Introducing Economic Order Quantity Model for Inventory Control in Web based Point of Sale Applications and Comparative Analysis of Techniques for Demand Forecasting in Inventory Management

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ABSTRACT
This paper has primary focus on the aspect of inventory management in web based point of sale applications for supermarkets. The major research focus include selection of efficient technique for demand forecasting in retail industry, the introduction of Economic Order Quantity model to reduce the overall inventory related costs and stock-out, analyzing customer transactions to improve sales, determining product shelving and supplier selection. For this purpose, Economic Order Quantity model is applied on the forecasted demands using simple moving average, linear regression, back propagation algorithm and afterwards a comparative analysis is conducted on the basis of costs generated by each demand forecasting technique. The comparison shows that back propagation algorithm is more efficient for demand forecasting and the overall inventory costs after applying Economic Order Quantity model are found to be lowest for back propagation algorithm as compared to the Linear Regression and Simple Moving Average.

Keywords
Apriori Algorithm, Back Propagation Algorithm, Data mining, Economic Order Quantity model, K-means Algorithm, Linear Regression, Naïve Bayesian Algorithm

1. INTRODUCTION
Point of sale (**POS**) or **checkout** describes a place of retail transaction occurrence. It is a point where a customer pays a merchant in return of goods or items bought. At the point of sale merchant can adopt the methods such as a manual system, barcode scanners, and electronic cash registers and touch screen displays to calculate the amount owing and to complete the transaction. Moreover, the merchant also issues a receipt for the transaction. The POS is customized by retail industry based on varied needs of small and medium sized retailers. Example can be a grocery store that may require a weighing scale at the point of sale, while restaurants may use automated computerized systems. The modern point of sale must include advanced functionalities such as inventory management, CRM (customer relation management), financials, warehousing, etc. Before the advent of the latest POS, all of the functions like inventory management, financials, warehousing were done independently and manually, which resulted in a lot of errors. The early cash registers were made in proprietary software and they had limited functions. Later, point of sale software was used to receive customer orders at the restaurant's entrance, and printing the preparation details in the kitchen. Such an intelligent process enabled customers to go to their tables where they can find the food already prepared for them. This software had an enhancement as compared to previous one as it also contained real time labor and food cost reports. With more technology advancements, points of sale applications are becoming common. Therefore, there is a need of incorporating advanced functionalities in a point of sale to cater different needs, like inventory is essential to keep up the pace with technological modernization and increasing retail management demands. Inventory management and inventory control is required to confirm control of quality in businesses in order to manage the transactions that focus consumer purchases. Without handling inventory control efficiently, large retail stores like Wal-Mart or JC Penny may face stock-out on an important product. In short, effective inventory control system will be able to alert the retailer at the reorder time.

1.1 Problem Description
Due to today's uncertain economy, companies are trying to adopt alternative ways to remain competitive. Different ineffective forecasting methods lead to multiple product stock outs. So research revolves around different forecasting techniques for demand prediction and determining what will be the optimal quantity of inventory to order and when it should be ordered so that out of stock inventory problems can be avoided.

1.2 Research Methodology
The proposed application can determine order quantity, reordering point, product shelving, inventory categorization and supplier selection mainly by using data mining techniques. The point of sale application can manage daily transactions and maintain record of customers, inventory and employees. The historical quarterly sales data for different products is saved in database so that sales behavior can be analyzed and to establish a forecasting trend for each product.

1.2.1 Main Tasks
- Demand forecast is done on the basis of three techniques namely Simple Moving Average, Linear Regression and Back Propagation.
- Apriori algorithm is used to analyze customer transactional data to determine which products are likely to be bought together in order to solve product shelving issues.
- Inventory Categorization (ABC Classification) is done by using K –means algorithm to figure out the products that are critical to control for effective inventory management.
- Knowledge base is maintained for supplier selection based on given criteria.

- An inventory control model i.e. Economic Order Quantity model is used. The predicted demand is used in Economic Order Quantity model which calculates optimum order quantity and reorder points for each product. At last comparison is done between the three technique results on the basis of cost saving.

The research paper is structured as follows - Section 2 begins with literature review. Section 3 addresses implementation of proposed application. Section 4 presents the results. Section 5 is about conclusion and future work.

2. LITERATURE REVIEW

Karthik Sundararaman et al. in [1] employed Baseline prediction as a means to present the marketing strategy for consumer goods. According to paper, in order to generate baseline for future techniques like Simulation techniques and time series algorithms are used. The algorithm that is suitable for a particular point of sales data changes depending on the datasets. POS data for the consumer goods of a store is introduced for a period of two years depending on the types of promotion, duration of occurrence and other requirements. Two methods are used to analyze the POS data. 1) Forecasting by combining Seasonal Adjustment and Linear Exponential Smoothening 2) Winters Model. The baseline prediction is for a period of one year. Results demonstrate that winters model is a better fit for the point of sales data used for testing purpose than LES model.

