March - April 2020
ISSN: 0193-4120 Page No. 4511 - 4520

A Product Demand Forecasting Model based on Exponential Smoothing through Analysis of Consumer Requirements

Yeong-Hwi Ahn[1], Koo-Rack Park[*2], Hwang-Rae Kim[3], Dong-Hyun Kim[4]
[1]Ph. D. Student, Department of Computer Engineering, Kongju National University, 31080, Rep. of Korea.
[*2,3]Professor, Department of Computer Science & Engineering, Kongju National University, 31080, Rep. of Korea.
[4]Ph. D., Department of Computer Engineering, Kongju National University, 31080, Rep. of Korea.
yhahn@trigem.co.kr[1], ecgrpark@kongju.ac.kr[*2], plusone@kongju.ac.kr[3], dhkim977@naver.com[4]

Article Info
Volume 83
Page Number: 4511 - 4520
Publication Issue:
March - April 2020

Abstract
Background/Objectives: The main factors that define a company's growth and performance are the product market demand that meets consumer needs and services, and it is important for companies to exactly identify trends in market demand. The existing demand forecasting technique is limited to analyzing rapidly changing market trends and ensuring the output of results, so it is necessary to establish and operate a system based on demand forecasting that enables rapid planning of global products.

Methods/Statistical analysis: System: In order for product planners to develop the best products that fully reflect the exact needs and services of consumers, we analyzed diverse and vast big data of portal companies, collected data on products based on web crawling. That can collect and utilize the data that users want in real time, and analyzed demand in the past, used additive seasonal exponential smoothing among time series forecasting techniques to forecast future demand as well as demand patterns at the present time. We also used Nelson Rules Logic to eliminate inaccurate demand needs, and analyzed and designed the exact demands of consumers to analyze out-of-range signals for demand forecasting. Based on the above, satisfaction with product usage was calculated and used for product planning.

Findings: For companies, product planning based on market demand forecasting is very important, which is to maximize the growth and performance of the company by making the best use of limited human resources. To this end, companies are spending enormous costs and outsourcing the analysis of consumer needs and services to external marketing companies to obtain data. It can be said that launching the right product at the right time controls the company's fate. The product demand forecasting model based on the time series forecasting technique proposed in this paper is a system for obtaining useful and accurate information for planning the best products. According to the results of a survey of the use of the proposed model for planners engaged in product planning, the satisfaction level was higher than expected in terms of system satisfaction, system efficiency, and system effectiveness.

Improvements/Applications: In order to analyze more sophisticated consumer needs and services in the future, research on product demand forecasting considering rapidly changing global environment and climate as well as consumer emotion analysis should continue with natural language processing using deep learning on customer reviews.

Keywords: *Web Crawling, Big data, Product planning, Nelson Rules, Exponential Smoothing, Demand forecasting.*

Article History
Article Received*: 24 July 2019*
Revised*: 12 September 2019*
Accepted*: 15 February 2020*
Publication*: 26 March 2020*

March - April 2020
ISSN: 0193-4120 Page No. 4511 - 4520

1. Introduction

Although the planning and development of new products play an important role in the performance and growth of the company, the success probability of new products is very rare and the failure rate is about 80-90% [1]. In particular, new products fail between 75-95% at the purchase site [2]. Therefore, a lot of research is being conducted to develop successful new products [3], and reducing the high failure rate is the biggest challenge of new product development research [4]. One of the important aspects in this new product development area is joint participation of consumers, where consumers provide with the meeting needs for existing products and ideas for new services and products [5], properly evaluate consumer needs, and impracticability may be a major cause of new product failures [6]. Therefore, companies forecast the success or failure of new product development before launch and decide whether to launch the product through demand forecasting analysis to minimize failure. Especially in the case of venture companies, a business model that explores new business opportunities based on technology is the core of the company's operations, so the function of R&D is important to develop innovative products based on technology [7]. Recently, fierce competition among companies and complex business environment require the introduction of a systematic product planning process that reflects thorough consumer needs and services for the successful commercialization of new products. In fact, portal companies such as Google analyze keyword data in big data to provide corporate users with a variety of information such as ranking by search, quarterly search volume and gender distribution. The data analysis data disclosed in this form is used to forecast consumer needs and service demand that define the company's performance and growth, but this alone makes it difficult to analyze the rapidly changing consumer needs and service market trends and produce the results. To compensate for this, companies are outsourcing consumer needs and services through external marketing companies and analyzing them with the submitted data. In product planning based on market demand forecasting, products should be launched in a timely manner to reflect the rapidly changing consumer needs and services in the new product planning by making full use of limited human resources.

