size and small size industry where the nature of operations tends to be less complex. In addition, simulation could be run for a longer period of time, e.g., 3-5 years. As is known, the pattern of demand in fast-moving-consumer industry is highly volatile hence the matrix could also be applied in these kinds of industries.

Finally, the focus of this study was on the retail supply chain in Thailand. Although it posited that the findings are likely to have wider general applicability across other economies, further studies in different cultural contexts should be undertaken to validate this assumption.

Notes

1. Service level is defined as, a measure (expressed as a percentage) of satisfying demand through inventory in time to satisfy the customer's requested delivery dates and quantities.
2. Lead time is defined as, the total time that elapses between an order's placement and its receipt. It includes the time required for order transmittal, order processing, order preparation, and transit.

References

Alftan, A., Kaipia, R., Loikkanen, L. and Spens, K. (2015), "Centralised grocery supply chain planning: improved exception management", *International Journal of Physical Distribution and Logistics Management*, Vol. 45 No. 3, pp. 237-259.

Bagozzi, R.P. (1994), *Principles of Marketing Research*, Blackwell Business, Cambridge, MA.

Beaumont, N. (2006), "Service level agreements: an essential aspect of outsourcing", *The Service Industries Journal*, Vol. 26 No. 4, pp. 381-395.

Biehl, M. (2005), "Selecting internal and external supply chain functionality: the case of ERP systems versus electronic marketplaces", *Journal of Enterprise Information Management*, Vol. 18 No. 4, pp. 441-457.

Brace, N., Kemp, R. and Snelgar, R. (2013), *SPSS for Psychologists*, 2nd ed., Palgrave Macmillian.

Cardos, M. and García-Sabater, J.P. (2006), "Designing a consumer products retail chain inventory replenishment policy with the consideration of transportation costs", *International Journal of Production Economics*, Vol. 104 No. 2, pp. 525-535.

Cattani, K.D., Jacobs, F.R. and Schoenfelder, J. (2011), "Common inventory modeling assumptions that fall short: arborescent networks, poisson demand, and single-echelon approximations", *Journal of Operations Management*, Vol. 29 No. 5, pp. 488-499.

Cheng, K.L. and Lee, H.L. (2001), "The inventory benefit of shipment coordination and stock rebalancing in a supply chain", *Management Science*, Vol. 48 No. 2, pp. 300-306.

Chou, Y.C., Chang, P.L. and Huang, M.G. (2003), "An inventory model for slow moving spare parts of semiconductor equipment", *Journal of Statistics and Management Systems*, Vol. 6 No. 2, pp. 193-205.

Christopher, M. and Ryals, L.J. (2014), "The supply chain becomes the demand chain", *Journal of Business Logistics*, Vol. 35 No. 1, pp. 29-35.

Chuang, H.H.C. and Oliva, R. (2015), "Inventory record inaccuracy: causes and labor effects", *Journal of Operations Management*, Vol. 39 No. 40, pp. 63-78.

Elsayed, K. (2015), "Exploring the relationship between efficiency of inventory management and firm performance: an empirical research", *International Journal of Services and Operations Management*, Vol. 21 No. 1, pp. 73-86.

Eltantawy, R., Paulraj, A., Giunipero, L., Naslund, D. and Thute, A. (2015), "Towards supply chain coordination and productivity in a three echelon supply chain: action research study", *International Journal of Operations and Production Management*, Vol. 35 No. 6, pp. 895-924.

Faisal, M.N., Banwet, D.K. and Shankar, R. (2007), "Information risks management in supply chains: an assessment and mitigation framework", *Journal of Enterprise Information Management*, Vol. 20 No. 6, pp. 677-699.

Fisher, M.L. (1997), "What is the right supply chain for your product?", *Harvard Business Review*, Vol. 75 No. 1, pp. 105-117.

Fleisch, E. and Thiesse, F. (2007), "On the management implications of ubiquitous computing: an IS perspective".

Graves, S.C. and Willems, S.P. (1998), "Strategic safety stock placement in supply chain", *Journal of Manufacturing and Operations Management*, Vol. 1, pp. 67-71.