Further, Numera Tahir et al. in [2] devised a decision support system that contains three different analysis methods which are: Price based Analysis; Quantity based Analysis and ABC Analysis. The research involves extension of the proposed decision support system to a gas plant inventory and a comparative analysis is conducted for the former two methods to separate the critical parts on the basis of their price and quantity respectively. Main inputs include the inventory, their price and quantity consumed. These inputs are then used by DSS to figure out the critical items based on price, quantity, annual cost separately and subsequently critical items considering all three components together. The results describe that according to price based analysis, 85.7% of revenue is used by 1.25% of the items. Whereas 10.1% by 8.45 % and 4.2% by 90.3 % of the items. In the quantity based analysis, 0.33% of revenue is used by 33.01 % of the total items, 0.76% by 33.33 % and 98.89% by only 33.66% of the total items. ABC analysis shows that 23% of items make 60% of annual cost whereas 36% of items make 22% of annual costs and 41% of items make 18% contribution to annual costs. Overall results show that almost 20% of the items make major amount of budget. For these 20% critical items, inventory costs must be decreased.

Yunkang Yue et al. in [3] presented that due to transformation in consumption conception, supermarkets invested a lot on constructing and applying the Information technology, the major aspects include barcode, POS and database technology, etc. Trade information is recorded still its utilization is unsatisfactory. For this, new technology i.e. Data Mining, is used by the supermarket administration which changes management of supermarket to knowledge management. Data mining finds its application in supermarkets, where business handling can be done with POS, customer's information can be collected and sales data can be accumulated. Paper describes data mining applications in supermarkets to major aspects like analyzing consumption behavior, commodities re-configuration, enhancing customer's relationship etc.

Qizhi Wu et al. in [4] in his research conducted an analysis of three models based on economic order quantity (EOQ) model in order to reduce inventory costs of items sold in one of the Carrefour supermarket outlets. Paper describes three models which are: 1. model with lots ordered and delivered separately, 2. model with lots ordered and delivered together, and 3. model with lots ordered and delivered for specific subset. These three models are discussed and mathematically compared in this paper. The third model includes greater specific procedures which can lead to an optimal solution due to its lowest cost.

Pradip Kumar Bala et al. in [5] argue that minimum error for demand forecast lead to success in supply chain management. With the advent of data mining systems, business intelligence has been introduced in varied domains of retail and business. The current paper attempts to describe the classification of the customers using decision tree approach which further acts as an input to the demand forecasting. The paper proposes a forecasting model based on decision tree approach for making demand forecast better and to improve the inventory performance in supply chain. The proposed forecasting model with the inventory replenishment system resulted in enhanced customer service level and reduction in inventory level.

Goswami D.N.* et al. in [6] presented that frequent pattern mining has large number of applications in data mining field. Frequent pattern mining from large databases results in an important problem in data mining. Apriori algorithm is firstly proposed in this field. With the passage of time Apriori algorithm has undergone various changes to enhance the performance. In this paper three different frequent pattern mining approaches: Record filter, Intersection and Proposed Algorithm are discussed which are based on Apriori algorithm. The findings of this paper are that the proposed algorithm performs better than other frequent pattern mining algorithm.

3. IMPLEMENTATION OF PROPOSED APPLICATION

The proposed point of sale application is designed specifically for the supermarket, for which the main features of inventory management, inventory control, real-time sales and purchase orders are considered. The order quantity and Reorder level is determined by using the EOQ (Economic Order Quantity) Model. This model can help to determine what would be the optimal order quantity along with limiting the inventory related costs (Holding cost, Ordering Cost) to minimum. Similarly Reorder point would determine the sufficient stock at hand in order to satisfy the customer demand till the next order arrives. The design of the proposed application is shown in Fig. 1:

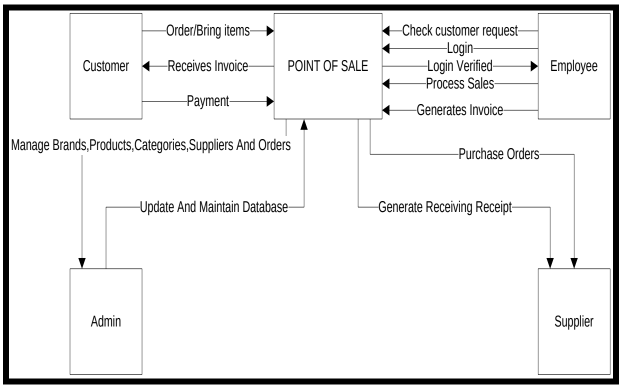


Fig. 1 Design of proposed application

Main objectives of application are described as:

3.1 Demand Forecasting

The demand forecast is done using statistical i.e. moving average and data mining techniques i.e. linear regression and back propagation and the parameters used in each technique for forecast are:

- Quarters
- Unit sales of each quarter
- Seasonal effect

3.1.1 Simple Moving Average

This statistical technique is mostly used for forecasting demands in the retail industry. But it is an ineffective forecasting technique as it does not take variability in consideration. Here EOQ model is not applied. The technique results for a particular selected product are as under:

Table 1: Steps for Simple Moving Average

Step1	Calculate the demand of each product based on the time period (Quarter)
Step 2	Use formula: $F = \frac{\sum_{i=1}^{n} S_{i-1}}{n}$ F= the forecast S= the sales of the periods. i, n= the periods.
Step 3	For each forecast, calculate MAD(Mean Absolute Deviation)

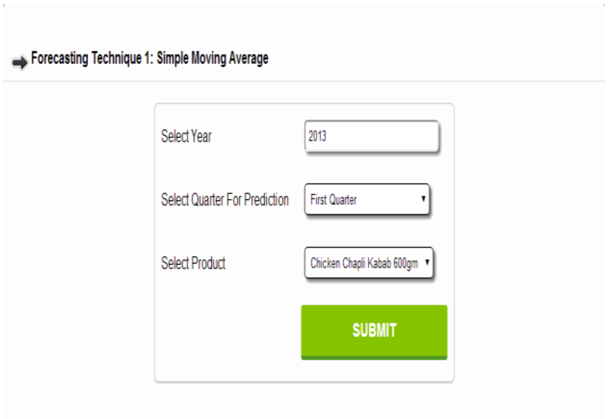


Fig. 2 User interface for simple moving average technique

Chicken Chapli Kabab 600gm

YEAR	QUARTERS	UNIT SALES
1	2011	158
2	2011	330
3	2011	311
4	2011	190
1	2012	209
2	2012	340
3	2012	309
4	2012	218

FORECAST(n=2)							MAD
244	320.5	250.5	199.5	274.5	324.5	263.5	86.8

FORECAST(n=3)						MAD
266.3	277	236.7	246.3	286	289	75.7

FORECAST(n=4)					MAD
247.3	260	262.5	262	269	52.2

FORECAST(n=5)				MAD
239.6	276	271.8	253.2	62.4

FORECAST(n=5)				MAD
239.6	276	271.8	253.2	62.4

FORECAST(n=6)			MAD
256.3	281.5	262.8	58.1

FORECAST(n=7)		MAD
263.9	272.4	45.9

FORECAST(n=8)
258.1

Fig. 3 Demand forecast results for one product for first quarter of year 2013

AVERAGE DEMAND	UNIT PRICE COST	HOLDING COST	FIX ORDER COST	LEAD TIME	TIMES ORDERED(n)	Q	QTR HOLDING COST	QTR ORDER COST	TOTAL QTR COST
183.5	266	0.25	181.2	8	1	183.5	6101.38	181.2	6282.58

Fig. 4 Estimation of total quarter costs using average demand

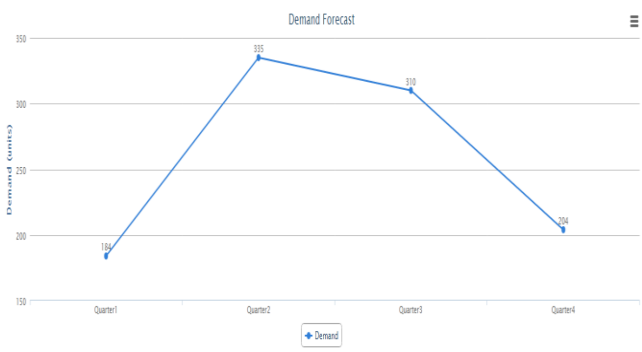


Fig. 5 Graph for demand forecast of one product using simple moving average

3.1.2 Linear Regression

This technique is used for forecasting demand. It considers quarters, unit sales to predict demand. Here the demand is not considered as constant from quarter to quarter. Here seasonal index is also used to consider the unpredictable demand.

Table 2: Steps for Linear Regression

Step1	Calculate the demand forecast equation for each product using formula: yt= axi+b
Step 2	Calculate seasonal Index=demand/forecast Expected Forecast= yt*(average seasonal index)
Step 3	Apply Economic Order Quantity Model, and put forecasted demand in formula:

	$$Q = \sqrt{\frac{2*D*S}{H*C}}$$
Step 4	Calculate reorder point using formula: Reorder Point= Demand usage*Lead time (in days)

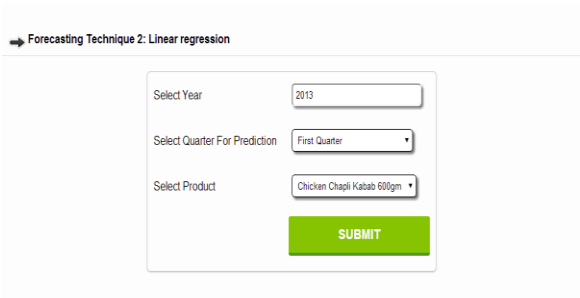


Fig. 6 User interface for linear regression technique

The equation is: y=235.57 + 5.0119 * x

Chicken Chapli Kabab 600gm

YEAR	QUARTERS	UNIT SALES	FORECAST	SEASONAL INDEX
2011	1	158	240.58	0.66
2011	2	330	245.6	1.34
2011	3	311	250.61	1.24
2011	4	190	255.62	0.74
2012	1	209	260.63	0.8
2012	2	340	265.64	1.28
2012	3	309	270.65	1.14
2012	4	218	275.67	0.79

AVERAGE SEASONAL INDEX			
0.73	1.31	1.19	0.77

Fig. 7 Demand forecast results for one product for first quarter of year 2013

Economic Order Quantity model is applied to determine optimal order quantity for the selected product.