This suggests the necessity of demand forecasting analysis that can reflect time cost investment economic feasibility and consumer demand quickly and accurately, in addition to the qualitative forecasting techniques that have been frequently applied. In particular, the quantitative forecasting technique can detect trends, seasonal fluctuations, cyclical factors, and irregular fluctuation factors using regression analysis, exponential smoothing, and moving average methods. It can also reflect the economic feasibility of time and money investment and rapidly changing consumer needs with the development of process using big data. In order to reflect rapidly changing consumer needs and services, this study analyzes keywords in big data provided by portal companies using additive seasonal exponential smoothing among time series forecasting techniques and proposes the most suitable demand forecasting model through signal detection by deriving forecasting models and using the residuals of actual search volume and forecasted search volume.

Existing product planners and companies were limited to guaranteeing demand forecasting data proportional to input time and cost, but it is expected that the use of the model proposed in this study will help to achieve the target demand forecasting goal.

2. Related Works

2.1. Product Planning Process

Companies which develop and release new products need to reflect consumers' opinions,

especially in order to provide consumers with improved or new products, so the approach to marketing and research and development focuses on the analysis of customer requirements [8]. For this reason, companies recognize that customer needs are directly and indirectly involved in product development, and try to create value by purchasing and renting various solutions such as services and products in order to satisfy consumer requirement [9,10].

In particular, early identification of new product development opportunities through the analysis of consumer needs is an important requirement for the product improvement process and the development of new product [11]. Early identification of these opportunities can enable companies to build customized and unique relationships with consumers, increasing their competitiveness because it cannot be easily copied by other companies [12]. Recently, as the life cycle of new products is decreasing and the demands of consumers are complicated and dynamically changed due to the complex business environment, related social media provide a lot of data in real time in relation to the opinions of consumers [13].

[Figure 1] below is a general product planning conceptual diagram.

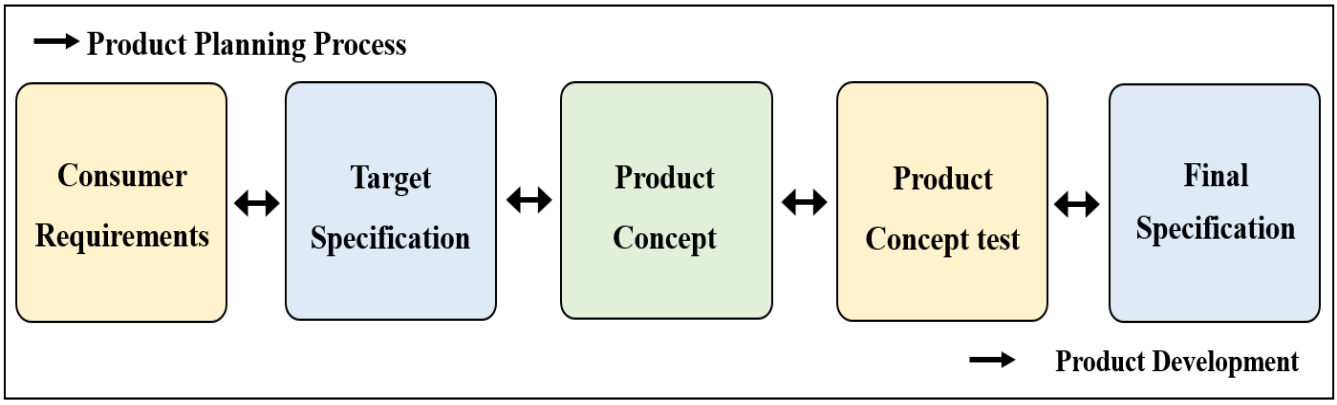

Figure 1. Product Planning Concept.

