E-Commerce Optimization on a B2C Type Website

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Received: June 28, 2021. Revised: June 18, 2022. Accepted: July 27, 2022. Published: September 8, 2022.

***Abstract*— In this study, an LP model was developed in order to determine the optimal working status in a B2C type e-commerce site. Prices were determined dynamically with the Q-learning algorithm, and dynamic cost values were determined with the help of dynamic prices and transferred into the LP model. The LP model is solved with the Lizprog library of the SCILAB language. The results found are effective and useful for the optimal operation of an e-commerce site, and faster results were obtained compared to similar studies.**

Keywords—e-commerce optimization, q-learning, linear programming, quadratic programming, business to customer (B2C) systems

I. Introduction

E-Commerce has gained importance as a result of the rapid development of the internet and has reached an indispensable point as a result of the pandemic that has shaken the world for the last 3 years. Although e-commerce is an effective way to market and sell products, it has become imperative for such companies to work very efficiently and optimally as a result of competition.

For this reason, scientific research on this subject has also come into play rapidly.

II. RELATED STUDIES

Bai et al. [1] developed a great detail-based human resource allocation method in e-commerce management. Thus, they had the opportunity to reach a much higher quality business level in the management of the e-commerce site.

F.A. Almeida et al. [2] developed a linear programming model to be used in decision making activities for an e-commerce firm in Brazil.

The model is programmed to maximize the revenue of the business in a certain period.

Shahhosseimi et al. [3] developed a method for optimizing the hyperparameters of machine learning models for regression problems. This method can be applied to various systems, including e-commerce models.

D.J. Kalita et al. [4] created a dynamic framework based on the Moth-Flame optimization method. In this way, SVM hyperparameters can set optimal evaluation. This method can also be used in various classification problems, including e-commerce sites.

Y. Hu et al. [5] developed an O2O model and developed an e-commerce management method that minimizes the total cost.

The obtained algorithm results are similar to the LINGO optimization results. But the processing time is very low.

N. Nishimura et al. [6] proposed a method for generating product lists using the quadratic allocation programming method on an e-commerce site. An important conclusion they reached is that serious strides must be made in both hardware and software in order to advance in quadratic programming.

L. Zhu [7] developed an optimization model that accurately predicts e-commerce product demand at every stage of the supply chain. This study is a useful reference in e-commerce supply chain research in the IoT environment.

D. Yang and P. Wu [8] presented a model for optimizing the logistics and distribution network of a B2C e-commerce site. For this purpose, an integer linear programming model has been established and expanded.

S.Krishnamoorty and D.Roy [9] proposed a new model for the storage assignment problem. The authors stated that it is very important to create and manage a mathematical model based on the B2C model in e-commerce sites where the number and distribution of customers is very diverse.

R.Fu et al. [10] proposed an optimization model for an e-commerce site that affects logistics distributions and shortens distribution distances. Thus, customer service quality and total cost are reduced.

S.Kedia et al. [11] presented a new machine learning and optimization model and estimated the optimal price point for each product in the e-commerce site. In addition, sales forecasts for the next day are also made.

Y.Huang [12] developed a theoretical framework on big data and developed a model that organizes product marketing sensitivities in e-commerce. Huang stated in his study that it is imperative for all e-commerce sites to include big data technologies in their management mechanism.

L.Ying and N.A.B.Aziz [13] proposed a linear programming model to minimize the total cost of an e-commerce site. The model determines the optimal product composition for the e-commerce site.

S. Das et al. [14] developed a forecasting model with machine learning methods for a three-month period. Thus, the e-commerce company will have the opportunity to make a reliable analysis among customers.

L. Vanneschi et al. [15] made an estimation of the risks that an e-commerce site will be exposed to, with the model they developed. The implementation method is based on the Genetic Algorithm approach.

S. Bay et al. [16] strengthened the prediction model by developing a feature-level decision system in order to provide customers with an effective e-commerce platform.

N. Gordini and V. Veglia [17] developed an approach for testing new forecasting models for a B2B model e-commerce site. Artificial neural networks, logistic regression and classical SVM are used to control the prediction performance.

J.R. Laurenco et al. [18] developed a model called PreX to prevent unwanted situations in e-commerce sites. According to the authors, PreX significantly improves the usability and performance of the system.

P.Yang et al. [19] conducted an optimization study on e-commerce stocking. A model has been developed that compares the options of serving from multiple warehouses at the same time or managing multiple products in a single warehouse.

V. Daultani et al. [20] developed a system that produces unsupervised summary texts for the description of products. It has been suggested that better results are obtained with the maximum coverage approach. In addition, such a product will make positive contributions to the transactions of e-commerce sites.

A.M. Florio et al. [21] developed a model that calculates the optimization of peak numbers in e-commerce. The authors considered the supply problem as a cluster fragmentation problem and used the "branch and price" algorithm for its solution.

Z. Tao et al. [22] developed a model that supports the decision-making system in an e-commerce distribution center with a mathematical approach. Linear programming was also used for the mathematical model.