FORECAST	UNIT PRICE COST	HOLDING COST	FIX ORDER COST	LEAD TIME	EOQ	ROP	OPTIMAL ORDERS(n*)	CYCLE TIME	QTR HOLDING COST	QTR ORDER COST	TOTAL QTR COST
204.9	266	0.25	181.2	8	33.4	5	6.1	15	1110.55	1111.61	2222.16

Fig. 8 Estimation of total quarter costs using EOQ Model

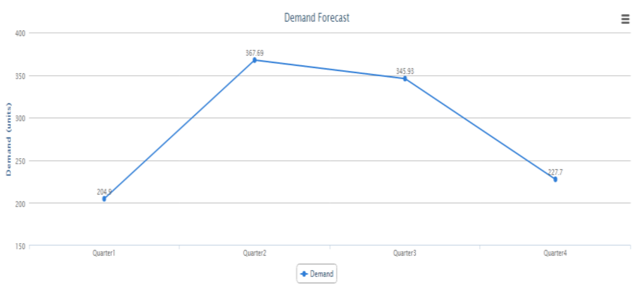


Fig. 9 Graph for demand forecast of one product using linear regression

3.1.3 Back Propagation

The algorithm considers quarters, sales and seasonal effect to predict the demand for selected quarter. The algorithm is trained on historical data of products during past two years and gives forecast for the selected quarter of current year for all products.

Table 3: Steps for Back Propagation Algorithm

Step1	Initialize training epoch =1
Step 2	Initialize weights with random values
Step 3	Present training data , calculate output and mean squared error (mse) for each output value and update weights accordingly
Step 4	When mse <= 0.0, stop training. Present testing data and calculate forecasted values
Step 5	Apply Economic Order Quantity Model by using forecasted demand

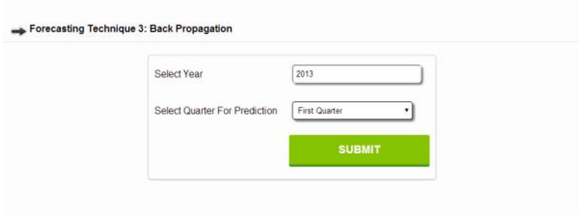


Fig. 10 User interface for back propagation algorithm

2013 QUARTER

First epoch Mean Square Error: 0.16903620819941

Network Trained. Threshold value achieved in 131 iterations.

MSE: 5.7056825642098E-6

Last epoch Mean Square Error: 5.7056825642098E-6

YEAR	QUARTERS	UNIT SALES	SEASONAL EFFECT	FORECAST
2011	1	158	1.04	152
2012	1	209	1.03	202
2013	1	N/A	1.03	174
2011	1	1044	1.04	1006
2012	1	1888	1.04	1820
2013	1	N/A	1.04	1641
2011	1	1	1	1
2012	1	17	1	17
2013	1	N/A	1	9
2011	1	1204	1.04	1161
2012	1	1256	1.04	1211
2013	1	N/A	1.04	964
2011	1	1686	1.04	1625
2012	1	1735	1.04	1673
2013	1	N/A	1.04	889
2011	1	9	1	9
2012	1	23	1.05	22
2013	1	N/A	1.03	29
2011	1	928	1.04	895
2012	1	1224	1.04	1180
2013	1	N/A	1.04	444
2011	1	10	1	10
2012	1	4	0.8	5
2013	1	N/A	1	9

2011	1	155	1.04	149
2012	1	212	1.03	205
2013	1	N/A	1.04	299
2011	1	268	1.04	258
2012	1	245	1.04	236
2013	1	N/A	1.03	207
2011	1	839	1.04	809
2012	1	964	1.04	930
2013	1	N/A	1.04	381
2011	1	100	1.04	96
2012	1	255	1.04	246
2013	1	N/A	1.04	367

Fig. 11 Demand forecast results for 12 products for first quarter of year 2013

Economic Order Quantity model is applied to determine optimal order quantity for 12 products.

FORECAST	UNIT PRICE COST	HOLDING COST	FIX ORDER COST	LEAD TIME	EOQ	ROP	OPTIMAL ORDERS(n*)	CYCLE TIME	QTR HOLDING COST	QTR ORDER COST	TOTAL QTR COST
174	266	0.25	181.2	8	30.8	4	5.6	16	1024.1	1023.66	2047.76
1641	299	0.25	304.71	8	115.7	36	14.2	6	4324.29	4321.77	8646.06
9	170	0.25	160.35	4	8.2	0	1.1	81	174.25	175.99	350.24
964	150	0.25	207.56	8	103.3	21	9.3	10	1936.88	1936.96	3873.84
889	117	0.25	258.41	8	125.3	20	7.1	13	1832.51	1833.41	3665.92
29	145	0.25	105.39	4	13	0	2.2	40	235.63	235.1	470.73
444	238	0.25	146.02	4	46.7	5	9.5	9	1389.33	1388.28	2777.61
9	87	0.25	132.33	4	10.5	0	0.9	99	114.19	113.43	227.62
299	100	0.25	129.24	4	55.6	3	5.4	16	695	695.01	1390.01
207	1935	0.25	181.23	8	12.5	5	16.6	5	3023.44	3001.17	6024.61
381	183	0.25	50.97	8	29.1	8	13.1	7	665.66	667.34	1333
367	250	0.25	207.56	8	49.4	8	7.4	12	1543.75	1541.99	3085.74