General product planning involves a series of processes: analysis of consumers' requirements, planning roadmaps for products, creation of planned products, evaluation of usability, production and commercialization of finished products.

Among them, the key elements of demand forecasting are consumer needs analysis and services reflecting the latest trends. In the product planning stage, the product development plan is established by examining the analysis of consumer needs, determining target specifications, selecting and testing product concepts, and setting final specifications.

Key activities include the analysis of major consumers, analysis of competitive products, feasibility review of product concepts, manufacturing cost estimates, evaluation of production feasibility, feedback of customers using current products, useful life related to product groups and status of new technology.

Therefore, the product planning process is a process of making a virtual product by examining consumers' needs and characteristics.

2.2. Demand Forecasting

In product planning, companies need to use regular demand forecasting techniques to forecast rapidly changing consumer needs and service demands. Traditional qualitative forecasting techniques include market survey method, Delphi method, panel survey, and salesman measurement method.

March - April 2020
ISSN: 0193-4120 Page No. 4511 - 4520

However, long-term forecasting techniques are not appropriate for forecasting the rapidly changing consumer needs and service demand of the current era. The quantitative forecasting technique can detect trends, seasonal fluctuations, cyclical factors, and irregular fluctuation factors using regression analysis, exponential smoothing, and moving average methods. It can also reflect the economic feasibility of time and money investment and rapidly changing consumer needs with the development of process using big data.

• Exponential Smoothing Methods

Traditionally, exponential smoothing methods have been used simply for forecasting, and are particularly used for forecasting demand for inventories [14], and have well-established sophisticated approaches for competitive forecasting [15]. These exponential smoothing methods are generally used through three basic modifications such as simple exponential smoothing, trend-corrected exponential smoothing, and Holt-Winters technique [16-18].

The characteristics of the approach to using exponential smoothing methods can be divided into two categories as follows [19]. First, it is assumed that time series consist of unobserved components such as growth, seasonal influences and levels. Second, if components of demand are affected by structural changes in the commodity market, the components must be adjusted over time. Therefore, these components can be combined by multiplication and addition operators, so exponential smoothing can identify 24 variations[20].

Exponential smoothing is an analytical method that forecasts smooth time series values of irregular fluctuations by applying methods such as moving average and weighted moving average to observed time series data. And the smoothing method can estimate the demand forecasting value reflecting the characteristics desired by the user by applying the seasonal fluctuation smoothing method depending on the type of seasonal variation [18]. In this study, we applied an additive seasonal variation smoothing method that consistently shows the seasonal amplitude of time series over time.

• Additive Seasonal Exponential Smoothing Method

Among the time series forecasting techniques, the additive seasonal exponential smoothing method is a method of adjusting the seasonal amplitude over time during the data analysis. If the current point in time is n, the predicted value after time point l is expressed as the sum of three components that smoothed horizontality, trending, and seasonality as shown in (Equation 1) below.

$$F_{n+1} = a_n + b_n l + S_{n+l-L}, \quad , l = 1, 2, \cdots, L \qquad (1)$$

$$a_n = \alpha(Z_n - S_{n-L}) + (1-\alpha)(a_{n-l} + b_{n-1})$$

$$b_n = \beta(a_n - a_{n-1}) + (1-\beta)b_{n-1}$$

$$S_n = \gamma(Z_n - a_n) + (1-\gamma)S_{n-L}$$

Where l = 1,2, ⋯, L is the length of seasonality, S_n is the seasonal factor, and α, β, and γ are the smoothing constants. In addition, a_n , b_n and S_n are a horizontal component, a trend component and a seasonal component, respectively.

