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Sustainable performance measurement of Indian retail chain using two-stage network DEA

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Abstract

Incorporating sustainable decisions with the retailer's operational management has attracted enormous significance due to government regulations and customer demand for environmental consciousness. However, incorporating sustainable operations may interfere with the operational performance of the firm and, hence, retail companies need to examine the influence of these operations on overall supply chain efficiency. The present study develops a performance measurement model based on a two-stage network data envelopment analysis (DEA) technique for measuring the joint impact of sustainable operations and operational activities on the business performance of a retail company. A case study of an Indian electronic retail chain is presented to reveal the potentiality and suitability of the proposed models. The novelty of the paper lies in establishing DEA models for an Indian retail chain company and for providing an analytical understanding of the conditions under which the strategic decisions at the operational level successfully support the integration of sustainable operations into the SC management. The results show that the additional sustainable constraints lead to improved operational efficiency of some firms of the retail chain and result in improved business efficiency, while for other firms the integration of sustainable objectives decrease business efficiency. The significance of the study lies in providing efficient target conditions for inefficient retail stores to improve their performance. The findings of the study provide meaningful insights to Indian retailers venturing into sustainable retailing operations for enhancing the operational and business efficiency of the supply chain.

Keywords Retail supply chain · Sustainable performance · Operational performance · Business efficiency · Two-stage network DEA

1 Introduction

In recent years, sustainability has gained prominence and relevance globally in the retail sector, driving retail organizations towards adapting sustainable practices in their business environments (Fatimah et al., 2020; Kannan et al., 2020; Schweikert et al., 2018).

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Integrating sustainability as a core value in Supply Chain (SC) activities is being seen by most global retailers as a key market opportunity for accomplishing competitive benefits (Fraj et al. 2011; Jouzdani & Govindan, 2021; Kannan, 2021), and it has become an imperative part of their business strategies (Hendiani et al., 2019; Mina et al., 2021). Retailers are thus striving to reduce operating expenses and enhance the profitability of their stores through environmentally-friendly practices like emission reduction, energy conservation, waste elimination, and recycling at the store level (Tang et al., 2016). Many global retailers, such as Tesco PLC, IKEA group, Walmart, H&M, and Carrefour, have adopted sustainability practices to manage their daily operations, strategies, and workforce engagement, leading to deeper customer relationships (Saha et al., 2017). However, the adoption of sustainable practices is still at the infancy stage in the Indian retail sector. Most Indian retailers acknowledge that the consumers are now conscious towards environmental issues and, thus, ecological conscious business strategies are essential for survival in the competitive market (Naidoo & Gasparatos, 2018). Nevertheless, there is still reluctance towards a commitment to sustainability since the challenges of incorporating sustainable activities within the operational management of supply chain activities are immense (Álvarez-Rodríguez et al., 2019b; Kannan et al., 2021). Few giant Indian retail firms, such as Future Group, Aditya Birla Group, Reliance Retail, and Shoppers Stop, have invested in sustainability as a core business strategy, but they do seek to increase their customer base and enhance their overall business performance. However, for most Indian retailers, analysing the impact of the implementation of sustainable activities on the operational performance of the SC is crucial as it may have an adverse impact on their business efficiency (Sharma et al., 2010). Moreover, retail companies need to strategize their operational and business activities to create a substantial sustainable impact (Sivagnanasundaram, 2018).

To achieve a sustainable business model, retail firms must attempt to align their sustainable strategies (including CSR), operational activities, and business operations along with their SCs (Govindan et al., 2021). Further, there is a severe necessity for identifying the conditions under which this integration can be profitable for the firm. Comprehension of the effect of sustainable practices on retail store operations to measure business performance requires examining the internal interaction of the subprocesses of operational decisions, sustainable decisions, and business decisions of retail stores (Wanke et al., 2016). The operational and business performance of retail stores depends on its decisions/activities such as inventory management (Keh & Chu, 2003), human resource management, store planning, operating expenses and profit (Yu & Ramanathan, 2009), operational competency, price competency (Gong et al., 2019), and customer satisfaction (Donthu & Yoo, 1998). Among these decisions, the first five are operating decisions; the remaining are business decisions. The incorporation of sustainable decisions like energy management, waste reduction, water conservation, employee benefits, and packaging can severely impact organizational/business activities (Zhang et al., 2011). This poses a great challenge to the firm in managing sustainable operations without compromising its operational and business performance. Thus, there is a need for an effective central mechanism to ensure that the retail store's strategic decisions at the operational level support the integration of sustainable operations into the SC management. This requires the development of an SC network model which integrates the operational decisions and sustainable decisions of the SC and their impact on the business performance. In the literature, a two-stage network DEA is most suitable for analysing the performance of a firm of subprocess (Wu, 2010). In the two-stage network DEA, outputs of the first stage are absorbed by the second stage as inputs and the performance of the firm can be measured by computing its efficiency values (Yu & Ramanathan, 2009). However, the two-stage network DEA models developed for

analysing the business efficiency of the SC only evaluate the operational inputs/outputs and business outputs. Sustainability related inputs/outputs have not been considered, highlighting a noteworthy research gap in the literature. In this regard, a recent study by Gong et al. (2019) is notable, in which authors have identified the ideal conditions under which sustainable operations can aid in improving operational efficiency and business performance. To contribute further to the field of sustainable retailing, this study develops mathematical formulations based on two-stage network DEA for analysing the impact of operational decisions as well as sustainable decisions on the business performance of an Indian retail chain. The key objectives of the study are as follows:

- To examine the impact of operational decisions on the business performance of retail stores; the effect of sustainable activities on the business performance of retail stores; and the joint effect of both operational and sustainable decisions on the retail stores' business performance.
- To measure the business efficiency of retail stores with consideration of multiple inputs and outputs from operational, sustainable, and business decisions and analysing the trade-off between operational decisions and sustainable decisions.
- To provide target values to inefficient retail stores as benchmarks for indicating the path by which they can improve their efficiency.

An Indian electronics retail chain case study is considered with appropriate input-output measures to validate the application of the DEA model established in the study. Further, useful insights are drawn from the result for providing managerial implications to Indian retailers for sustainable management of retail stores.

The rest of the manuscript is outlined as follows: Section 2 reviews the literature relevant to the sustainable performance of retailers using DEA and demonstrates the research gap. The case problem is defined in Sect. 3. Section 4 demonstrates the appropriate input-output measures and the formulation of the mathematical models. Section 5 presents the empirical results and analysis, and Sect. 6 concludes the manuscript giving useful managerial insights.

2 Literature review

This paper strives to present a two-stage network DEA based mathematical model aimed at analysing the impact of operational and sustainable decisions on retail stores' business performance. The literature review discusses the recent research studies related to these fields in Sect. 2.1, 2.2 and 2.3, which include sustainability in the retail sector, sustainable efficiency evaluation in retail, and the methodology assessment for sustainable efficiency evaluation. Further, Sect. 2.4 recognizes the research gap and develops the contributions of the study.

2.1 Sustainability in the retail sector

Retailers need to adopt sustainable practices as they are intermediaries between producers and customers, and they play more active roles in driving customers' demand (Corbett & Klassen, 2006; Jones et al., 2005). In the literature, several authors have worked on sustainability in the retail sector with a different perspective as discussed below.

Jones et al. (2005) in their study reviewed the practices adopted by most of the UK retailers for resolving sustainable development issues. Goworek (2011) evaluated the issues associated with environmental and social sustainability in the clothing industry in UK. The author observed that the demand for UK clothing retailers increased with the adoption of CSR policies. Lukić (2012) examined the significance of sustainable development of retail SC on the Serbian economy through hypothesis analysis. Hampl and Loock (2012) conducted a web-based conjoined survey with customers from Switzerland, Germany, and Austria to highlight the customers' perspective towards sustainable initiatives on store choice. Claro et al. (2013) presented a framework to integrate three drivers (internal, supplier relationship, and external) for sustainable retail business; in addition, their study sought to identify the drivers that enhanced retailer's investment in sustainability. Lehner (2015) concentrated on the role of Swedish food retail stores in sustainable consumption through their operational decisions. The study observed that retail stores can serve as significant facilities in the SC to operationalize sustainable food choices. Tang et al. (2016) presented a real study relevant to retailers and explored their green operations. The authors collected data from Japanese and Hong Kong trade retailers and determined that the adoption of green retail operations has a positive impact on the retailer's financial performance. Youn et al. (2017) proposed a framework based on an integrated top-down and bottom-up approach for incorporating the customers' perspective related to sustainable activities of retailers. Saha et al. (2017) analysed that sustainability initiatives such as investing in preservation technology and green operations prove to be financially beneficial for retailers dealing with deteriorating items. Naidoo and Gasparatos (2018) reviewed the literature to determine the drivers for retailers relevant to corporate environmental sustainability actions and strategies. Ferreira et al. (2019) examined the link between carbon and energy intensity of food and non-food retailers for determining sustainable retail stores through hypothesis analysis. It is apparent from the above discussion that there is an ample number of studies considering sustainable operations in the retail sector. Retailers can help in the development of a sustainable supply chain through their sustainable decisions due to their strategic positioning in the SC (Ruiz-Real et al., 2019). The integration of operational and sustainable decisions can assist retailers to enhance their business competitiveness (Gong et al., 2019). This study contributes further to related research by developing a sustainable business model for integrating sustainability operations into the supply chain operations management by Indian retailers.

The following section demonstrates the studies relevant to the evaluation of sustainable efficiency and its effect on the operational efficiency of retailers.

2.2 Sustainable efficiency evaluation in retail

Data envelopment analysis (DEA) has been among the most popular techniques (Ghiyasi, 2019) among researchers (Gupta et al., 2019) for operational efficiency measurement of retailers (Zhan et al., 2020). The effect of sustainable activities on the operational performance of retailers has also been studied by many authors using DEA models in the existing literature. Some of the recent works have been discussed further. Song et al. (2016) developed an approach based on DEA for evaluating environmental efficiency and improving the resources. The authors measured the efficiency based on resource input—"fixed social assets and electricity usage", desirable output—"total output", and undesirable outputs—"water wastage, discharge of exhaust gas and waste". The applicability of the approach is shown by analysing China's 31 regions. Li et al. (2018) calculated the comprehensive

evaluation index of sustainable development of the Yangtze River Economic Belt of China using the DEA super-slack based measure and Malmquist evaluation model. The model considered the inputs (natural resource usage, social resource utilization), undesirable outputs (accidents, pollution, and disasters), and desirable outputs (social and economic growth). Álvarez-Rodríguez et al. (2019a) examined the effect of sustainable based management of 30 Spanish grocery retail stores on their operational performance over the period 2015 to 2017 through life cycle assessment (LCA) and dynamic DEA. The authors considered six inputs (electricity, working hours, wax paper, receipt paper, waste, and plastic bag) and one output turnover. The authors also presented another study for benchmarking the environmental and operational performance of similar entities (Álvarez-Rodríguez et al., 2019b). Further, they extended their work by determining the operational and environmental efficiency values using weighted DEA and LCA (Álvarez-Rodríguez et al., 2020). Gong et al. (2019) measured the joint effect of sustainable decisions and operational decisions on the performance of a retailer's SC using DEA and hierarchical regression analysis. The outputs of operational performance (cost competence and flexibility competence) and the outputs of sustainable performance (social competence and environmental competence) were taken as inputs for business performance. In the present study, the work in efficiency evaluation in sustainable retailing is extended further by establishing three models based on two-stage network DEA for business efficiency evaluation of an Indian retail chain. The novelty of the study also lies in the consideration of the input–output (I/O) measures such as environmental competence, social competence, price competence, and customer satisfaction.