Fig. 12 Estimation of total quarter costs for 12 products using EOQ Model

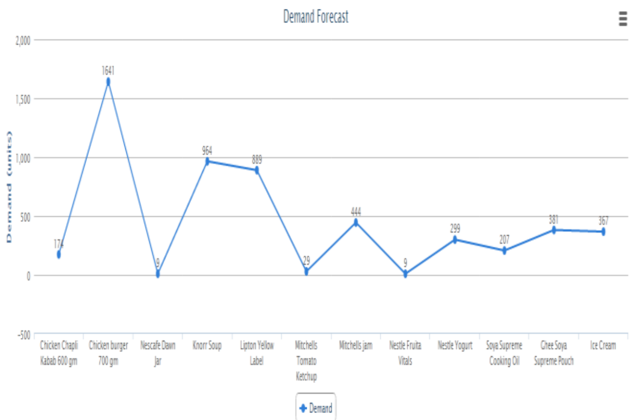


Fig. 13 Graph for demand forecast of 12 products using back propagation algorithm

3.2 Analyze Sales Transaction Data for Product Shelving by Apriori Algorithm

The patterns in transactional data will be analyzed using:

- Basket data of each customer
- Unique code for each customer

Table 4: Steps for Apriori Algorithm for Analyzing Transactions

Step1	Consider basket data of each customer
Step 2	Generate candidate item sets and define a minimum support
Step 3	When count of each product becomes less than minimum support i.e. 1, eliminate that item set
Step 4	Get frequent item sets

➡ Transaction for Most Frequently Bought Items Together

Trans No.	Items
1	Chicken Chapli Kabab 600gm,Lipton Yellow Label,Chicken burger 700 gm
2	Mitchells Tomato Ketchup,Lipton Yellow Label,Nestle Fruita Vitals
3	Chicken Chapli Kabab 600gm,Mitchells Tomato Ketchup,Lipton Yellow Label,Nestle Fruita Vitals
4	Mitchells Tomato Ketchup,Nestle Fruita Vitals
5	Nestle Fruita Vitals,Ice Cream,Soya Supreme Cooking Oil
6	Lipton Yellow Label
7	Knorr Soup,Chicken Chapli Kabab 600gm,Ghee Soya Supreme Pouch
8	Ice Cream,Mitchells jam
9	Ghee Soya Supreme Pouch,Nestle Fruita Vitals

➡ Candidate C-1

1-Itemset
Chicken Chapli Kabab 600gm
Chicken burger 700 gm
Ghee Soya Supreme Pouch
Ice Cream
Knorr Soup
Lipton Yellow Label
Mitchells Tomato Ketchup
Mitchells jam
Nestle Fruita Vitals
Soya Supreme Cooking Oil

➡ Join C- 1

1-Itemset	Count
Chicken Chapli Kabab 600gm	3
Chicken burger 700 gm	1
Ghee Soya Supreme Pouch	2
Ice Cream	2
Knorr Soup	1
Lipton Yellow Label	4
Mitchells Tomato Ketchup	3
Mitchells jam	1
Nestle Fruita Vitals	5
Soya Supreme Cooking Oil	1

➡ Prune L- 1

1-Itemset	Count
Chicken Chapli Kabab 600gm	3
Ghee Soya Supreme Pouch	2
Ice Cream	2
Lipton Yellow Label	4
Mitchells Tomato Ketchup	3
Nestle Fruita Vitals	5

Candidate C-2

2-itemset
Chicken Chapli Kabab 600gm,Ghee Soya Supreme Pouch
Chicken Chapli Kabab 600gm,Ice Cream
Chicken Chapli Kabab 600gm,Lipton Yellow Label
Chicken Chapli Kabab 600gm,Mitchells Tomato Ketchup
Chicken Chapli Kabab 600gm,Nestle Fruita Vitals
Ghee Soya Supreme Pouch,Ice Cream
Ghee Soya Supreme Pouch,Lipton Yellow Label
Ghee Soya Supreme Pouch,Mitchells Tomato Ketchup
Ghee Soya Supreme Pouch,Nestle Fruita Vitals
Ice Cream,Lipton Yellow Label
Ice Cream,Mitchells Tomato Ketchup
Ice Cream,Nestle Fruita Vitals
Lipton Yellow Label,Mitchells Tomato Ketchup
Lipton Yellow Label,Nestle Fruita Vitals
Mitchells Tomato Ketchup,Nestle Fruita Vitals