Gurgur, C.Z. (2013), "Optimal configuration of a decentralized, market-driven production/ inventory system", *Annals of Operations Research*, Vol. 209 No. 1, pp. 139-157.

Herron, D.P. (1997), "Integrated inventory management", *Journal of Business Logistics*, Vol. 8 No. 1, pp. 96-116.

Holmström, J., Brax, S. and Ala-Risku, T. (2010), "Comparing provider-customer constellations of visibility-based service", *Journal of Service Management*, Vol. 21 No. 5, pp. 675-692.

Hübner, A.H., Kuhn, H. and Sternbeck, M.G. (2013), "Demand and supply chain planning in grocery retail: an operations planning framework", *International Journal of Retail & Distribution Management*, Vol. 41 No. 7, pp. 512-530.

Hunneman, A., Verhoef, P.C. and Sloot, L.M. (2015), "The impact of consumer confidence on store satisfaction and share of wallet formation", *Journal of Retailing*, Vol. 91 No. 3, pp. 516-532.

Isaacs, B.A. (2009), "Imagining Thailand in european hypermarkets: new class-based consumption in chiang mai's cruise ships", *The Asia Pacific Journal of Anthropology*, Vol. 10 No. 4, pp. 348-363.

Jammernegg, W. and Reiner, G. (2007), "Performance improvement of supply chain processes by coordinated inventory and capacity management", *International Journal of Production Economics*, Vol. 108 No. 1, pp. 183-190.

Kosior, J.M. and Strong, D. (2006), "Supply/demand chain modeling utilizing logistical-based costing", *Journal of Enterprise Information Management*, Vol. 19 No. 3, pp. 346-360.

Levi, S.D. and Kaminsky, P. (2003), *Designing and Managing the Supply Chain*, McGraw-Hill International, Singapore.

Li, D. and Wang, X. (2015), "Dynamic supply chain decisions based on networked sensor data: an application in the chilled food retail chain", *International Journal of Production Research*, pp. 1-15.

Löfberg, N., Witell, L. and Gustafsson, A. (2010), "Service strategies in a supply chain", *Journal of Service Management*, Vol. 21 No. 4, pp. 427-440.

Panahifar, F., Byrne, P.J. and Heavey, C. (2015a), "A hybrid approach to the study of CPFR implementation enablers", *Production Planning & Control*, Vol. 26 No. 13, pp. 1-20.

Panahifar, F., Heavey, C., Byrne, P.J. and Fazlollahtabar, H. (2015b), "A framework for collaborative planning, forecasting and replenishment (CPFR) state of the art", *Journal of Enterprise Information Management*, Vol. 28 No. 6, pp. 838-871.

PWC (2013), *Outlook for the Retail and Consumer Products Sector in Asia*, available at: www.pwc.co.nz/KenticoFiles/5d/5dff81f2-7242-43e0-87ff-941e1d02e8df.pdf (accessed August 23, 2015).

Retailing in Thailand (2015), available at: www.euromonitor.com/retailing-in thailand/report on (accessed August 23, 2015).

Shockley, J. and Fetter, G. (2015), "Distribution co-opetition and multi-level inventory management performance: an industry analysis and simulation", *Journal of Purchasing and Supply Management*, Vol. 21 No. 1, pp. 51-63.

Sterman, J.D. and Dogan, G. (2015), "I'm not hoarding, I'm just stocking up before the hoarders get here": behavioral causes of phantom ordering in supply chains", *Journal of Operations Management*, Vol. 39 No. 40, pp. 6-22.

Teixeira, J., Patrício, L., Nunes, N.J., Nóbrega, L., Fisk, R.P. and Constantine, L. (2012), "Customer experience modeling: from customer experience to service design", *Journal of Service management*, Vol. 23 No. 3, pp. 362-376.

Tyagi, R. and Das, C. (1998), "Extension of the square root law for safety stock to demand with unequal variances", *Journal of Business Logistics*, Vol. 19 No. 2, pp. 87-103.