2.3 The methodology assessment for sustainable efficiency evaluation

In the literature, almost all existing studies related to efficiency evaluation have employed DEA (Yang et al., 2019) due to its wide application among the multi criteria decision-making methods (Rashidi & Cullinane, 2019). From the above literature review, it can be seen that most of the studies of DEA related to the sustainable assessment of retailers employed traditional DEA models. Conventional DEA, evolved by Charnes et al. (1978), is a non-parametric tool to analyse the performance of an organization based on multiple I/Os. DEA provides the weight flexibility that each DMU can assign I/O weights to maximize efficiency. From the last 4 decades, the concept of DEA has been discussed at great length in the literature by several researchers (Yu & Ramanathan, 2009). There are many extensions of DEA and among these most used models are Charnes Cooper and Rohdes model (CCR model) (Charnes et al., 1978), BCC (Banker et al., 1984), peer evaluation (Sexton et al., 1986), super efficiency (Andersen & Petersen, 1993), additive DEA model (Charnes et al., 1985), the weight-restricted model (Dyson & Thanassoulis, 1988), and network DEA model (Seiford & Zhu, 1999). All basic DEA models except network DEA models treat the Decision-Making Units (DMUs) as a black box and overlook the internal process, interaction, and transformation (Yang et al., 2019). To overcome these limitations, network DEA models have been evolved considering multiple stages in a DMU. Every stage has its separate I/Os; some or all outputs of the previous stage are taken as inputs of the next stage which are known as intermediate I/Os. It not only computes the efficiency values of each stage and overall DMU but also provides inefficiencies between two stages. Results provide clear insights to decision-makers for enhancing the performance of a DMU. In the literature, an ample number of scholars have worked on it (Cook & Seiford, 2009) under different applications (Gong et al., 2019). However, according to our knowledge, no study has

applied two-stage network DEA models to data collected from an Indian retail chain company. In this study, three DEA models are established with two models considering sustainable/operational decisions at the first stage and business decisions at the second stage. The third model considers two parallel stages of operational and sustainable decisions at the first stage and business decisions at the second stage.

2.4 Research gap and contribution

The significance of sustainable decisions in retail supply chain management on the operational performance is discussed by very few studies in the literature. The work done in these studies is summarized in Table 1. From the above review of literature), we establish the following gap in the existing studies which marks the requirements for the present work.

- Although issues related to sustainable efficiency assessment are explored in the literature (Álvarez-Rodríguez et al., 2019a, b, 2020), a similar research study in the Indian retail sector, however, does not exist according to our knowledge.
- None of the papers in the literature analyses the joint effect of sustainable activities with operational decisions on the business performance of retailers with exception of Gong et al. (2019). However, the stand-alone impact of sustainability on business performance has not been analysed in the mentioned study, which is necessary for understanding the trade-off required between sustainability performance and operational performance for improving the business efficiency of retailers.
- None of the studies based on Indian sustainable retailing has provided mathematical computation of slacks of I/O for inefficient retailers along with efficiency values, and no study has derived the efficient target conditions for inefficient retailers based on slack values of I/O.

In this respect, the novel contributions of the proposed study are highlighted below:

- DEA based approach for the evaluation of the sustainable efficiency of retail stores of an Indian electronic retail chain is proposed. It is the first such study in context to the Indian retail sector.
- The study considers three decisions: operational, sustainable, and business. Further, this work examines the effect of operational decisions on business, sustainable decisions on business, and both operational and sustainable decisions on the business.
- The two-stage network DEA methodology is effectively used for assessing sustainable efficiency and providing improvement directions to inefficient retail stores.
- Valuable insights are drawn from the empirical analysis which can be helpful in making critical managerial decisions with regard to sustainable retailing.

3 Problem definition

In today's challenging business environment, the adoption of sustainable practices in retailing has become imperative for retailers to gain a competitive advantage in the market. Sustainable activities aid retail stores in reducing operating costs, enhancing

Table 1 Review of existing studies related to sustainable efficiency evaluation

Study	Network DEA	Operational performance (OP)	Sustainable performance (SP)	Business performance (BP)	Effect of OP on BP	Effect of SP on BP	Effect of OP and SP on BP	Case study of Indian Retail Sector
Song et al. (2016)	×	✓	×	×	×	×	×	×
Li et al. (2018)	×		✓	×	×	×	×	×
Álvarez-Rodríguez et al. (2019a)	×	✓	✓	×	×	×	×	×
Álvarez-Rodríguez et al. (2019b)	×	✓	✓	×	×	×	×	×
Gong et al. (2019)	✓	✓	✓	✓	×	×	✓	×
Álvarez-Rodríguez et al. (2020)	×	✓	✓	×	×	×	×	×
Our study	✓	✓	✓	✓	✓	✓	✓	✓

profitability, and improving operational efficiency. However, the inclusion of sustainability within the operational management of SC is very challenging. Thus, retailers require to monitor SC performance based on their operations as well as on sustainable decisions. An effective mechanism is very significant for retailers to evaluate the performance for leveraging their SC as a strategic capability. The efficiency analysis of a retail firm based on operational decisions and sustainable decisions is useful in this context of assessing a firm's business performance.

The current study addresses the problem of an electronics retail chain based in North India having more than 150 stores of consumer electronic goods (name not disclosed due to confidentiality). The company offers more than 9500 products; it has revenue of around 3000 crores INR in a year; and it employs around 2100 workers. From the last 5 years, the company has been adopting sustainability initiatives as an integral part of its core strategy. The management of the company seeks to reduce energy consumption by using sunlight during daytime and LED lights in their stores, conserving water, minimising wastage in packaging, providing a healthy and safe working environment to employees, and setting working hours according to the government rules. However, the inclusion of sustainable activities may not always be beneficial for the company since it sometimes incurs higher costs and may lead to lower business performance. Clearly, sustainable decisions may have a direct and indirect effect on the operational decisions of the retail stores. Moreover, since every store is operated at a different level in terms of its market conditions, product assortment, sales, staff, store maintenance, energy management, and customer satisfaction, the impact of sustainable activities on the operational performance of retail stores varies. Hence, for the effective management of the retail stores, centralized management needs to devise a strategy for improving their business performance. The decision-makers need to analyse the effect of operational and sustainable decisions on the business performance of each retail store of the company and provide feasible solutions to the retail store managers to reduce internal conflicts. The company can also control the operations of their store by efficiency analysis and setting up benchmarks (Yu & Ramanathan, 2009). Further efficiency analysis based on input and outputs of business is useful for managers in gaining insights on their business and examining the business's competitiveness compared to other units.

Prior to devising an effective mechanism for evaluation of its business performance, the company needs to understand the impact of the implementation of sustainable activities in the existing store operations on the business performance of each retail store. There are two possible cases: (1) retail stores may achieve higher operational performance while its sustainable and business performances are low. It means that there is inappropriate management of sustainable activities with operational decisions of the store, and (2) the store may gain higher sustainable performance but its operational as well as business performance is low. The higher sustainable performance of a retail store may involve higher costs and consequently may affect its operational decisions as well as its business performance. With strategic decision making at the managerial level, a retail store can perform well by creating a balance between operational and sustainable activities of a store (Álvarez-Rodríguez et al., 2019b). Hence, the management requires to examine the joint impact of sustainable decisions and operational decisions on business performance as well as their individual effect on business performance. The top management of the company plans to (a) evaluate its business performance based on operational and sustainable decisions, (b) identify inefficient retail stores, and (c) establish improvement strategies for these stores. The company is therefore looking for innovative solutions to the following issues:

- What are the inputs, outputs, and intermediate measures to effectively measure the performance of a store?
- What is an appropriate methodology to investigate the effect of operational decisions, sustainable decisions on the business decisions of a store?
- What are the suitable approaches for inefficient stores to enhance their performance?

To address the above issues, the present study focusses on performing efficiency evaluation analysis for 24 stores of the company from the Delhi NCR region with the following objectives:

- Identification of performance measures of retail stores for evaluating operational performance, sustainable performance, and business performance.
- Formulation of a DEA based mathematical model to analyse the impact of operational and sustainable decisions on business performance.
- Determination of efficient target values for inefficient stores for further improvement.

Identification of better performing stores based on operational, sustainable, and business performance can aid the management in devising performance improvement strategies for the inefficient retail stores. Henceforth, these valuable managerial implications can aid in devising long-term strategies for stores located in other regions of the country.

4 Methodology

The study analyses the efficiency of retail stores of an electronics chain employing a network DEA based approach. We determine the effect of operational and sustainable decisions on overall business decisions of retail stores through performance measurement and we compute the efficiency targets for inefficient retail stores to improve their efficiency level. The methodology has two stages: (1) identification of performance measures, and (2) development of mathematical models based on two-stage network DEA. Details of the methodology stages are described as follows:

4.1 Performance measures

The study elects appropriate measures from a detailed review of existing literature and with the help of decision-makers. The elected measures are in the form of input and output measures. Table 2 represents the inputs and outputs of operational, sustainable, and business performance of retail stores.

4.1.1 Measures of operational performance

The selected input and output measures related to operational decisions of each retail store are described as follows:

Operational Expenses (x_1^O) The study considers monthly (average of a year) maintenance, rent, transportation, and other expenses of retail stores (Balios et al., 2015; Xavier et al., 2015). Its level of measure is thousands.

Table 2 Inputs and outputs

Inputs		Outputs		
Operational inputs	Sustainable inputs	Operational outputs	Sustainable outputs	Business outputs
Operational expenses	Energy reduction	Profit	Environmental competence	Price competence
Average inventory cost	Waste management	Operational competence	Social competence	Customer satisfaction
Assurance of product delivery	No. of working hours			
Number of employees	No. of women employees			
Product assortment	Employee benefits			
Store size				

Average Inventory Cost (x_2^O) It assesses monthly (average of a year) expenditure of retail stores in thousands for carrying and holding the inventory (Pande & Patel, 2013; Uyar et al., 2013).

Assurance of Product Delivery (x_3^O) It assures that merchandise is available in the right condition and at the right time at the retail stores (Duman et al., 2017). It is a qualitative variable. The study measures the variable through Analytical Hierarchal Process (AHP) (Saaty, 1990) with the help of decision makers.

Number of Employees (x_4^O) It consists of a total number of employees working in retail stores (Gupta & Mittal, 2010; Ko et al., 2017; Uyar et al., 2013).

Product Assortment (x_5^O) It consists of details of the variety of the products that the retail store offers to the customers (Keh & Chu, 2003).

Store Size (x_6^O) It considers the total area of retail stores in square feet (Ko et al., 2017; Pande & Patel, 2013).

Profit (y_1^O) It includes monthly (average of a year) total profit of retail stores in thousands (Gandhi & Shankar, 2014; Lau, 2013).

Operational Competence (y_2^O) It assesses the cost of products and quality of services at retail stores (Halley & Beaulieu, 2009). Quality is rated in terms of how often do sales executives attend to customers and respond to customers' complaints at stores. The operational competence of the store is measured based on its past data (averaging the past data).

4.1.2 Measures of sustainable performance

The description of inputs and outputs measures related to sustainable performance decisions of each retail store is given below:

Energy Reduction (x_1^S) The study assesses energy usage by incorporating renewable energy sources such as lighting, heating, fitting day-night sensors and refrigeration at retail stores (Erol et al., 2009; Lukić, 2012). It is a qualitative variable and is measured through AHP.

Waste Management (x_2^S) It assesses the waste minimization at retail stores such as a reduction in excessive packaging, starting the buy-back scheme, and minimization of paper waste (Erol et al., 2009; Lukić, 2012; Sodhi et al., 2020). The study measures the retail stores' level of waste management using AHP to incorporate the decision-maker's opinions.

Number of Working Hours (x_3^S) It consists of the number of working hours of retail stores' employees in a week (Gupta & Mittal, 2010).

Number of Women Employees (x_4^S) It consists of the number of women employees out of a total number of employees at retail stores (Lukić, 2012).