Join C- 2

2-itemset	Count
Chicken Chapli Kabab 600gm,Ghee Soya Supreme Pouch	1
Chicken Chapli Kabab 600gm,Ice Cream	0
Chicken Chapli Kabab 600gm,Lipton Yellow Label	2
Chicken Chapli Kabab 600gm,Mitchells Tomato Ketchup	1
Chicken Chapli Kabab 600gm,Nestle Fruita Vitals	1
Ghee Soya Supreme Pouch,Ice Cream	0
Ghee Soya Supreme Pouch,Lipton Yellow Label	0
Ghee Soya Supreme Pouch,Mitchells Tomato Ketchup	0
Ghee Soya Supreme Pouch,Nestle Fruita Vitals	1
Ice Cream,Lipton Yellow Label	0
Ice Cream,Mitchells Tomato Ketchup	0
Ice Cream,Nestle Fruita Vitals	1
Lipton Yellow Label,Mitchells Tomato Ketchup	2
Lipton Yellow Label,Nestle Fruita Vitals	2
Mitchells Tomato Ketchup,Nestle Fruita Vitals	3

Prune L- 2

2-itemset	Count
Chicken Chapli Kabab 600gm,Lipton Yellow Label	2
Lipton Yellow Label,Mitchells Tomato Ketchup	2
Lipton Yellow Label,Nestle Fruita Vitals	2
Mitchells Tomato Ketchup,Nestle Fruita Vitals	3

Candidate C-3

3-itemset
Chicken Chapli Kabab 600gm,Lipton Yellow Label,Mitchells Tomato Ketchup
Chicken Chapli Kabab 600gm,Lipton Yellow Label,Nestle Fruita Vitals
Chicken Chapli Kabab 600gm,Mitchells Tomato Ketchup,Nestle Fruita Vitals
Lipton Yellow Label,Mitchells Tomato Ketchup,Nestle Fruita Vitals

Join C- 3

3-itemset	Count
Chicken Chapli Kabab 600gm,Lipton Yellow Label,Mitchells Tomato Ketchup	1
Chicken Chapli Kabab 600gm,Lipton Yellow Label,Nestle Fruita Vitals	1
Chicken Chapli Kabab 600gm,Mitchells Tomato Ketchup,Nestle Fruita Vitals	1
Lipton Yellow Label,Mitchells Tomato Ketchup,Nestle Fruita Vitals	2

Prune L- 3

3-itemset	Count
Lipton Yellow Label,Mitchells Tomato Ketchup,Nestle Fruita Vitals	2

Fig. 14 Applying apriori algorithm to find products frequently bought together using customer transactions

3.3 Inventory Categorization(ABC Classification) Based on Product Annual Usage Percentage by K-means Algorithm

The inventory will be classified into 3 categories based on annual usage % of products:

- Category A
- Category B
- Category C

Table 5: Steps for K-Means Algorithm for Categorizing Inventory

Step1	Calculate annual usage = annual demand *unit price
Step 2	Set number of clusters = 3 (A, B and C)
Step 3	Calculate average of each cluster and distance of each value in cluster from the average
Step 4	Group values based on minimum distance

Annual Demand and Usage for each item

ID	ITEM NAME	ANNUAL DEMAND	UNIT PRICE	ANNUAL USAGE	ANNUAL USAGE %
10	Soya Supreme Cooking Oil	3820	1935	7391700	61.86
2	Chicken burger 700 gm	6939	299	2074761	17.36
4	Knorr Soup	3827	150	574050	4.8
5	Lipton Yellow Label	4055	117	474435	3.97
7	Mitchells jam	1542	238	366996	3.07
12	Ice Cream	1338	250	334500	2.8
9	Nestle Yogurt	2457	100	245700	2.06
1	Chicken Chapli Kabab 600gm	906	266	240996	2.02
11	Ghee Soya Supreme Pouch	1207	183	220881	1.85
6	Mitchells Tomato Ketchup	76	145	11020	0.09
3	Nescafe Dawn Jar	62	170	10540	0.09
8	Nestle Fruita Vitals	40	87	3480	0.03

Total Annual Usage =11949059

Fig. 15 Estimation of annual usage percentage for each product using annual demand and unit price

Inventory Categorization

Cluster1: Low Level Items = C
4.8,3.97,3.07,2.8,2.06,2.02,1.85,0.09,0.09,0.03

Cluster2: Medium level items = B
17.36

Cluster3: Most Critical Items = A
61.86

Fig. 16 Inventory (product) categorization into A (most critical), B (medium level) and C (low level) products using k-means algorithm

3.4 Supplier Selection based on Given Criteria Through Expert System using Naïve Bayesian Algorithm

Supplier will be selected on the basis of:

- Item name
- Delivery duration
- Payment duration
- Discount percentage

Table 6: Steps for Naïve Bayesian Algorithm

Step1	Maintain a knowledge base in database
Step 2	Determine a class variable such as suppliers
Step 3	For each input attribute (item name, delivery duration, payment duration, discount), find probabilities using the data maintained in knowledge base
Step 4	Multiply the probabilities of input attributes for each class variable
Step 5	Return the class variable (supplier) with minimum probability