2.2. Nelson Rules

Nelson rules, additional action rules for detecting specific causes in SPC (Statistical Process Control), is a method used to proactively prevent defects that may occur in product processes. Inaccurate demands can be eliminated and more accurate demands can be analyzed by applying Nelson's 8 rule to the quantitative forecasting method [21,22]. The statistical process control usually includes the function that SPC solution software automatically detects the abnormal patterns according to 8 laws and informs the user, while the quality manager monitors the abnormality of the SPC program, and determines the corrective action based on the analyzed data.

March - April 2020
ISSN: 0193-4120 Page No. 4511 - 4520

3. Proposed Model

3.1. Model Configuration

[Figure 2] below is the system diagram of the proposed model. It manages data on demand forecasting and manages data related to membership registration, monthly search trend, product demand forecasting, notice uploading, environment setting, and external demand forecasting site connection.

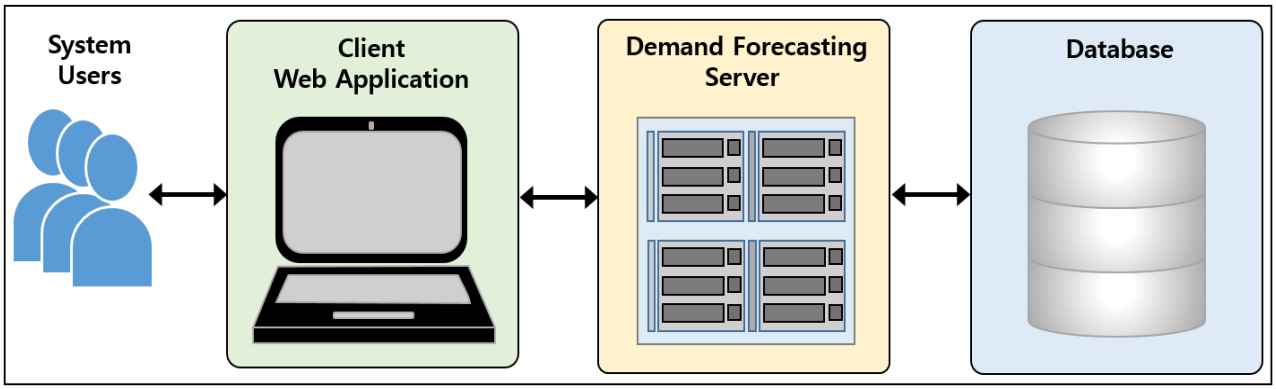

Figure 2. Proposed Model Configuration.

3.2. System Architecture

[Figure 3] below is the architecture of the proposed model, which consists of three parts: The first is an analysis part, which consists of the collection, analysis, and refinement of big data, which is the basis of demand forecasting model. The second is a database part in which the extracted data is stored in the demand forecasting server and visualized through a web application. The third is a demand forecasting server part, which compares the residuals of the demand forecasting model with real-time big data to detect and extract deviated signals.