Employee Benefits (x_5^S) It assesses opportunities for employees at retail stores such as medical insurance, training, and flexible spending accounts (Lukić, 2012) and is measured through AHP.

Environmental competence (y_1^S) The study assesses the environmental competence of retail stores based on energy usage and waste minimization (Gong et al., 2019). It is measured through AHP.

Social competence (y_2^S) This variable assesses the social competence of retail stores based on employment opportunities and the ratio of women employees (Gong et al., 2019). It is evaluated using AHP.

4.1.3 Measures of business performance

The input measures for business performance for each retail store are discussed in Sects. 4.1.1 and 4.1.2. The explanation of output measures is as follows:

> *Price Competence (y_1^B)* It assesses retail store's price competence on the basis of products' prices and quality (Zhang, 2015) and is measured through AHP.
> *Customer satisfaction (y_2^B)* It assesses customer's level of satisfaction at retail stores based on operational, social, and environmental competency (Donthu & Yoo, 1998; Gupta et al., 2019).

4.2 DEA model formulations

In DEA, the performance of homogeneous decision-making units (DMUs) is evaluated based on their inputs and outputs. DMU is accountable for consuming inputs to produce outputs. The study considers three decisions for evaluating the performance of retail stores (DMUs) which are operational, sustainable, and business decisions, and also examines the impact of operational and sustainable decisions on business decisions.

The mathematical models are evolved in this section for examining the effect of performance of operational and sustainable decisions on the performance of business decisions of a retail store. The study proposes three models to evaluate the business performance which are (1) OB Model determines the impact of operational decisions on business performance; (2) SB Model assesses the business performance of retail stores to check the effect of sustainable decisions; and (3) OSB Model measures the business performance of retail stores by incorporating both operational and sustainable decisions, simultaneously.

The following notations are used for developing the mathematical model formulations:
Notations.

jj	index for DMU (retail store); $j = 1, 2, …, J$
i	index for operational performance's input; $i = 1, 2, …, I$
l	index for sustainable performance's input; $l = 1, 2, …, L$
p	index for operational/business performance's output/input; $p = 1, 2, …, P$
q	index for sustainable/business performance's output/input; $q = 1, 2, …, Q$
r	index for business performance's output; $r = 1, 2, …, R$
y_{rj}^B	rth output of jth retail store for business performance.
x_{ij}^O	ith input of jth retail store for operational performance.
x_{lj}^S	lth input of jth retail store for sustainable performance.
y_{pj}^O	pth output/input of jth retail store for operational/business performance.
y_{qj}^S	qth output/input of jth retail store for sustainable/business performance.

Decision variables

μ_p^O weights of pth output/input for operational/business performance.
μ_q^S weights of qth output/input for sustainable/business performance.
μ_r^B weights of rth output for business performance.
μ_i^O weights of ith input for operational performance.
μ_l^S weights of lth input for sustainable performance.

4.2.1 OB model: operational performance and business performance

Let us assume that there are J retail stores. Based on the basic DEA model (CCR) (Charnes et al., 1978), the efficiency value of operational decisions and business decisions of the retail store j^*(where $j^* \in j$) can be calculated from the model (M1) and model (M2), respectively. Figure 1 depicts the two-stage decision structure of the OB model. It determines the effect of operational decisions on business performance. Operational performance (name of stage1) consumes inputs $X^O = \left\{ x_{ij}^O ; i = 1, ..., I ; j = 1, ..., J \right\}$ to generate outputs $Y^O = \left\{ y_{pj}^O ; p = 1, ..., P ; j = 1, ..., J \right\}$ and these outputs are used by business performance (name of stage2) as inputs $Y^O = X^B$; $X^B = \left\{ x_{pj}^B ; p = 1, ..., P ; j = 1, ..., J \right\}$ to produce outputs $Y^B = \left\{ y_{rj}^B ; r = 1, ..., R ; j = 1, ..., J \right\}$.

$$\max \theta_{j^*}^{OP} = \frac{\sum_{p=1}^P \mu_p^O y_{pj^*}^O}{\sum_{i=1}^I \mu_i^O x_{ij^*}^O}$$

$$\text{s.t.} \quad \frac{\sum_{p=1}^P \mu_p^O y_{pj}^O}{\sum_{i=1}^I \mu_i^O x_{ij}^O} \leq 1, \quad \forall j \tag{M1}$$

$$\mu_p^O, \mu_i^O \geq 0$$

$$\max \theta_{j^*}^{BP} = \frac{\sum_{r=1}^R \mu_r^B y_{rj^*}^B}{\sum_{p=1}^P \mu_p^O y_{pj^*}^O}$$

$$\text{s.t.} \quad \frac{\sum_{r=1}^R \mu_r^B y_{rj}^B}{\sum_{p=1}^P \mu_p^O y_{pj}^O} \leq 1, \quad \forall j \tag{M2}$$

$$\mu_p^O, \mu_r^B \geq 0$$

Now, we calculate the overall efficiency of the two-stage network structure using the below model (M3) which is based on additive efficiency decomposition (Chen et al., 2009) given as follows:
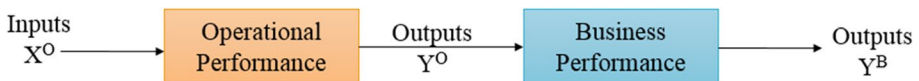

Fig. 1 Decision structure of operational and business performance

$$\max \theta_{j*}^{OB} = w_1 \frac{\sum_{p=1}^{P} \mu_p^O y_{pj*}^O}{\sum_{i=1}^{I} \mu_i^O x_{ij*}^O} + w_2 \frac{\sum_{r=1}^{R} \mu_r^B y_{rj*}^B}{\sum_{p=1}^{P} \mu_p^O y_{pj*}^O}$$

$$\text{s.t.} \quad \frac{\sum_{p=1}^{P} \mu_p^O y_{pj}^O}{\sum_{i=1}^{I} \mu_i^O x_{ij}^O} \le 1, \quad \forall j$$

(M3)

$$\frac{\sum_{r=1}^{R} \mu_r^B y_{rj}^B}{\sum_{p=1}^{P} \mu_p^O y_{pj}^O} \le 1, \quad \forall j$$

$$\mu_i^O, \mu_p^O, \mu_r^B \ge 0$$

where w_1 and w_2 denote weights (functions of optimization variables) defined by the user and their sum must be equal to one. These weights represent the ratio of resources used in individual stages and total resources consumed in all the stages (Chen et al., 2009).

$$w_1 = \frac{\sum_{i=1}^{I} \mu_i^O x_{ij*}^O}{\sum_{i=1}^{I} \mu_i^O x_{ij*}^O + \sum_{p=1}^{P} \mu_p^O y_{pj*}^O}, \quad w_2 = \frac{\sum_{p=1}^{P} \mu_p^O y_{pj*}^O}{\sum_{i=1}^{I} \mu_i^O x_{ij*}^O + \sum_{p=1}^{P} \mu_p^O y_{pj*}^O}$$

After using the functions of w_1 and w_2, model (M3) transforms to

$$\max \theta_{j*}^{OB} = \frac{\sum_{p=1}^{P} \mu_p^O y_{pj*}^O + \sum_{r=1}^{R} \mu_r^B y_{rj*}^B}{\sum_{i=1}^{I} \mu_i^O x_{ij*}^O + \sum_{p=1}^{P} \mu_p^O y_{pj*}^O}$$

$$\text{s.t.} \quad \frac{\sum_{p=1}^{P} \mu_p^O y_{pj}^O}{\sum_{i=1}^{I} \mu_i^O x_{ij}^O} \le 1, \quad \forall j$$

(M4)

$$\frac{\sum_{r=1}^{R} \mu_r^B y_{rj}^B}{\sum_{p=1}^{P} \mu_p^O y_{pj}^O} \le 1, \quad \forall j$$

$$\mu_i^O, \mu_p^O, \mu_r^B \ge 0$$

Using the Charnes–Cooper transformation, model (M4) is reformulated as model (M5):

$$\max \theta_{j^*}^{OB} = \sum_{p=1}^{P} \mu_p^O y_{pj^*}^O + \sum_{r=1}^{R} \mu_r^B y_{rj^*}^B$$

$$\text{s.t. } \sum_{i=1}^{I} \mu_i^O x_{ij^*}^O + \sum_{p=1}^{P} \mu_p^O y_{pj^*}^O = 1$$

$$\sum_{p=1}^{P} \mu_p^O y_{pj}^O \le \sum_{i=1}^{I} \mu_i^O x_{ij}^O, \forall j \tag{M5}$$

$$\sum_{r=1}^{R} \mu_r^B y_{rj}^B \le \sum_{p=1}^{P} \mu_p^O y_{pj}^O, \forall j$$

$$\mu_i^O, \mu_p^O, \mu_r^B \ge 0$$

The above input-oriented model is used for calculating the overall efficiency of retail stores concerning operational and business decisions. Where $\theta_{j^*}^{OB} \in [0, 1]$ and this value is equal to one, then retail store j^* is efficient; otherwise, it is inefficient. A retail store will become efficient if and only if its both operational performance and business performance are lying on the efficient frontier. In this model, $\mu_i^O, \mu_p^O, \mu_r^B$ are decision variables of jth retail store. The dual version of the model (M5) is

$$Min \, \theta_{j^*}$$

$$s.t \quad \sum_{j=1}^{n} \lambda_j x_{ij}^O \le \theta_{j^*} x_{ij^*}^O; \quad \forall i$$

$$\sum_{j=1}^{n} (\lambda_j - \eta_j) y_{pj}^O \ge (1 - \theta_{j^*}) y_{pj^*}^O; \quad \forall p \tag{M5a}$$

$$\sum_{j=1}^{n} \eta_j y_{rj}^B \ge y_{rj^*}^B; \forall r$$

$$\lambda_j, \eta_j \ge 0$$

where λ_j and η_j are the decision variables and the non–zero weights of these variables with respective DMUs represent the reference set for DMU j^*. The possible slacks of I/Os can be determined from the model (M5a) through following linear programming problem (LPP)

$$Max \sum_{i=1}^{I} T_{1i} + \sum_{p=1}^{P} T_{2p} + \sum_{r=1}^{R} T_{3r}$$

$$s.t \quad \sum_{j=1}^{n} \lambda_j x_{ij}^{O} + T_{1i} = \theta_{j^*} x_{ij^*}^{O}; \quad \forall i$$

$$\sum_{j=1}^{n} (\lambda_j - \eta_j) y_{pj}^{O} - T_{2p} = (1 - \theta_{j^*}) y_{pj^*}^{O}; \quad \forall p \qquad \text{(M5b)}$$

$$\sum_{j=1}^{n} \eta_j y_{rj}^{B} - T_{3r} = y_{rj^*}^{B}; \quad \forall r$$

$$\lambda_j, \eta_j, T_{1i}, T_{2p}, T_{3r} \geq 0$$

where T_{1i}, T_{2p} and T_{3r} represent the input, intermediate I/O and output slacks, respectively. DMU k is efficient iff $\theta_{j^*} = 1$ and T_{1i}, T_{2p}, T_{3r} equal to zero. Otherwise, it is non-efficient. If $\theta_{j^*} = 1$ and value of T_{1i}, T_{2p}, T_{3r} are non - zero then DMU j^* is weakly efficient.