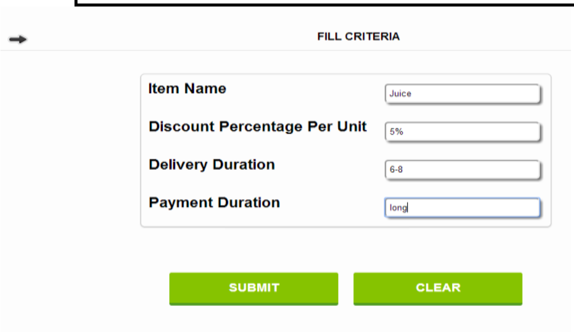


Fig. 17 Interface for filling criteria for a particular purchase order

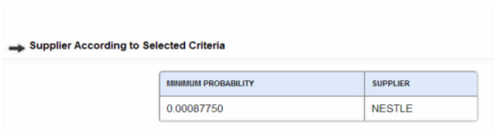
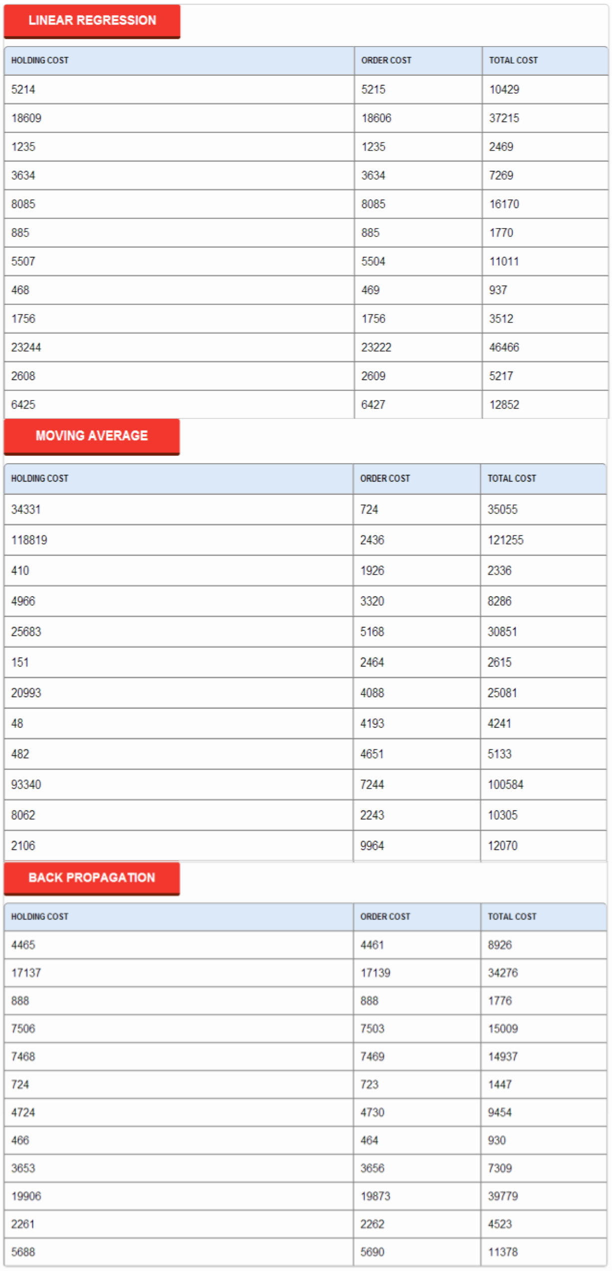


Fig. 18 Applying naïve bayesian algorithm to find suitable supplier for a purchase order

4. RESULTS

The application uses HTML, JavaScript, Jquery and CSS for front-end development while PHP for the implementation of back-end development and MySQL is used as database server. As a part of research, a comparative analysis of inventory costs determined using three different techniques (Linear Regression, Moving Average and Back Propagation) is carried out. The historical data, past two years (2011 and 2012) on quarterly basis, of 12 products from a supermarket is collected to determine demand forecast for the current year (2013) and to analyze products sales behavior due to demand.

4.1 Cost Comparison



LINEAR REGRESSION

HOLDING COST	ORDER COST	TOTAL COST
5214	5215	10429
18609	18606	37215
1235	1235	2469
3634	3634	7269
8085	8085	16170
885	885	1770
5507	5504	11011
468	469	937
1756	1756	3512
23244	23222	46466
2608	2609	5217
6425	6427	12852

MOVING AVERAGE

HOLDING COST	ORDER COST	TOTAL COST
34331	724	35055
118819	2436	121255
410	1926	2336
4966	3320	8286
25683	5168	30851
151	2464	2615
20993	4088	25081
48	4193	4241
482	4651	5133
93340	7244	100584
8062	2243	10305
2106	9964	12070

BACK PROPAGATION

HOLDING COST	ORDER COST	TOTAL COST
4465	4461	8926
17137	17139	34276
888	888	1776
7506	7503	15009
7468	7469	14937
724	723	1447
4724	4730	9454
466	464	930
3653	3656	7309
19906	19873	39779
2261	2262	4523
5688	5690	11378