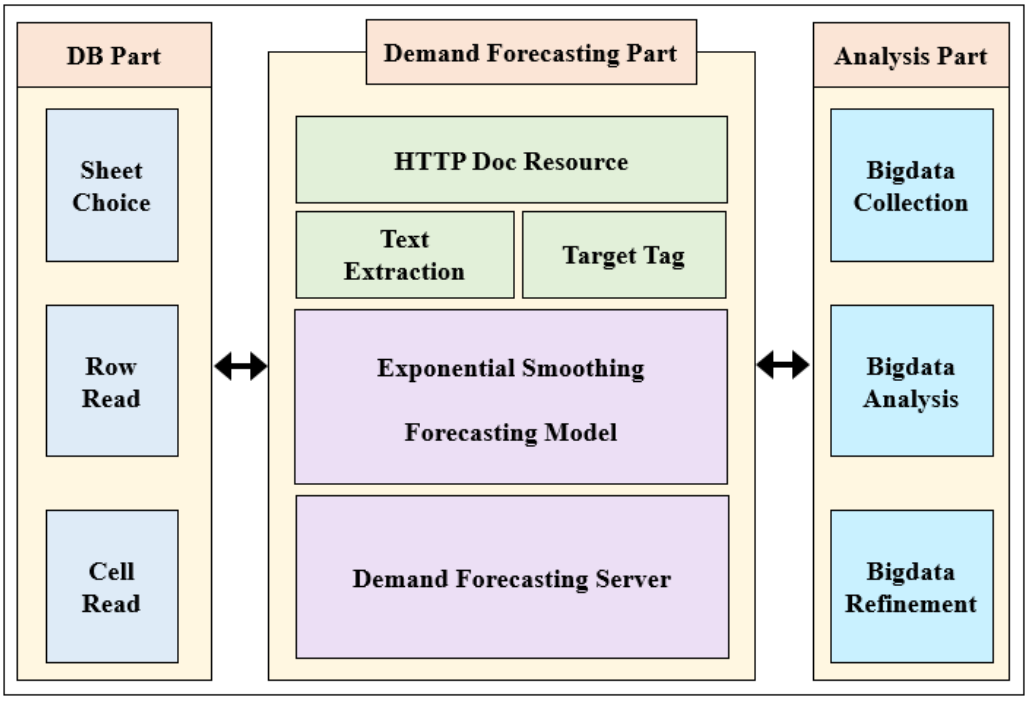

Figure 3. Proposed System Architecture.

March - April 2020
ISSN: 0193-4120 Page No. 4511 - 4520

3.3. System Process

[Figure 4] below is a system process of the proposed model, which is composed of 4 steps: First, it collects and analyzes big data of portal site and creates a demand forecasting model using time series forecasting technique. Second, when the product line of interest is entered into the search box, the relevant data is extracted through real-time big data analysis and delivered to the demand forecasting server. Third, the demand forecasting server of the algorithm reflecting the Nelson's 8 rule compares the residuals of extracted real-time big data and extracts core data used in practical demand forecasting and product planning. Fourth, the data extracted by comparing the residuals are stored in the database and can be used according to user requirements.

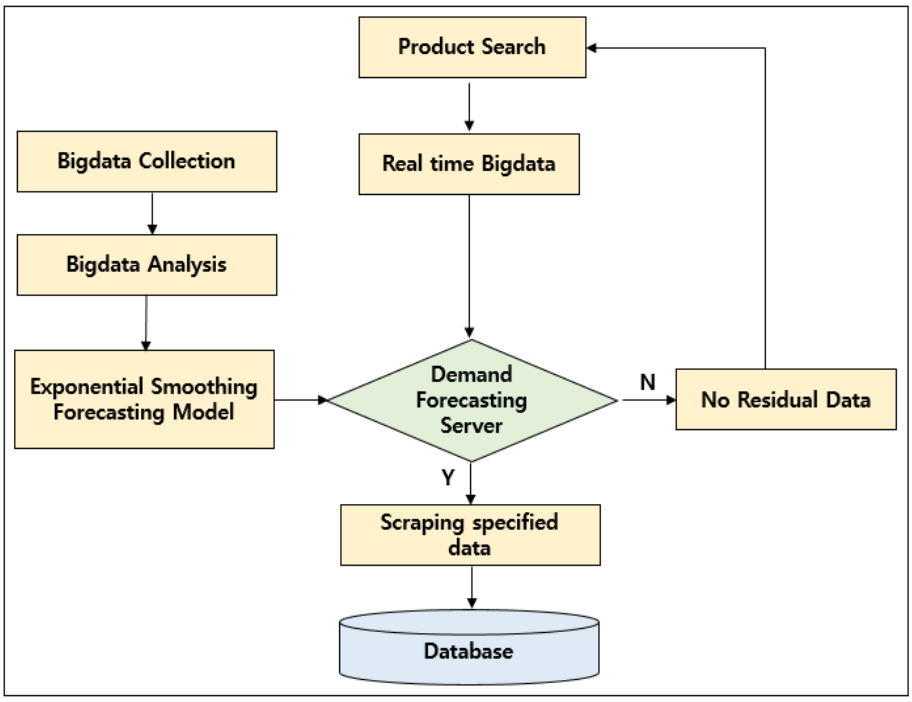

Figure 4. Proposed System Flowchart.