W. Liu [23] has developed a method that finds the optimal distribution in rural e-commerce environments through heuristic optimization. The optimization model is based on the “Ant Colony Optimization” method.

M. Çetin and Y. Koç [24] carried out a study showing how to apply machine learning algorithms to many fields such as finance, education, industry, e-commerce and medicine. The performance of ML algorithms depends on the dataset and processing steps.

K. Namir et al. [25] developed a model using ML algorithms together with combinatorial optimization to perform stock prices and demand forecasts.

III. PROPOSED MODEL

Models that will maximize the revenue or minimize the cost of e-commerce sites are generally designed in accordance with the mathematical programming model.

F. A. Almeida et al. [2] presented a model, they solved the problem with the linear programming method. The objective function is given in the following form.

$$max\,F(y) = \sum_{j\geq 0}[\beta_j \quad X_J]$$

Here, β_j ‘s are unit prices for different products, and X_J’s are the sales amount of the product j. In addition, linear constraint equations were arranged in accordance with LP and the problem was solved using the simplex method.

Naoki Nishimura et al. [6] handled the optimization problem of the products on the e-commerce site as a QAP (Quadratic Assignment Problem) and expressed it as follows.

$$max\sum_{i\in I}\sum_{j\in j}P_{ij} \quad X_{ij} - w\sum_{i\in I}\sum_{i\in I}\sum_{j\in J}\sum_{j\in j}f_{ii} \quad d_{jj} \quad x_{ij} \quad x_{ij}$$

Details of this model can be found in [6]. This problem was later transformed into a QUBO optimization model and solved with D-Wave 2000Q software.

Since we are concerned with the global performance of the e-commerce system in out study, a relatively less complex model is used.

The objective function is chosen as the total cost function and is expressed as follows.

$$\min Z = \textstyle\sum_{j=1}^{m}\sum_{i=1}^{n} C_{ij} \quad S_{ij} \qquad (1)$$

Where

m: maximum types of product

n: number of different types or sizes for each product

c_{ij}: unit cost

s_{ij}: sales amount

The constraints can be expressed as follows.

$$\textstyle\sum S_j \geq Q_{kj} \qquad (2)$$

Q_{kj} is the minimum demand amount committed to the jth supplier.

Also S_i, i. supplier’s minimum sales volume must be greater than or equal to one M_i minimum.

$$\textstyle\sum S_i \geq M_i \qquad (3)$$

$$\textstyle\sum_{i=1}^{m}\sum_{j=1}^{n} S_{ij} \leq U_{ij} \qquad (4)$$

Here U_{ij} represents the resource upper limit for each individual case.

Of course, here S_{ij} sales values have to be positive or zero.

$$S_{ij} \geq 0 \qquad (5)$$

Since the objective function and constraints are linear here, the model is the linear programming (LP) model and the classical solution is the simplex algorithm.

IV. DYNAMIC PRICE SETTING

The selling price of the products can be calculated dynamically. Various methods have been proposed in this regard. When it comes to using such a model, unit costs can also be made dynamic.

$$C_{ij} = f_{ij} - kar_{ij}$$

Here, when f_{ij} is dynamic, C_{ij} will also create a dynamic model.

Dynamic price determination Y. Chang [26] suggested the following algorithm.

Algorithm: Q-learning for dynamic pricing arbitrarily all Q(s,a) values

[Repeat]

a)Initiate the stock of target product

b)Let t=0

c)Input the demand parameters obtained through presale research

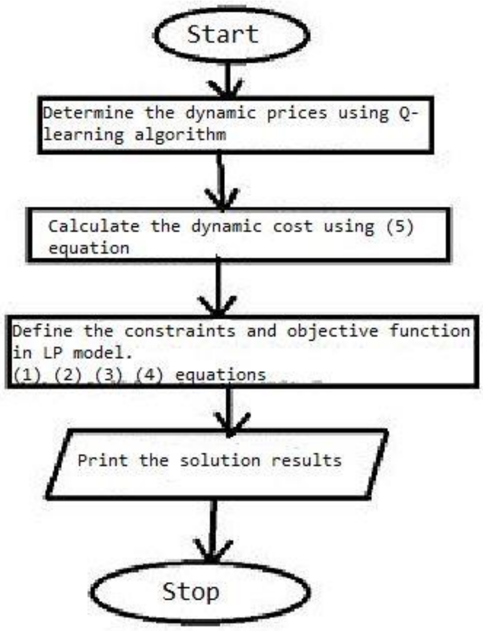
d)repeat

[Ten steps in [26]]

e)If the desired number of episodes loop has been large enough or Q value to convergent end calculation

V. SOLUTION STEPS

Apply the following algorithm to determine the optimal state of the e-commerce site.



VI. RESULTS

Here, in a real e-commerce site, the number of products (m) and the number of varieties (n) for each product is very high. Therefore, it will not be realistic to list the numerical results of such a system here.

However, when the system is run with a prototype data containing a small number of data, it gives fast and effective results.

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