4.2.1.1 Efficient Targets The efficient targets demonstrate how much change in inputs and outputs make the inefficient DMU efficient (Zhu, 2014). The equations of efficient targets are as follows:

$$\hat{x}_{ij^*}^{O} = \theta_{j^*} x_{ij^*}^{O} - T_{1i}; \forall i$$

$$\hat{y}_{rj^*}^{B} = y_{rj^*}^{B} + T_{3r}; \forall r$$

when $y_{pj^*}^{O}$ is as output for first stage

$$\hat{y}_{pj^*}^{O} = y_{pj^*}^{O} + T_{2p}; \forall p \qquad \text{(M5c)}$$

when $y_{pj^*}^{O}$ is as input for second stage

$$\hat{y}_{pj^*}^{O} = \theta_{j^*} y_{pj^*}^{O} - T_{2p}; \forall p$$

4.2.2 SB model: sustainable performance and business performance

In this, the study measures the business performance of a retail store concerning sustainable decisions and characterizes the effect of sustainable decisions on the business performance of the retail store. Based on the two-stage decision structure of SB model, sustainable performance (name of stage1) ingests inputs $X^S = \left\{ x_{lj}^{S}; l = 1, \dots, L; j = 1, \dots, J \right\}$ to produce outputs $Y^S = \left\{ y_{qj}^{S}; q = 1, \dots, Q; j = 1, \dots, J \right\}$ and these outputs are carried over as inputs $Y^S = X^B; X^B = \left\{ x_{qj}^{B}; q = 1, \dots, Q; j = 1, \dots, J \right\}$ for business performance (name of stage2) to generate outputs $Y^B = \left\{ y_{rj}^{B}; r = 1, \dots, R; j = 1, \dots, J \right\}$ as depicted in Fig. 2.
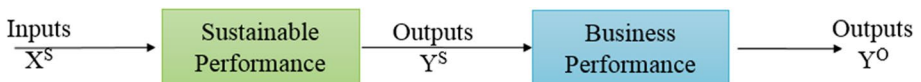

Fig. 2 Decision structure of sustainable and business performance

The CCR DEA models for sustainable and business performance are given as follows:

$$
\max \theta_{j^*}^{SP} = \frac{\sum_{q=1}^{Q} \mu_q^S y_{qj^*}^S}{\sum_{l=1}^{L} \mu_l^S x_{lj^*}^S}
$$

$$
s.t. \quad \frac{\sum_{q=1}^{Q} \mu_q^S y_{qj}^S}{\sum_{l=1}^{L} \mu_l^S x_{lj}^S} \leq 1, \quad \forall j \qquad (M6)
$$

$$
\mu_q^S, \mu_l^S \geq 0
$$

$$
\max \theta_{j^*}^{BP} = \frac{\sum_{r=1}^{R} \mu_r^B y_{rj^*}^B}{\sum_{q=1}^{Q} \mu_q^S y_{qk}^S j^*}
$$

$$
s.t. \quad \frac{\sum_{r=1}^{R} \mu_r^B y_{rj}^B}{\sum_{q=1}^{Q} \mu_q^S y_{qj}^S} \leq 1, \quad \forall j \qquad (M7)
$$

$$
\mu_r^B, \mu_q^S \geq 0
$$

Now, we follow the similar procedure of the OB model to get a final version of the SB model for calculating the overall performance of retail stores based on their sustainable and business decisions using models (M6) and (M7). The SB model transforms to the following:

$$
\max \theta_{j^*}^{SB} = \sum_{q=1}^{Q} \mu_q^S y_{qj^*}^S + \sum_{r=1}^{R} \mu_r^B y_{rj^*}^B
$$

$$
\sum_{l=1}^{L} \mu_l^S x_{lj^*}^S + \sum_{q=1}^{Q} \mu_q^S y_{qj^*}^S = 1
$$

$$
\sum_{q=1}^{Q} \mu_q^S y_{qj}^S \leq \sum_{l=1}^{L} \mu_l^S x_{lj}^S, \forall j \qquad (M8)
$$

$$
\sum_{r=1}^{R} \mu_r^B y_{rj}^B \leq \sum_{q=1}^{Q} \mu_q^S y_{qj}^S, \forall j
$$

$$
\mu_l^S, \mu_q^S, \mu_r^B \geq 0
$$

From model (M8), we can compute the business performance of the retail store j^* in relation to its sustainable decisions. If $\theta_{j^*}^{SB} = 1$ the retail store j^* is efficient in the use of its sustainability operations. This model provides directions for accomplishing the DEA frontier. In this model, $\mu_l^S, \mu_q^S, \mu_r^B$ are decision variables for a retail store j^*. The dual version of the model (M8) is

$$Min\ \theta_{j^*}$$

$$s.t \quad \sum_{j=1}^{n} \lambda_j x_{lj}^S \le \theta_{j^*} x_{lj^*}^S; \quad \forall l$$

$$\sum_{j=1}^{n} (\lambda_j - \eta_j) y_{qj}^S \ge (1 - \theta_k) y_{qj^*}^S; \quad \forall q \qquad \text{(M8a)}$$

$$\sum_{j=1}^{n} \eta_j y_{rj}^B \ge y_{rj^*}^B; \quad \forall r$$

$$\lambda_j, \eta_j \ge 0$$

where λ_j and η_j are the decision variables and the non-zero weights of these variables, and respective DMUs represent the reference set for DMU j^*. The possible slacks of I/Os can be determined from the model (M8a) through the following LPP:

$$Max \ \sum_{l=1}^{L} T_{4l} + \sum_{q=1}^{Q} T_{5q} + \sum_{r=1}^{R} T_{6r}$$

$$s.t \quad \sum_{j=1}^{n} \lambda_j x_{lj}^S + T_{4l} = \theta_{j^*} x_{lj^*}^S; \quad \forall l$$

$$\sum_{j=1}^{n} (\lambda_j - \eta_j) y_{qj}^S - T_{5q} = (1 - \theta_{j^*}) y_{qj^*}^S; \quad \forall q \qquad \text{(M8b)}$$

$$\sum_{j=1}^{n} \eta_j y_{rj}^B - T_{6r} = y_{rj^*}^B; \quad \forall r$$

$$\lambda_j, \eta_j, T_{4l}, T_{5q}, T_{6r} \ge 0$$

where T_{4l}, T_{5q} and T_{6r} represent the input, intermediate I/O, and output slacks, respectively. DMU j^* is efficient iff $\theta_{j^*} = 1$ and T_{4l}, T_{5q}, T_{6r} equal to zero. Otherwise, it is non-efficient. If $\theta_{j^*} = 1$ and value of T_{4l}, T_{5q}, T_{6r} are non - zero then DMU j^* is weakly efficient.

4.2.2.1 Efficient Targets The efficient targets equations for SB model are as follows:

$$\hat{x}_{lj^*}^S = \theta_{j^*} x_{lj^*}^S - T_{4l}; \quad \forall l$$

$$\hat{y}_{qj^*}^S; = y_{qj^*}^S; + T_{6r}; \quad \forall r$$

when $y_{qj^*}^S$ is as output for first stage

$$\hat{y}_{qj^*}^S = y_{qj^*}^S + T_{5q}; \quad \forall q \qquad \text{(M8c)}$$

when $y_{qj^*}^S$ is as input for second stage

$$\hat{y}_{qj^*}^S = \theta y_{qj^*}^S - T_{5q}; \quad \forall q$$

4.2.3 OSB model: operational performance, sustainable performance, and business performance

The two-stage decision structure of the OSB model consists of operational performance, sustainable performance, and business performance as demonstrated in Fig. 3. The operational performance and sustainable performance are considered two parallel processes of retail stores at the first stage, and the business performance of retail stores is in the second stage. The outputs Y^O of operational performance (stage1) and outputs Y^S of sustainable performance (stage1) are consumed by business performance (stage2) as inputs for producing final outputs Y^B. In this, we measure the efficiency of the stage2 of the retail store concerning its operational and sustainable decisions and further portray the impact of operational and sustainable decisions on the business performance of the retail store.

The mathematical formulation of the OSB model is the same as the multi-stage model of Gong et al. (2019), while further, the study presents a dual version of the OSB model to derive efficient targets based on I/O slacks. The CCR formulation of operational and sustainable performance is given in model (M1) and (M6), respectively. The CCR model of business performance for the OSB model is given as follows:

$$\max \theta_{j*}^{BP} = \frac{\sum_{r=1}^{R} \mu_r^B y_{rj*}^B}{\sum_{p=1}^{P} \mu_p^O y_{pj*}^O + \sum_{q=1}^{Q} \mu_q^S y_{qj*}^S}$$

$$s.t. \quad \frac{\sum_{r=1}^{R} \mu_r^B y_{rj}^B}{\sum_{p=1}^{P} \mu_p^O y_{pj}^O + \sum_{q=1}^{Q} \mu_q^S y_{qj}^S} \leq 1, \quad \forall j \qquad (M9)$$

$$\mu_p^O, \mu_q^S, \mu_r^B \geq 0$$

The overall efficiency of the OSB model can measure from models (M1), (M6), and (M9) through additive efficiency decomposition (Chen et al., 2009). The OSB model is now as follows:
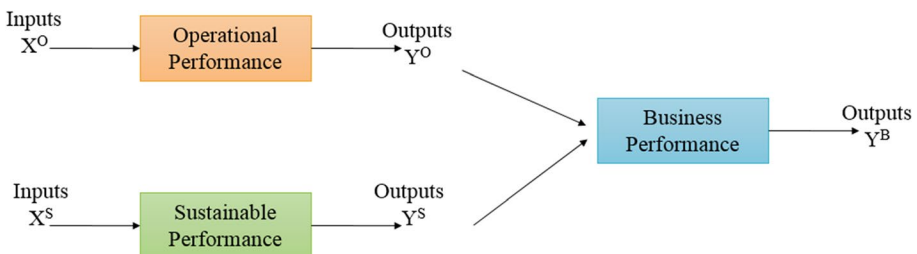

Fig. 3 Decision structure of operational, sustainable, and business performance

$$\max \theta_{j^*}^{OSB} = w_1 \frac{\sum_{p=1}^{P} \mu_p^O y_{pj^*}^O}{\sum_{i=1}^{I} \mu_i^O x_{ij^*}^O} + w_2 \frac{\sum_{q=1}^{Q} \mu_q^S y_{qj^*}^S}{\sum_{l=1}^{L} \mu_l^S x_{lj^*}^S} + w_3 \frac{\sum_{r=1}^{R} \mu_r^B y_{rj^*}^B}{\sum_{p=1}^{P} \mu_p^O y_{pj^*}^O + \sum_{q=1}^{Q} \mu_q^S y_{qj^*}^S}$$

$$s.t. \quad \frac{\sum_{p=1}^{P} \mu_p^O y_{pj}^O}{\sum_{i=1}^{I} \mu_i^O x_{ij}^O} \le 1, \quad \forall j$$

$$\frac{\sum_{q=1}^{Q} \mu_q^S y_{qj}^S}{\sum_{l=1}^{L} \mu_l^S x_{lj}^S} \le 1, \quad \forall j$$

$$\frac{\sum_{r=1}^{R} \mu_r^B y_{rj}^B}{\sum_{p=1}^{P} \mu_p^O y_{pj}^O + \sum_{q=1}^{Q} \mu_q^S y_{qj}^S} \le 1, \quad \forall j$$

$$\mu_p^O, \mu_l^S, \mu_i^O, \mu_q^S, \mu_r^B \ge 0$$

(M10)

Where

$$w_1 = \frac{\sum_{i=1}^{I} \mu_i^O x_{ij^*}^O}{\sum_{i=1}^{I} \mu_i^O x_{ij^*}^O + \sum_{l=1}^{L} \mu_l^S x_{lj^*}^S + \sum_{p=1}^{P} \mu_p^O y_{pj^*}^O + \sum_{q=1}^{Q} \mu_q^S y_{qj^*}^S}, w_2 = \frac{\sum_{l=1}^{L} \mu_l^S x_{lj^*}^S}{\sum_{i=1}^{I} \mu_i^O x_{ij^*}^O + \sum_{l=1}^{L} \mu_l^S x_{lj^*}^S + \sum_{p=1}^{P} \mu_p^O y_{pj^*}^O + \sum_{q=1}^{Q} \mu_q^S y_{qj^*}^S}$$

$$w_3 = \frac{\sum_{p=1}^{P} \mu_p^O y_{pj^*}^O + \sum_{q=1}^{Q} \mu_q^S y_{qj^*}^S}{\sum_{i=1}^{I} \mu_i^O x_{ij^*}^O + \sum_{l=1}^{L} \mu_l^S x_{lj^*}^S + \sum_{p=1}^{P} \mu_p^O y_{pj^*}^O + \sum_{q=1}^{Q} \mu_q^S y_{qj^*}^S}.$$