3.4. Nelson Rules

The following [Figure 5] is an algorithm for detecting deviated signals based on Nelson Rules of the proposed model. In the items of the algorithm, one of eight consecutive points (measured values) does not exist in one sigma line, and the distribution of measured values in both directions based on the average line rarely occurs randomly, so the determination of a deviated signal for any cause is notified to the demand forecasting server.

```
for i in range(len(chunks)):
    if all(i < (mean – sigma) or i > (mean + sigma) for i in chunks[i]) \
            and any(i < (mean – sigma) for i in chunks[i]) \
            and any(i < (mean + sigma) for i in chunks[i]) :
        results.append(True)
    else:
        results.append(False)
```

Figure 5. Proposed 8rule of Nelson Rules Algorithm.

March - April 2020
ISSN: 0193-4120 Page No. 4511 - 4520

3.5. Database Table

[Table 1] below is a table structure that stores information about outsourced global products. This is a table structure that applies and stores the analysis results of web crawling and product review through similar product images. In the product sourcing information data table, the item is a primary key, and the manufacturer, amount, repurchase rate, transaction volume, satisfaction, URL, contact person, phone number, and email can be stored.

Table 1. Structure of product outsourcing information table.

No.	Field	Description	Data Type
1	Item (PK)	Product Name	Varchar(120)
2	Manufacturer	Product Manufacturer	Varchar(70)
3	Unit_Price	Product Unit Price	Number(15)
4	Repur_Rate	Product Repurchase Rate	Number(10)
5	Tran_Quan	Product Transaction Quantity	Number(10)
6	Satisfaction	Product Satisfaction	Number(10)
7	URL	Product Site Address	Varchar(200)
8	Manager	Person in Charge	Varchar(60)
9	Telephone	Phone Number	Number(30)
10	Email	Person in Charge E-mail	Varchar(50)

4. Test and Results

4.1. Main Screen of the Suggested Model

[Figure 6] below shows the main screen of the product demand forecasting management model. Membership is essential to access and use the system of the forecasting management model. Membership is essential because it is a system for product developers to forecast product demand. Membership is carried out through the user authentication step for identity verification, and one can use the product demand forecasting management model after signing up as a member.

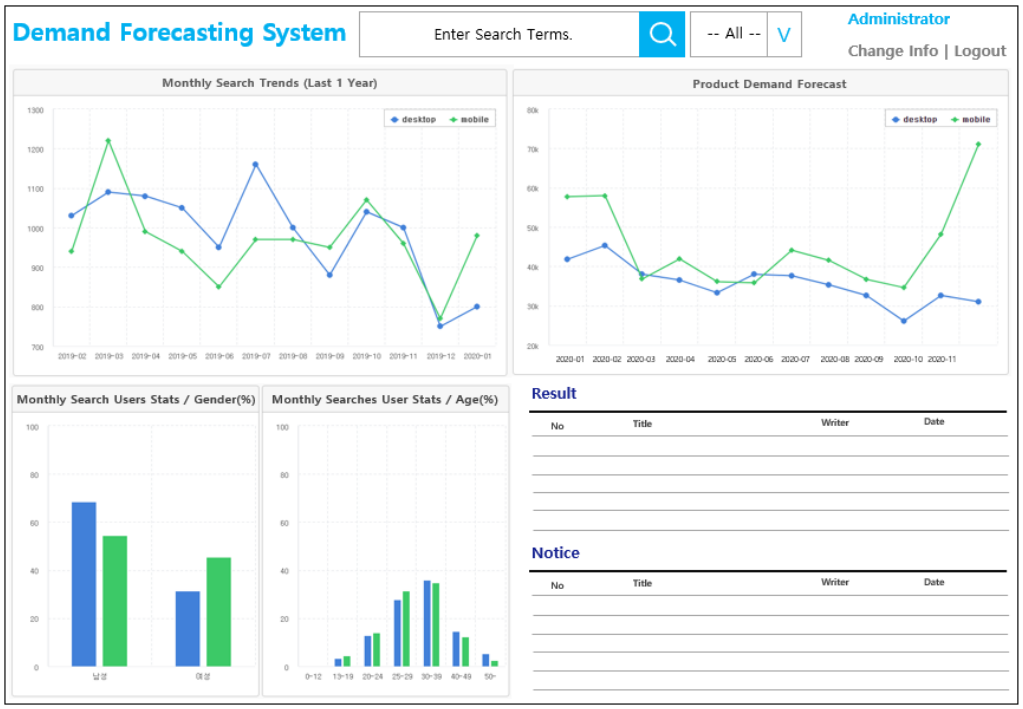

Figure 6. Proposed Model Main Screen.