Fig. 19 Calculation of total costs i.e. holding cost and order cost for linear regression, moving average and back propagation

Table 7: Comparison of Demand Forecast Techniques

Demand for Year 2013 Quarter 1st				
Products	**Original demand**	**SMA Forecast**	**LR forecast**	**BP forecast**
1	176	184	205	174
2	1650	1466	1748	1641
3	9	9	9	9
4	980	1230	1006.4	964
5	900	1711	982	889
6	30	16	28	29

7	460	1076	518	444
8	9	9	9	9
9	310	184	300	299
10	214	257	264	207
11	390	902	446	381
12	370	178	429	367

From table VII, it is evident that demand forecast using back propagation algorithm comes out to be nearest to the original demand for products in first quarter of year 2013 as obtained from the supermarket. Therefore, back propagation algorithm is efficient for demand forecasting purpose in inventory management as compared to simple moving average and linear regression.

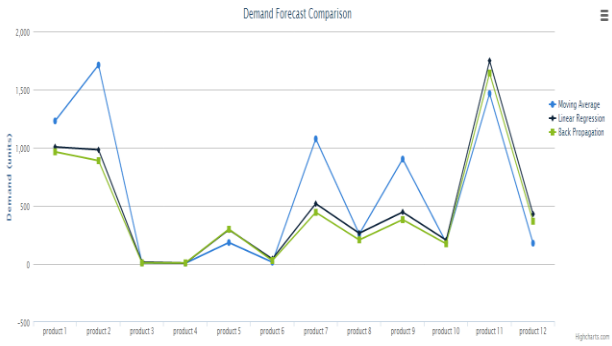


Fig. 21 Graph showing demand forecast comparison among techniques for first quarter of year 2013

Table 8: Cost Comparison

Cost Comparison of Demand Forecasting Techniques			
Techniques	**EOQ Model**	**Total Annual Costs**	**Savings Percentage**
Simple Moving Average	No	Rs. 357808	------
Linear Regression	Yes	Rs. 155326	57%
Back Propagation	Yes	Rs. 149745	58%

Moving Average is mostly used for forecasting demands in the retail industry. But it is considered to be an ineffective forecasting technique as it incurs high costs due to sales loss and multiple stock outs. Table VIII shows that using simple moving average for demand forecasting purpose results in highest costs per year. Moreover using linear regression for forecasting demand and afterwards using this demand in Economic Order Quantity model to calculate annual costs results in 57% savings when compared with simple moving average. Using back propagation for forecasting demand and putting the forecasted demand in Economic Order Quantity model results in 58% savings when compared with simple moving average. Therefore, it is deduced from the above comparison that the overall inventory costs after applying Economic Order Quantity model are found to be lowest for back propagation algorithm as compared to linear regression and simple moving average.

5. CONCLUSION AND FUTURE WORK

This work involves the development of point of sale application with the basic features of managing customers, employees, products, categories, brands, suppliers etc. Moreover it focuses on inventory management and inventory control by using demand forecasting techniques of moving average, linear regression and back propagation. Application of Economic Order Quantity model for reducing the costs related to inventory. It also analyzes the sales data of customers to determine which products must be shelved together to increase sales. It also incorporates the functionality of supplier selection based on given criteria by maintaining knowledge base. Another factor of inventory categorization is handled based on annual usage of products. All these features can make inventory management feasible for a supermarket. Future work can be including the credit and debit card processing functionality in application. Moreover further enhancements are required to consider security issues. The application can include wireless security channel.

6. REFERENCES

[1] Karthik Sundararaman, Jinka Parthasarathi, G Subrahmanya VRK Rao, S Nandha Kumar," Baseline Prediction of Point of Sales data for Trade Promotion Optimization", The 2nd International Conference on Communications and Information Technology (ICCIT): Digital Information Management, Hammamet, IEEE 978-1-4673-1950 8/12/$31.00, 2012.

[2] Numera Tahir, Muhammad Abbas Choudhary," Development of a Decision Support System for Inventory Analysis and Control", IEEE 978-1-61284-952-2/11/$26.00, 2011.

[3] Yunkang Yue, Tiebao Zhang, Xingbing Xu," Analysis on the Effect of Data-mining to Supermarket", The 5th International Conference on Computer Science & Education Hefei, China. August 24–27, 2010 IEEE.

[4] Qizhi Wu, Aihua Fang, He Gao," A Study on Inventory Cost Reduction Based on Economic Order Quantity Model", The International Conference on Logistics Systems and Intelligent Management, 2010 IEEE.

[5] Pradip Kumar Bala," Decision Tree Based Demand Forecasts for Improving Inventory Performance", International Conference on Industrial Engineering and Engineering Management (IEEM), 2010 IEEE.

[6] Goswami D.N., Chaturvedi Anshu., Raghuvanshi C.S.," An Algorithm for Frequent Pattern Mining Based On Apriori", International Journal on Computer Science and Engineering, Vol. 02, No. 04, 2010, 942-947.