Using these values and the Charnes-Cooper transformation, model (M10) transforms to:

$$\max \theta_{j^*}^{OSB} = \sum_{p=1}^{P} \mu_p^O y_{pj^*}^O + \sum_{q=1}^{Q} \mu_q^S y_{qj^*}^S + \sum_{r=1}^{R} \mu_r^B y_{rj^*}^B$$

$$\sum_{i=1}^{I} \mu_i^O x_{ij^*}^O + \sum_{l=1}^{L} \mu_l^S x_{lj^*}^S + \sum_{p=1}^{P} \mu_p^O y_{pj^*}^O + \sum_{q=1}^{Q} \mu_q^S y_{qj^*}^S = 1$$

$$\sum_{p=1}^{P} \mu_p^O y_{pj}^O \le \sum_{i=1}^{I} \mu_i^O x_{ij}^O, \forall j$$

(M11)

$$\sum_{q=1}^{Q} \mu_q^S y_{qj}^S \le \sum_{l=1}^{L} \mu_l^S x_{lj}^S, \forall j$$

$$\sum_{r=1}^{R} \mu_r^B y_{rj}^B \le \sum_{p=1}^{P} \mu_p^O y_{pj}^O + \sum_{q=1}^{Q} \mu_q^S y_{qj}^S, \forall j$$

$$\mu_p^O, \mu_q^S, \mu_r^B, \mu_i^O, \mu_l^S \ge 0$$

The overall efficiency of retail stores' OSB decision structure is determined using the model (M11). The retail store j^* lies in the DEA frontier which indicates the retail store j^* is efficient and effectively integrates the operational and sustainable decisions. In this

model, $\mu_p^O, \mu_q^S, \mu_r^B, \mu_i^O, \mu_l^S$ are decision variables of retail store j^*. The dual version of the model (M11) is as follows:

$$Min \; \theta_{j^*}$$

$$s.t \quad \sum_{j=1}^{n} \lambda_j x_{ij}^O \leq \theta_{j^*} x_{ij^*}^O; \quad \forall i$$

$$\sum_{j=1}^{n} \rho_j x_{lj}^S \leq \theta_{j^*} x_{lj^*}^S; \quad \forall l$$

$$\sum_{j=1}^{n} (\lambda_j - \eta_j) y_{pj}^O \geq (1 - \theta_{j^*}) y_{pj^*}^O; \forall p \qquad (M11a)$$

$$\sum_{j=1}^{n} (\rho_j - \eta_j) y_{qj}^S \geq (1 - \theta_{j^*}) y_{qj^*}^S; \forall q$$

$$\sum_{j=1}^{n} \eta_j y_{rj}^B \geq y_{rj^*}^B; \forall r$$

$$\lambda_j, \eta_j, \rho_j \geq 0$$

where λ_j, η_j and ρ_j are the decision variables and the non–zero weights of these variables with respective DMUs represent the reference set for DMU j^*. The possible slacks of I/Os can determine from model (M11a) through the following LPP:

$$Max \; \sum_{i=1}^{I} T_{7i} + \sum_{l=1}^{L} T_{8l} + \sum_{p=1}^{P} T_{9p} + \sum_{q=1}^{Q} T_{10q} + \sum_{r=1}^{R} T_{11r}$$

$$s.t \quad \sum_{j=1}^{n} \lambda_j x_{ij}^O + T_{7i} = \theta_{j^*} x_{ij^*}^O; \quad \forall i$$

$$\sum_{j=1}^{n} \rho_j x_{lj}^S + T_{8l} = \theta_{j^*} x_{lj^*}^S; \quad \forall l$$

$$\sum_{j=1}^{n} (\lambda_j - \eta_j) y_{pj}^O - T_{9p} = (1 - \theta_{j^*}) y_{pj^*}^O; \quad \forall p \qquad (M11b)$$

$$\sum_{j=1}^{n} (\rho_j - \eta_j) y_{qj}^S - T_{10q} = (1 - \theta_{j^*}) y_{qj^*}^S; \quad \forall q$$

$$\sum_{j=1}^{n} \eta_j y_{rj}^B - T_{11r} = y_{rj^*}^B; \quad \forall r$$

$$\lambda_j, \eta_j, \rho_j, T_{7i}, T_{8l}, T_{9p}, T_{10q} \; and \; T_{11r} \geq 0$$

where $T_{7i}, T_{8l}, T_{9p}, T_{10q}$ and T_{11r} represent the input, intermediate I/O, and output slacks, respectively. DMU j^* is efficient iff $\theta_{j^*} = 1$ and $T_{7i}, T_{8l}, T_{9p}, T_{10q}$ and T_{11r} equal to zero. Otherwise, it is non-efficient. If $\theta_{j^*} = 1$ and value of $T_{7i}, T_{8l}, T_{9p}, T_{10q}$ and T_{11r} are non-zero then DMU j^* is weakly efficient.

4.2.3.1 Efficient Targets The inefficient DMU can be computed using efficient targets for the OSB model from the following equations:

$$\hat{x}_{ij*}^O = \theta_{j*} x_{ij*}^O - T_{7i}; \quad \forall i$$

$$\hat{x}_{lj*}^S = \theta_{j*} x_{lj*}^S - T_{8l}; \quad \forall l$$

$$\hat{y}_{rj*}^B = y_{rj*}^B + T_{11r}; \quad \forall r$$

when y_{pj*}^O is as output for first stage(operational)

$$\hat{y}_{pj*}^O = y_{pj*}^O + T_{9p}; \quad \forall p$$

when y_{pj*}^O is as input for second stage(business) $\qquad$ (M11c)

$$\hat{y}_{pj*}^O = \theta y_{pj*}^O - T_{9p}; \quad \forall p$$

when y_{qj*}^S is as output for first stage(sustainable)

$$\hat{y}_{qj*}^S = y_{qj*}^S + T_{10q}; \quad \forall q$$

when y_{qj*}^S is as input for second stage(business)

$$\hat{y}_{qj*}^S = \theta y_{qj*}^S - T_{10q}; \quad \forall q$$

The efficient targets equations of OB, SB, and OSB models aid to derive a range for intermediate I/Os. The following section shows the application of the DEA models established in the study and provides the result analysis.

5 Results and discussion

The focal aim of the study is to develop mathematical models for examining the business performance of retail stores based on the operational and sustainable decisions made and to identify both areas where stores are performing better and where they are lacking so that improvement strategies can be derived for inefficient stores. Targeting this aim, DEA models are developed in Sects. 4.2.1, 4.2.2, and 4.2.3. The multiple input and output measures considered for the models are listed and explained in Table 2 of Sect. 4.1.

5.1 Results of the study

In this section, the DEA models are validated using a specific case study of 24 retail stores of an Indian retail chain. The quantification of the I/O measures is achieved using the data provided by the company with some modifications due to the confidentiality issue. The objective is to analyse the I/O measures related to operational decisions, sustainable decisions, and business decisions which are summarized in Tables 3, 4, and 5, respectively. This final dataset is used to run OB, SB, and OSB models developed in Sect. 4.2 and Lingo11.0 software is used to solve the mathematical formulations. The efficiency scores derived through each of the models are demonstrated in Table 6.

The result demonstrated in Table 6 shows that retail stores R3, R13, and R21 are OB efficient; R2 and R13 are SB efficient; and R3, R4, and R13 are OSB efficient. The graphical representation of the efficiencies of the retail stores of the OB, SB, and OSB models are given in Figs. 4, 5, and 6, respectively.

Table 3 Data of input/output measures of operational performance

DMU	Inputs						Outputs	
	x_1^O	x_2^O	x_3^O	x_4^O	x_5^O	x_6^O	y_1^O	y_2^O
R1	2050	500	79	1800	1080	0.115	4715	2.59
R2	1400	400	53	1350	767	0.116	2212	4.45
R3	1150	305	27	800	560	0.106	1980	4.86
R4	1320	320	49	1300	965	0.096	4220	3.23
R5	1309	309	63	1550	921	0.075	3250	2.92
R6	1450	450	59	1600	945	0.065	3460	3.8
R7	1400	400	61	1650	943	0.063	3808	4.28
R8	1300	300	52	1325	752	0.057	2690	3
R9	1700	400	42	1200	721	0.047	2560	3.42
R10	1455	355	51	1100	695	0.039	2230	4.36
R11	1850	450	58	1500	954	0.028	3250	3.28
R12	1905	305	57	1450	918	0.024	3678	4.02
R13	1450	350	47	1150	678	0.024	2980	4.42
R14	1407	407	54	1300	745	0.020	3489	3.23
R15	1290	290	32	850	589	0.021	2687	3.48
R16	1500	400	49	1100	667	0.014	2467	4.02
R17	1605	405	43	1050	613	0.015	3690	3.23
R18	1750	450	56	1400	889	0.013	3489	2.86
R19	1550	550	67	1600	952	0.009	3567	3.15
R20	1140	340	49	1200	752	0.008	3236	4.5
R21	1030	306	46	1050	676	0.015	3943	3.42
R22	1389	385	57	1400	898	0.013	2258	2.48
R23	1489	398	64	1550	917	0.009	2986	3.02
R24	1695	425	65	1650	954	0.008	3546	4.36

The comparative analysis of the result of the three models is pictorially presented in Fig. 7. Regardless of the specificity of the outcomes to the case problem, these results can serve as a broad base for other retailers. Figure 7 provides interesting comparisons amongst the OB, SB, and OSB efficiency of the retail stores. It is observed that retail store R2 has the best SB efficiency score (one) but its rank is third in OSB efficiency. Similarly, retail store R21 is OB efficient (efficiency score is one) and it has the third rank in OSB efficiency. It is of great importance to the company to understand how R2 can improve its OSB efficiency; similarly, R21 wants to learn improvement strategies to become OSB efficient. This can be achieved by determining the change needed in the inputs and outputs which can make the inefficient DMU efficient. Hence, we calculate slack values in I/Os of the first stage and second stage at OB level using the model (M5b) developed in Sect. 4.2.1 and we determine the efficient target values for inefficient stores from the model (M5c) developed in Sect. 4.2.1. The resultant slack values are demonstrated in Table 7. Similarly, we compute the slack values of I/Os at SB and OSB level from the models (M8b) and (M11b) developed in Sect. 4.2.3, respectively; and we enumerate efficient targets values from models (M8c) and (M11c) developed in Sects. 4.2.2 and 4.2.3, respectively. Table 8 depicts the slacks and reference set of the SB model. OSB model's slacks of I/O are shown in Table 9. The reference set of OSB model are represented in Table 10 shown below:

Table 4 Data of input/output measures of sustainable performance

DMU	Inputs					Outputs	
	x_1^S	x_2^S	x_3^S	x_4^S	x_5^S	y_1^S	y_2^S
R1	0.118	0.127	192	1	0.112	0.108	0.110
R2	0.106	0.115	190	3	0.116	0.106	0.106
R3	0.107	0.105	195	1	0.106	0.107	0.107
R4	0.097	0.096	198	2	0.096	0.097	0.097
R5	0.075	0.074	185	2	0.075	0.075	0.075
R6	0.072	0.065	187	1	0.065	0.079	0.078
R7	0.063	0.062	191	2	0.063	0.063	0.063
R8	0.056	0.057	186	5	0.066	0.057	0.057
R9	0.048	0.042	195	2	0.042	0.048	0.048
R10	0.039	0.038	187	3	0.039	0.039	0.039
R11	0.028	0.028	192	3	0.028	0.029	0.029
R12	0.024	0.023	186	1	0.024	0.024	0.024
R13	0.024	0.023	189	3	0.024	0.024	0.024
R14	0.021	0.020	186	1	0.020	0.021	0.021
R15	0.021	0.020	193	2	0.020	0.021	0.021
R16	0.014	0.014	191	2	0.014	0.014	0.014
R17	0.015	0.015	194	1	0.015	0.015	0.015
R18	0.013	0.013	189	4	0.013	0.013	0.013
R19	0.009	0.009	187	2	0.009	0.010	0.009
R20	0.008	0.008	184	2	0.008	0.008	0.008
R21	0.015	0.015	193	3	0.015	0.015	0.015
R22	0.013	0.013	191	1	0.013	0.013	0.012
R23	0.009	0.009	183	3	0.009	0.010	0.009
R24	0.008	0.008	186	2	0.008	0.008	0.008

The implications of these results are discussed in detail in Sect. 5.2.