Wang, Y., Wallace, S.W., Shen, B. and Choi, T.M. (2015), "Service supply chain management: a review of operational models", *European Journal of Operational Research*, Vol. 247 No. 3, pp. 685-698.

Waters, C.D.J. (1999), *Inventory Control and Management*, 1st ed., John Wiley & Sons, Chi Chester.

World Bank (2015), World Bank Open Data, available at: http://data.worldbank.org/ (accessed August 23, 2015).

Xu, K., Yin, R. and Dong, Y. (2016), "Stockout recovery under consignment: the role of inventory ownership in supply chains", *Decision Sciences*, Vol. 47 No. 1, pp. 1-19.

Further reading

Aye, G.C., Balcilar, M., Gupta, R. and Majumdar, A. (2015), "Forecasting aggregate retail sales: the case of South Africa", *International Journal of Production Economics*, Vol. 160, pp. 66-79.

Chen, F., Drezner, Z., Ryan, J.K. and Simchi-Levi, D. (2000), "Quantifying the bullwhip effect in a supply chain: the impact of forecasting, lead-time, and information", *Management Science*, Vol. 46 No. 3, pp. 436-443.

Economist Intelligence Unit (2012), "Industry report, consumer goods and retail: Thailand", May.

Economist Intelligence Unit (2013), "Industry report, consumer goods and retail: Thailand", June.

Ghoniem, A. and Maddah, B. (2015), "Integrated retail decisions with multiple selling periods and customer segments: optimization and insights", *Omega*, Vol. 55, September, pp. 38-52.

Gunasekaran, A., Irani, Z., Choy, K. L., Filippi, L. and Papadopoulos, T. (2014), "Performance measures and metrics in outsourcing decisions: a review for research and applications", *International Journal of Production Economics*, Vol. 161, March, pp. 153-166.

Holzapfel, A., Hübner, A., Kuhn, H. and Sternbeck, M. G. (2015), "Delivery pattern and transportation planning in grocery retailing", *European Journal of Operational Research*, Vol. 252 No. 1, pp. 54-68.

Russell, R.S. and Taylor, B.W. (2002), *Operations Management*, 4th ed., Prentice Hall, Upper Saddle River, NJ.

Salehi, H., Taleizadeh, A.A. and Tavakkoli-Moghaddam, R. (2015), "An EOQ model with random disruption and partial backordering", *International Journal of Production Research*, Vol. 54 No. 9, pp. 1-10.

Stock, J.R. and Lambert, D.M. (2001), *Strategic Logistics Management*, 4th ed., McGraw-Hill International, Singapore.

Waller, D.L. (1999), *Operations Management: A Supply Chain Approach*, International Thomson Business Press, London.

Zhu, X. and Cetinkaya, S. (2015), "A stochastic inventory model for an immediate liquidation and price-promotion decision underprice-dependent demand", *International Journal of Production Research*, Vol. 53 No. 12, pp. 3789-3809.

About the authors

Asif Salam is an Associate Professor of Marketing and Supply Chain Management in Ted Rogers School of Management at the Ryerson University of Toronto. He is a Doctorate in Business Administration in Supply Chain Management from the Thammasat University, Thailand. His research interests include interdisciplinary issues in marketing and supply chain management, supply chain collaboration, supply chain integration, healthcare logistics, lean and agile logistics, and humanitarian disaster logistics.

Farhad Panahifar is an Assistant Professor of Industrial Engineering and Operations Management at Shahid Beheshti University. His research interests include supply chain design and planning, simulation modelling, fuzzy logic, operation research and management, and strategic planning. Farhad has published in *International Journal of Production Research, Production Planning & Control, and Industrial Management & Data Systems*. Farhad Panahifar is the corresponding author and can be contacted at: farhad.panahifar@ul.ie

P. J. Byrne is an Associate Professor of Operations/Supply Chain Management in Dublin City University Business School and the Head of the Management Group in the school. His research interests include supply chain design, analysis and optimization, cloud based simulation, discrete event simulation, industrial applications of simulation modeling for the manufacturing and services sectors and business process optimization.