4.2. Service Evaluation

While the demand forecasting model proposed in this paper was operated and used for 40 days during the test period, the user service evaluation of the proposed model was conducted by conducting a survey of user satisfaction, system effectiveness, and system efficiency. [Table 2] below summarizes the service evaluation.

Table 2. General matters of service evaluation.

Category	Contents
Survey method	A Survey for Product Demand Forecasting Model Users
Test period	2020. 01. 01 ~ 2020. 02. 09.
Age of survey subjects	20s ~ 60s
Subjects	Product planners and product sourcing officials

In order to evaluate the use of the product demand forecasting system, items were classified into user satisfaction, system effectiveness, and system efficiency, and detailed evaluation items were prepared for each item. The survey was conducted for 50 product planners engaged in product sourcing. [Table 3] below is the survey result table.

Table 3. Survey results.

Category	User Satisfaction	System Efficiency	System Effectiveness
Very satisfied	38	36	34
Satisfied	9	12	11
Moderate	2	1	3
Unsatisfied	1	1	2
Very unsatisfied	0	0	0

The survey results of the product demand forecasting system model showed that the quality of the system, the system effect of the service, the system efficiency, and the user satisfaction were 93.3% or higher on average, which was found to be positive for the system of the proposed model. In addition to the general seasonal factors, opinions on more sophisticated demand forecasting models were drawn in the revision and supplementation of active data on seasonally occurring climate changes.

5. Conclusion

The planning and development of new products play an important role in the performance and growth of the company. One of the important aspects in the new product development area is joint participation of consumers, where consumers need to properly evaluate the meeting needs for

March - April 2020
ISSN: 0193-4120 Page No. 4511 - 4520

existing products and ideas for new services and products and expand the business model. In product planning based on market demand forecasting, products should be launched in a timely manner to reflect the rapidly changing consumer needs and services in the new product planning by making full use of limited human resources. Demand forecasting of new products is a very important factor for the development and success of companies, and it is necessary to plan products by making full use of the limited manpower. In this paper, we propose a new demand forecasting process that combines time series forecasting and big data to achieve the objectives of the company's growth and performance. This study is meaningful in that it systematically organizes the analysis process of release time, family group, gender and age, which are information needed for product planning through the big data analysis and demand forecasting technique. Through this, it is expected that product planners will spend less time developing products. In order to analyze more sophisticated consumer needs and services in the future, research on product demand forecasting considering rapidly changing global environment and climate as well as consumer emotion analysis should continue with natural language processing using deep learning on customer reviews.

References

[1] Castellion, G., & Markham, S. K. Perspective: New Product Failure Rates: Influence of A rgumentum ad Populum and Self-Interest. Journal of Product Innovation Management. 2013;30(5):976-979. DOI: 10.1111/j.1540-5885.2012.01009.x.

[2] Crawford, M. New Product Failure Rates : Facts and Fallacies, R&D Management. The journal of science policy and research management. 1988 Mar;3(4):512. DOI: 10.20801/jsrpim.3.4_512_3.

[3] D.G. Markovitch, J.H. Steckel, A. Michaut, D. Ph ililp, W.M. Tracy. Behavioral reasons for New Product Failure: Does Overconfidence Induce Overforecasts. Journal of Product Innovation Management. 2015;32(5):825-841. DOI: 10.1111/jpim.12252.

[4] Derbyshire, J., & Giovannetti, E. Understanding the failure to understand New Product Development failures: Mitigating the uncertainty associated with innovating new products by combining scenario planning and forecasting. Technological Forecasting and Social Change. 2017 Dec;125:334-344. DOI: 10.1016/j.techfore.2017.02.007.