5.2 Result discussion

For the practical application of the mathematical models developed in the study, it is essential to draw meaningful insights from the result derived in Sect. 5.1. For this, we consider the specific case of the retail stores R2 and R21. The performances of these two retail stores, in particular, are analysed in detail. Both R2/R21 are efficient with regard to the OB/SB model but they are inefficient w.r.t the OSB model. The analysis can aid in comprehending improvement strategies for other inefficient retail stores too.

The efficiency scores of the retail store R2 are.

- OB efficiency is 0.84;
- SB efficiency is 1; and
- OSB efficiency is 0.89.

The retail store R2 can maximize its OB performance by focusing on its operational and business decisions. The performance of OB depends on its inputs

Table 5 Data of output measures of business performance

DMU	Outputs	
	y_1^B	y_2^B
R1	0.112	3.590
R2	0.106	3.450
R3	0.107	4.860
R4	0.107	4.000
R5	0.075	2.920
R6	0.078	4.080
R7	0.063	3.280
R8	0.056	3.000
R9	0.048	4.420
R10	0.039	3.360
R11	0.028	3.280
R12	0.023	4.020
R13	0.124	4.900
R14	0.021	3.230
R15	0.021	3.480
R16	0.014	4.020
R17	0.015	3.230
R18	0.013	2.860
R19	0.009	3.450
R20	0.008	3.180
R21	0.015	4.200
R22	0.012	3.480
R23	0.009	4.020
R24	0.008	3.360

$(x_1^O, x_2^O, x_2^O, x_4^O, x_5^O$ and $x_6^O)$, intermediates $(y_1^O$ and $y_2^O)$, and outputs $(y_1^B$ and $y_2^B)$ measures. From Table 6, we can infer that retail store R3 and R21 are benchmarks for stage1 (operational performance) and R13 for stage 2 (business performance) of store R2. It means that the projection of R2 at an efficient frontier of operational performance is a convex combination of R21 and R3. The store R2 should reduce its operational inputs to R3 and enhance its operational outputs to R21. The store R2's input values $(x_1^O, x_2^O, x_2^O, x_4^O, x_5^O$ and $x_6^O)$ of operational performance are Rs 1400, Rs 400, 53, 767, and 0.116, respectively. The efficient targets result from the OB model (M5c) suggest to decision-makers that store R2 should reduce its inputs operating expenses, average inventory cost, number of employees, product assortment, and assurance of product delivery by Rs 1175.17, Rs 325.23, 34.54, 644.28, and 0.078, respectively and set its intermediate I/Os: profit is between Rs 1855.23 and Rs 2229.8 and market competence is 4.45, respectively for accomplishing an efficient frontier. From these values, we observe that the retail store R3's market competence is better than retail store R2 as demonstrated in Fig. 8. It means retail store R2 needs to enhance its quality of services by level 4.45 (near about). Similarly, the reduction in inputs' operating expenses and average inventory costs are depicted graphically by Fig. 9. The current output customer satisfaction is 3.45 and price competence is 0.103 for stage2 of store R2.

Table 6 Efficiency value of retail stores derived from OB, SB, and OSB models

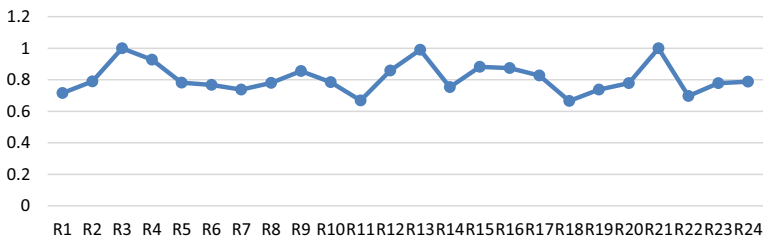| DMU	Eff_OB	Eff_SB	Eff_OSB
R1	0.74	0.93	0.94
R2	0.84	1.00	0.89
R3	1.00	0.96	1.00
R4	0.93	0.98	1.00
R5	0.79	0.62	0.87
R6	0.77	0.86	0.87
R7	0.74	0.60	0.74
R8	0.78	0.61	0.78
R9	0.86	0.65	0.86
R10	0.78	0.62	0.79
R11	0.66	0.65	0.70
R12	0.86	0.69	0.86
R13	1.00	1.00	1.00
R14	0.75	0.68	0.78
R15	0.88	0.69	0.90
R16	0.87	0.81	0.88
R17	0.83	0.74	0.83
R18	0.66	0.75	0.79
R19	0.74	0.90	0.87
R20	0.78	0.91	0.88
R21	1.00	0.81	0.93
R22	0.69	0.153	0.69
R23	0.77	0.125	0.78
R24	0.78	0.1	0.78

Fig. 4 Graphical representation of efficiency scores of OB model
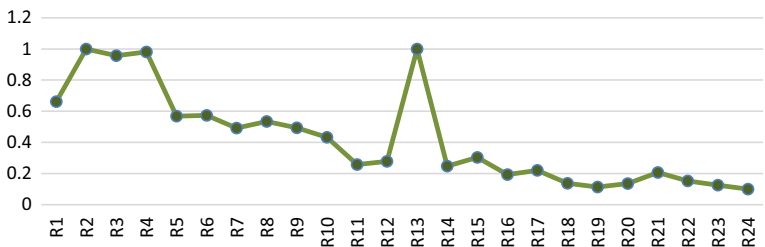

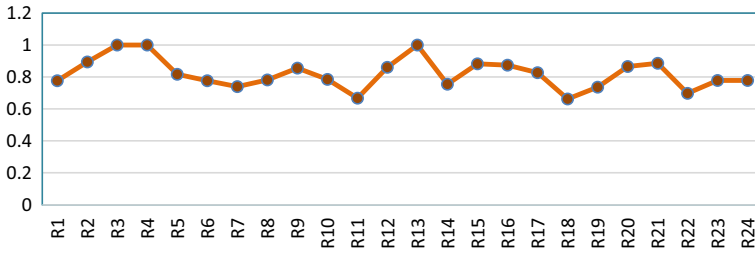**Fig. 5** Graphical representation of efficiency scores of SB model

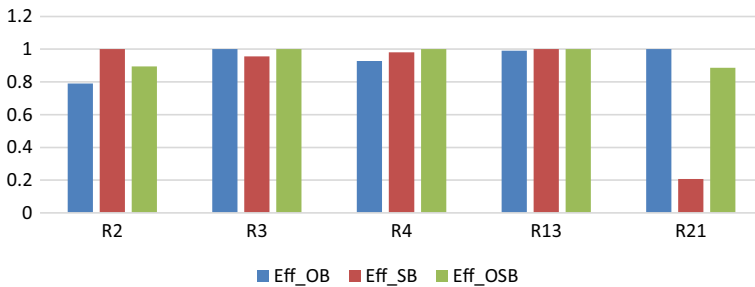**Fig. 6** Graphical representation of efficiency scores of OSB model

Fig. 7 Comparison in OB, SB and OSB efficiency scores

From Fig. 10, we infer that R2 needs to enhance its level of customer satisfaction and price competence to reach 4.15 and 0.106, respectively, to become OB efficient.

Similarly, the retail store R2 can enrich its OSB efficiency by focusing on its slack values of inputs, intermediates I/O and outputs as given in Table 9. The store R2 can enhance its efficiency by reducing its operational and sustainable inputs OE, AIC, employees, store area, product assortment, energy reduction, waste management, number of working hours, women employees, employee benefits up to Rs 1047.65, Rs 309.04, 40.03, 1037.21 sq feet, 682.63, 0.01, 0.09, 0.07, 129.11 h, 2.01, 0.07. They should set intermediate I/Os as profit between Rs 242.18 to Rs 3938.50, market competence is between 3.96 and 4.45, EEC is between 0.094 and 0.106, and ESC is between 0.094 and 0.106, respectively. Finally, they are encouraged to maximise output customer satisfaction up to 3.51. From Table 9, we observe that the store R2 can project on an efficient frontier by following their respective benchmarks. Benchmarks of the store R2: in the first stage, retail stores R3 and R21 for operational performance; retail stores R2 and R4 for sustainable performance; and retail store R13 for the second stage (business performance).

The retail store R2 has the same benchmarks for operational decisions and business decisions from the OB and OSB models. In sustainable decisions, store R2 is efficient through the SB model and has benchmarks R2 and R4 in the OSB model. It means that store R2 can maximise its business performance by focusing on operational decisions.

Now, we analyse the performance of the retail store R21 and its efficiencies are given below:

Table 7 Slack values of inputs, intermediate I/O and outputs; and reference sets from OB model

DMU	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}	T_{16}	T_{21}	T_{22}	T_{31}	T_{32}	Reference sets 1st stage	Value	2nd stage	Value
R1	228.56	0	13.72	148.37	21	0.03	314.33	0	0	0.738	R3, R21	0.348, 0.861	R13	0.854
R2	0.825	10.77	9.98	178.79	0	0.02	17.8	0	0	0.738	R3, R21	0.652, 0.412	R13	0.854
R3	0	0	0	0	0	0	0	0	0	0	R3	1	R3	1
R4	25.88	0	9.69	240.16	254.82	0.02	0	0	0	0.228	R3, R12, R21	0.475, 0.16, 0.338	R13	0.862
R5	106.32	0	21.19	452.91	214.7	0.013	0	0	0	0.04	R3, R12, R21	0.366, 0.072, 0.37	R13	0.604
R6	0	18.075	0	104.93	13.99	0.0314	189.82	0	0	0	R3, R20	0.115, 0.875	R3, R9, R13	0.338, 0.31, 0.216
R7	0	0	8.27	270.79	82.3	0.005	22.97	0	0	0	R3, R20	0.341, 0.563	R3, R9, R13	0.49, 0.18, 0.008
R8	173.27	0	13.6	316.83	112.7	0	0	0	0	0	R3, R12, R20, R21	0.394, 0.009, 0.29, 0.041	R3, R9	0.43, 0.203
R9	268.85	28.42	0	85.28	0	0	0	0	0	0	R3, R15, R17, R20, R21	0.28, 0.21, 0.12, 0.16, 0.203	R9	1
R10	223.45	17.75	6.88	13.87	0	0	0	0	0	0	R3, R13, R20, R21	0.32, 0.05, 0.412, 0.105	R3, R9	0.04, 0.709
R11	195.12	5.73	0	15.75	0	0	140.98	0	0	0	R3, R15, R20, R21	0.066, 0.133, 0.310, 0.427	R9, R22	0.509, 0.295
R12	279.72	0	5.33	137.18	84.52	0	0	0	0	0	R3, R12, R20, R21	0.047, 0.54, 0.16, 0.09	R9, R22	0.27, 0.8
R13	0	0	0	0	0	0	0	0	0	0	R13	1	R13	1
R14	142.61	45.3	5.1	88.65	0	0	0	0	0.014	0	R3, R13, R20, R21	0.04, 0.12, 0.35, 0.27	R9	0.73
R15	95.82	8.9	0	4.32	10.87	0	0	0	0.0006	0	R3, R15, R21	0.02, 0.67, 0.15	R9, R22	0.29, 0.62
R16	250.19	64.41	3.79	5.03	0	0	0	0	0.02	0	R13, R17, R20, R21	0.32, 0.06, 0.42, 0.01	R9	0.909
R17	215.97	49.45	0.76	17.47	0	0	0	0	0.01	0	R13, R17, R20	0.235, 0.363, 0.16	R9, R22	0.44, 0.36
R18	271.78	33.95	0	4.78	5.18	0	3.84	0	0.019	0	R20, R21	0.49, 0.30	R3, R9	0.03, 0.61
R19	100.11	108.966	5.96	105.67	42.83	0	0	0	0.03	0	R20, R24	0.65, 0.17	R3, R9	0.212, 0.54
R20	0	0	0	0	0	0	15.49	0	0.02	0	R20	0.78	R3, R9	0.054, 0.66
R21	0	0	0	0	0	0	0	0	0	0	R21	1	R21	1
R22	76.87	0	2.46	45.06	37.49	0	1294.06	0	0.052	0	R20, R21	0.54, 0.404	R3, R9	0.49, 0.24