[5] Hoyer, W. D., Chandy, R., Dorotic, M., Krafft, M., & Singh, S. S. (2010). Consumer Cocreation in New Product Development. Journal of service research. 2010 Aug;13(3):283-296. DOI: 10.1177/1094670510375604.

[6] Ogawa S, Piller FT. Reducing the risks of new product development. MIT Sloan management review. 2006;47(2):65-71.

[7] Cooper RG, Edgett SJ, Kleinschmidt EJ. Benchmarking best NPD practices—I. Research-Technology Management. 2004 Jan;47(1):31-43. DOI: 10.1080/08956308.2004.11671606.

[8] Jeong, B., Yoon, J., & Lee, J. M. Social media mining for product planning: A product opportunity mining approach based on topic modeling and sentiment analysis. International Journal of Information Management. 2019 Oct;48:280-290. DOI: 10.1016/j.ijinfomgt.2017.09.009

[9] Silverstein, D., Samuel, P., & DeCarlo, N. The innovator's toolkit: 50+ techniques for predictable and sustainable organic growth. John Wiley & Sons; 2013.

[10] Griffin, A., & Hauser, J. R. The voice of the customer. Marketing Science. 1993 Feb;12(1):1-27. DOI: 10.1287/mksc.12.1.1.

[11] Van Kleef, E., van Trijp, H. C., & Luning, P. Consumer research in the early stages of new product development: A critical review of methods and techniques. Food Quality and Preference. 2005 Apr;16(3):181-201. DOI: 10.1016/j.foodqual.2004.05.012.

[12] Park, H., & Yoon, J. A chance discovery-based approach for new product–service system (PSS) concepts. Service Business. 2015 Dec;9(1):115-135. DOI: 10.1007/s11628-013-0222-x.

[13] Brooks, S. Does personal social media usage affect efficiency and well-being. Computers in

March - April 2020
ISSN: 0193-4120 Page No. 4511 - 4520

Human Behavior. 2015 May;46:26-37. DOI:10.1016/j.chb.2014.12.053.

[14] Gardner, E. S. Exponential smoothing: The state of the art. Journal of Forecasting. 1985;4(1):1-28. DOI:10.1002/for.3980040103.

[15] Makridakis, S., & Hibon, M. The M3-Competition: Results, conclusions and implications. International Journal of Forecasting. 2000 Dec;16(4):451-476. DOI:10.1016/S0169-2070(00)00057-1.

[16] Brown, R. G. Statistical forecasting for inventory control. New York7 McGraw Hill. 1959.

[17] Holt, C. C. Forecasting Seasonals and Trends by Exponentially Weighted Moving Averages, ONR Memorandum, vol. 52, Carnegie Institute of Technology. Pittsburgh, PA, USA. 1957. (published in International Journal of Forecasting 2004, 20, 5–13).

[18] Winters, P. R. Forecasting sales by exponentially weighted moving averages. Management Science. 1960 Apr;6(3):324-342. DOI: 10.1287/mnsc.6.3.324.

[19] Billah, B., King, M. L., Snyder, R. D., & Koehler, A. B. Exponential smoothing model selection for forecasting. International journal of forecasting. 2006 Jun;22(2):239-247. DOI: 10.1016/j.ijforecast.2005.08.002.

[20] Hyndman, R. J., Koehler, A. B., Snyder, R. D., & Grose, S. A state space framework for automatic forecasting using exponential smoothing methods. International Journal of Forecasting. 2002 Sep;18(3):439-454. DOI: 10.1016/S0169-2070(01)00110-8.

[21] Nelson, L. S. The Shewhart Control Chart–Tests for Special Causes. Journal of Quality Technology. 1984;16(4):237-239. DOI: 10.1080/00224065.1984.11978921.

[22] Nelson, L. S. Interpreting Shewhart X Control Charts. Journal of Quality Technology. 1985;17(2):114-116. DOI: 10.1080/00224065.1985.11978945.