Table 7 (continued)

DMU	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}	T_{16}	T_{21}	T_{22}	T_{31}	T_{32}	Reference sets			
											1st stage	Value	2nd stage	Value
R23	123.86	6.39	5.84	125.83	41.83	0	0	0	0.04	0	R20, R24	0.81, 0.06	R3, R9	0.14, 0.74
R24	109.43	16.76	3.14	88.73	39.83	0	0	0	0.02	0	R20, R24	0.19, 0.59	R9, R22	0.59, 0.204

Table 8 Slack values of inputs, intermediate I/O and outputs; and reference sets from SB model

| DMU | T_{41} | T_{42} | T_{43} | T_{44} | T_{45} | T_{51} | T_{52} | T_{61} | T_{62} | Reference sets | | | |
										1st stage	Value	2nd stage	Value
R1	250.93	41.57	12.01	178.11	0	0	0	0	0.422	R1, R4	0.83, 0.07	R2, R24	0.764, 0.04
R2	0	0	0	0	0	0	0	0	0	R2	1	R2	1
R3	0.002	0	8.9	0	0.003	0	0	0	0	R1, R3, R4	0.54	R2, R24	0.76, 0.04
R4	0.03	0.03	81.47	0.82	0.03	0	0	0	0.62	R4	0.57	R13, R24	0.56, 5.18
R5	0.0001	0	20.85	0.29	0.0006	0	0	0	0.44	R4, R13	0.5, 0.003	R13, R24	0.51, 1.44
R6	0.009	0.002	61.24	0	0.004	0	0	0	0	R1, R4	0.15, 0.32	R2, R13, R24	0.28, 0.26, 0.44
R7	0.0001	0	28.42	0.24	0.0005	0	0	0	0.1	R4, R13	0.38, 0.08	R2, R13, R24	0.013, 0.47, 0.26
R8	0	0	35.49	2.25	0.005	0	0	0	0.24	R2, R4, R13	0.009, 0.34, 0.05	R13, R24	0.46, 0.62
R9	0.002	0.0003	22.95	0.15	0	0	0	0	0	R4, R6, R13	0.07, 0.21, 0.26	R13, R23	0.33, 0.68
R10	0	0	29.26	0.89	0.0004	0	0	0	0	R2, R4, R6, R13	0.08, 0.07, 0.16, 0.208	R13, R23	0.27, 0.49
R11	0	0.0001	63.05	1.29	0	0	0	0	0	R2, R4, R6, R13	0.009, 0.05, 0.13, 0.12	R13, R23	0.18, 0.59
R12	0	0	72.42	0.14	0.0005	0	0	0	0	R2, R4, R6, R13	0.005, 0.02, 0.16, 0.1	R13, R23	0.12, 0.84
R13	0	0	0	0	0	0	0	0	0	R13	1	R13	1
R14	0	0.0001	73.63	0.144	0	0	0	0	0	R2, R4, R6, R13	0.003, 0.004, 0.15, 0.12	R13, R23	0.12, 0.65
R15	0	0.0001	79.81	0.84	0	0	0	0	0	R2, R4, R6, R13	0.003, 0.001, 0.15, 0.11	R13, R23	0.11, 0.72
R16	0	0.00001	128.28	1.42	0	0	0	0	0	R2, R3, R4, R6	0.005, 0.13, 0.05, 0.06	R13	0.04
R17	0	0.000002	114.87	0.48	0	0	0	0	0	R2, R4, R6, R13	0.005, 0.05, 0.07, 0.01	R13	0.06
R18	0	0.000004	119.24	2.81	0	0	0	0	0	R2, R3, R4, R6	0.003, 0.0004, 0.06, 0.04	R13, R23	0.05, 0.65
R19	0	0.00002	149.62	1.67	0	0	0	0	0	R2, R3, R4, R6	0.003, 0.02, 0.01, 0.05	R13, R23	0.01, 0.84
R20	0	0.00003	152.92	1.74	0	0	0	0	0	R2, R3, R4, , R6	0.02, 0.03, 0.01, 0.03	R13, R23	0.003, 0.007
R21	0	0.000009	126.8	2.2	0	0	0	0	0	R2, R3, R4, , R6	0.006, 0.003, 0.05, 0.09	R13, R23	0.04, 1.04
R22	0	0.00001	125.5	0.6	0	0	0	0	0	R2, R3, R4, , R6	0.004, 0.013, 0.047, 0.58	R13, R23	0.03, 0.82
R23	0	0.00004	158.65	2.79	0	0	0	0	0	R2, R3, R4, , R6	0.003, 0.04, 0.008, 0.03	R23	1
R24	0	0.00003	158.11	1.7	0	0	0	0	0	R2, R3, R4, , R6	0.003, 0.03, 0.01, 0.04	R13	0.004
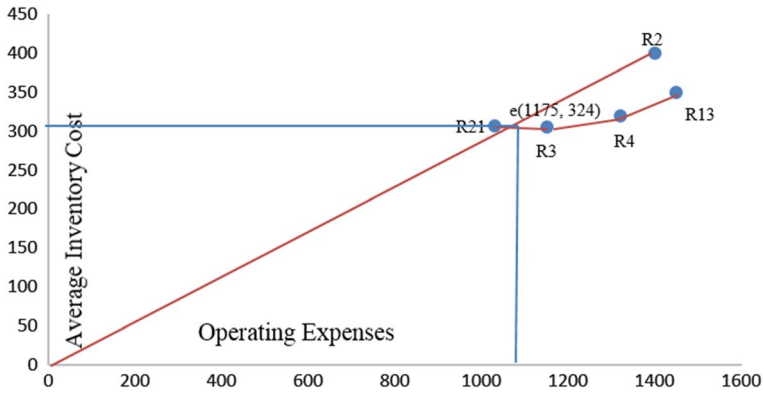
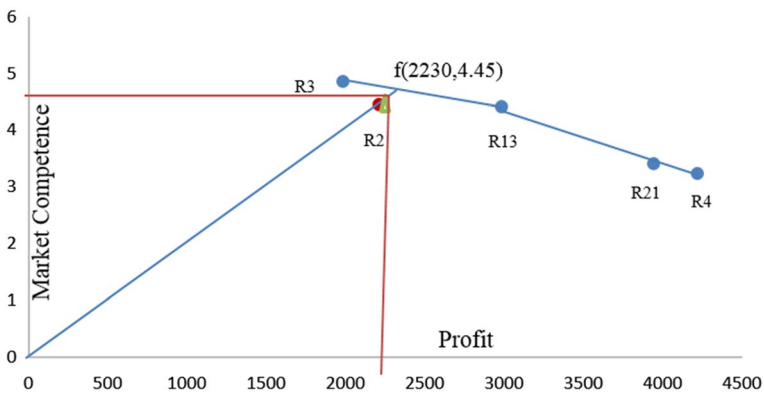**Fig. 8** Graphical representation of profit and market competence of DMUs

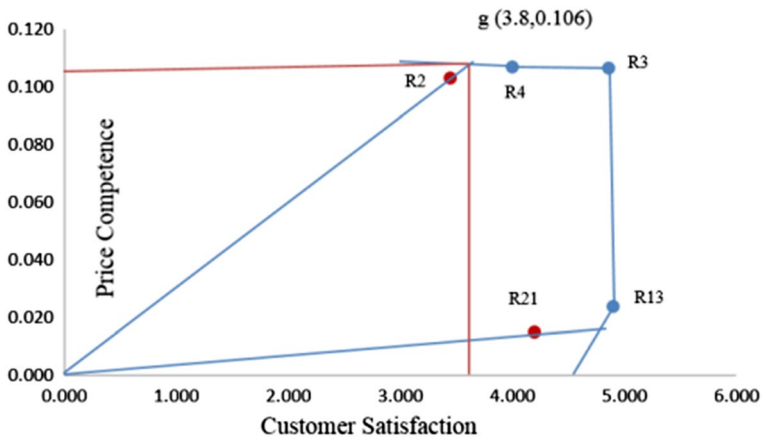**Fig. 9** Graphical representation of average inventory cost and operating expenses of DMUs

Fig. 10 Graphical representation of customer satisfaction and price competence of DMUss

Table 9 Slack values of inputs, intermediate I/O and outputs from OSB model

DMU	T_{71}	T_{72}	T_{73}	T_{74}	T_{75}	T_{76}	T_{91}	T_{92}	T_{81}	T_{82}	T_{83}	T_{84}	T_{85}	T_{101}	T_{102}	T_{111}	T_{112}
R1	404.44	11.12	13.50	122.49	0.00	0.09	4154.35	0.11	0.00	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R2	198.35	46.95	7.14	164.29	0.00	0.09	1726.50	0.00	0.00	0.02	39.99	0.66	0.03	0.00	0.00	0.00	0.06
R3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R5	223.33	0.00	20.50	457.54	222.04	0.04	1101.10	0.00	0.00	0.04	0.02	0.02	78.37	0.91	0.03	0.00	0.02
R6	0.00	16.13	0.00	93.43	2.56	0.03	0.00	0.00	0.00	0.00	0.00	209.08	30.01	790.77	406.89	0.00	0.00
R7	0.00	0.00	9.41	282.92	82.30	0.00	136.59	0.00	0.00	0.00	574.97	0.00	50.66	0.71	0.00	0.00	0.00
R8	107.19	0.00	12.69	285.51	90.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.30	3.26	0.01	0.00	0.00
R9	422.00	47.69	0.00	86.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.49	1.07	0.00	0.00	0.00
R10	249.03	20.33	7.47	21.10	0.00	0.00	43.73	0.00	0.00	0.00	0.00	0.00	73.58	1.85	0.00	0.00	0.00
R11	258.12	9.32	0.00	12.14	0.00	0.00	544.28	0.00	0.00	0.00	0.00	0.00	80.14	1.58	0.00	0.00	0.00
R12	254.25	0.00	4.85	124.70	76.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	102.28	0.47	0.00	0.00	0.00
R13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R14	198.10	51.85	6.40	107.13	0.00	0.00	198.49	0.00	0.00	0.00	0.00	0.00	107.49	0.49	0.00	0.00	0.00
R15	140.71	13.15	0.00	6.39	16.06	0.00	64.34	0.00	0.00	0.00	0.00	0.00	124.81	1.50	0.00	0.00	0.00
R16	295.74	68.23	5.02	21.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	135.02	1.56	0.00	0.00	0.00
R17	389.15	81.87	2.49	45.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	124.47	0.55	0.00	0.00	0.00
R18	591.22	119.51	12.03	289.45	179.78	0.00	313.69	0.00	0.00	0.00	0.00	0.00	117.77	2.93	0.00	0.00	0.00
R19	312.82	169.70	14.01	304.29	145.31	0.00	0.00	1.01	0.00	0.00	0.00	0.00	139.04	1.57	0.00	0.00	0.00
R20	53.54	16.03	2.46	58.01	35.49	0.00	0.00	0.77	0.00	0.00	0.00	0.00	141.01	1.61	0.00	0.00	0.00
R21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	165.79	2.86	0.00	0.00	0.00
R22	196.57	36.12	7.98	175.24	117.00	0.00	128.05	0.00	0.00	0.00	0.00	0.00	118.58	0.53	0.00	0.00	0.00
R23	298.60	46.31	13.15	301.46	136.65	0.00	0.00	0.95	0.00	0.00	0.00	0.00	146.33	2.63	0.00	0.00	0.00
R24	533.65	86.72	15.97	442.00	204.43	0.00	0.00	0.92	0.00	0.00	0.00	0.00	146.45	1.66	0.00	0.00	0.00

- OB efficiency is 1;
- SB efficiency is 0.81; and
- OSB efficiency is 0.93.

In a manner similar to R2, we analyse the SB performance of R21 on the basis of its input and output measures. $x_1^S, x_2^S, x_3^S, x_4^S, x_5^S$ and x_6^S are input measures, and y_1^S and y_2^S are output measures of SB decisions. It can become a linear combination of R2, R3, R4, and R6 at the frontier for stage1; and R13 and R23 for stage2. The store R21 should reduce its sustainable performance inputs energy reductions, waste management, number of working hours, the number of women employees, employee benefits, environmental competence, and social competence by 0.012, 0.013, 29.53, 0.23, and 0.12, 0.12 and 0.12, respectively. The store can enhance its outputs price competency and customer satisfaction by 0.015 and 4.4, respectively, to become efficient.

Now, we discuss the OSB performance of the store R21 based on its slack values which are given in Table 9. The store R21 should focus on its both operational and sustainable inputs OE, AIC, employees, store area, product assortment, energy reduction, waste management, number of working hours, employee benefits up to Rs 957.9, Rs 284.58, 42.78, 976.5, 628.68, 0.013, 0.013, 0.013, 13.79, and 0.013; keep the output level same; and also set the intermediate I/Os profit, market competence, EEC and ESC between (3666.9, 3943), (3.18, 3.42), (0.013, 0.15) and (0.013, 0.15). The store R21 can become efficient through its benchmarks as given in Table 10. The store R21 serves itself as a benchmark for operational performance and business performance; and stores R1, R2 and R3 are benchmarks for sustainable performance in the OSB model. Hence, the retail store R21 requires to focus on its sustainable performance to enrich its OSB performance.

Store R3 projects on the efficiency frontier for OB and OSB performances while it is inefficient for SB performance. Its SB efficiency value is 0.96; i.e., the store R3 is lying near the frontier or performing very well at SB decisions. It requires to focus only on sustainable decisions to improve its SB performance according to the model (M8c); stores R1, R3 and R4 are its benchmarks. The store R3 should reduce energy consumption, number of working hours, and employee benefits by 0.100, 178.3, and 0.009, respectively. Similarly, store R4 is OSB efficient but OB and SB inefficient; its OB and SB efficiency values are 0.93 and 0.98, respectively. It is performing well at both OB and SB performances (above 0.9) and doesn't have too much distance from the efficiency frontier. The store R4 comes under the best OSB performing store but still has the scope of improvement at OB and SB performances. It can improve OB and SB performances by reducing its inputs at operational and sustainable decisions according to their slack values as given in Tables 7 and 8, and the store should increase customer satisfaction for both OB and SB performances up to 4.458, and 4.850, respectively. The store R4 has R3, R12, and R21 as OB performance benchmarks, and R4 (itself) is a benchmark for SB performance; i.e., it needs to monitor its internal sustainable activities for improving SB performance. From the above results, the study infers that the retail stores R3 and R4 both are OSB efficient but have some deficiency at either OB or SB performance or at both performances. Thus, they require to monitor their operational and sustainable decisions and have some improvement plans in place to maintain their OSB performance.

A retail store can maximize its OSB performance by focusing on both operational and sustainable decisions simultaneously. Retail stores R3, R4, and R13 are performing better than others because they are performing well in terms of both operational and sustainable

Table 10 Reference set from OSB model

DMU	1st stage	Value	2nd stage	Value	3rd stage	Value
R1	R21	1.23	R1	1	R3, R21	1.003, 0.04
R2	R3, R21	0.1, 1.03	R2, R4	0.75, 0.02	R13	0.85
R3	R3	1	R3	1	R3	1
R4	R4	1	R4	1	R4	1
R5	R3, R21	0.11, 0.71	R4	0.42	R13	0.6
R6	R3, R20, R21	0.03, 0.12, 1.05	R3, R4	0.27, 0.18	R3, R9, R13, R21	0.21, 0.34, 0.3, 0.004
R7	R3, R20, R21	0.33, 0.22, 0.39	R3, R4	0.15, 0.31	R3, R9, R13	0.09, 0.29, 0.31
R8	R3, R12, R20, R21	0.36, 0.08, 0.08, 0.22	R2, R3, R4	0.013, 0.21, 0.22	R3, R9, R13	0.13, 0.27, 0.22
R9	R3, R15, R20, R21	0.3, 0.029, 0.217, 0.4	R4, R6, R13	0.104, 0.4, 0.018	R9, R13, R22	0.59, 0.12, 0.33,
R10	R3, R20, R21	0.23, 0.36, 0.21	R2, R4, R6	0.01, 0.12, 0.26	R9, R13, R22	0.41, 0.12, 0.25
R11	R3, R15, R20, R21	0.06, 0.001, 0.16, 0.74	R2, R4, R6, R13	0.008, 0.1, 0.11, 0.058	R13, R22	0.15, 0.72
R12	R3, R12, R20, R21	0.04, 0.54, 0.16, 0.09	R2, R6, R13	0.01, 0.27, 0.02	R9, R13, R22	0.19, 0.02, 0.87
R13	R13	1	R13	1	R13	1
R14	R3, R20, R21	0.05, 0.24, 0.54	R2, R4, R6	0.0002, 0.09, 0.1	R9, R13, R22	0.02, 0.08, 0.78
R15	R3, R15, R21	0.03, 0.58, 0.22	R2, R4, R6	0.006, 0.02, 0.22	R9, R13, R22	0.207, 0.021, 0.71
R16	R13, R17, R20, R21	0.19, 0.08, 0.28, 0.29	R2, R6, R13	0.01, 0.16, 0.006	R21, R22, R23	0.009, 0.93, 0.17
R17	R13, R17, R20, R21	0.22, 0.12, 0.11, 0.3	R3, R4	0.15, 0.007	R9, R22	0.11, 0.77
R18	R20, R21	0.16, 0.6	R2, R6, R13	0.008, 0.13, 0.03	R13, R22, R23	0.03, 0.6, 0.14
R19	R20, R21	0.78, 0.04	R2, R6, R13	0.006, 0.09, 0.01	R13, R16, R23	0.007, 0.0005, 0.78
R20	R20, R21	0.55, 0.16	R3, R4	0.1, 0.007	R16, R22	0.16, 0.72
R21	R21	1	R1, R2, R3	0.01, 0.001, 0.12	R21	1
R22	R20, R21	0.33, 0.5	R2, R6, R13	0.008, 0.13, 0.03	R13, R22, R23	0.02, 0.29, 0.58
R23	R20, R21	0.86, 0.09	R2, R6, R13	0.007, 0.11, 0.007	R16, R23	0.02, 0.97
R24	R20, R21	0.8, 0.03	R2, R6, R13	0.006, 0.09, 0.009	R13, R16, R23	0.004, 0.001, 0.82

areas. The performance of a retail store can be influenced by both operational and sustainable decisions.

6 Conclusion and insights

In India, sustainability practices in retailing still exist at the initial stage. The incorporation of sustainable decisions within a store's operation is beneficial not only for business but also it enhances a positive image in society; such decisions also assist in a store's operational management of SC. Thus, retailers need to evaluate their SC performance according to their operations and sustainable activities. In this direction, the focus of the current study is to (1) Identify performance measures of stores related to operational performance, sustainable performance, and business performance; (2) Develop mathematical formulations to examine the effect of operational decisions and sustainable decisions on business performance; and (3) Derive the efficient target values for inefficient stores for further improvement. For this, the paper evolves an approach based on a two-stage network DEA to analyse the effect of sustainable decisions with operational management on stores' business performance. The study demonstrates the applicability of the approach through the case study of an electronics retail company in India. The efficiencies of 24 retail stores located in Delhi, NCR region are examined based on their operational, sustainable, and business decisions. The main findings from our analysis of the empirical results are summarized and provide an insight to the management for developing an effective strategy related to the incorporation of sustainable practices with operational management of the supply chain. Based on these main findings, the managerial insights are drawn the sustainable management of retail stores as discussed below:

- The study suggests to decision-makers that the business performance of a store depends on both operational and sustainable decisions. The results show that any store is inefficient due to the inappropriate inclusion of either operational decisions or sustainable decisions. A sustainable inefficient store requires more focus on its waste management, the number of working hours and women employees, environmental competence, social competence, and customer satisfaction to enhance its OSB performance. Thus, the inefficient store needs to monitor input and output measures of its operational performance and sustainable performance to enhance its business performance.
- Incorporation of sustainable practices may increase the operational expenditure of the store. Decision-makers need to create an appropriate balance between operational decisions and sustainable decisions to enhance overall business performance. From the results, we infer that a store can become efficient at a sustainable level while still be inefficient in the OSB model. The inefficient store needs to give more attention to its inventory carrying cost, assurance of product delivery, number of employees, profit, price competence, and customer satisfaction measures to enrich overall business performance.
- The study provides meaningful suggestions on the further possibility of improvement for an OSB efficient store at operational and sustainable level decisions to handle its deficiency.
- The benchmarks of inefficient stores provide their weak and strong areas by taking into account the measures of operational and sustainable performance. The result

shows that the inefficient store can enhance its sustainable performance through its respective benchmarks in the OSB model. Decision-makers of the inefficient store (at a sustainable level) need to focus on input measures: number of working hours, number of women employees, and employee benefits for benchmarking.

The proposed approach can be employed by other industries for examining the effect of operational and sustainable decisions on its business performance based on the above implications. The study has some limitations and may require future research. For example, (1) the proposed models provide the efficient target values in a range for intermediate measures (I/Os) of inefficient stores. It is not able to determine exact values for intermediate I/Os. (2) the proposed approach is based on a single period. A period-oriented efficiency assessment can be measured to analyse the effect of inputs over the period. (3) In the present study, the relationship between exogenous inputs and efficiency values was not assessed. (4) the study has focused on the effect of sustainable practices with operational decisions of forwarding logistics of stores but has not considered the decisions in relation to reverse logistics. Implementation of reverse logistics can substantially improve the sustainable performance of the stores and this aspect can be delved deeper in future research work (Chen et al., 2021). Despite the identified limitations, the I/O measures and the DEA models developed in the study for assessing the individual and joint impact of sustainability and operation activities on the business efficiency of the retail chain do provide a significant contribution in the research area of sustainable retailing in India. The results of the mathematical analysis will guide the retailers in several strategic, tactical, and operating decisions for integrating sustainability decisions into their operations management.

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