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Two-Stage Production System Pondering upon Corporate Social Responsibility in Food Supply Chain: A Case Study

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Abstract: Corporate social responsibility (CSR) has witnessed remarkable attention in academic studies as well as being widely conducted in different industries globally. This specific case was chosen as one of the biggest dairy companies that may be represented for Vietnam dairy supply chain management. This research aims to integrate CSR initiatives into food supply chain management to clarify the optimal replenishment policy, paying close attention to the relationship between midstream manufacturers and final customers. The classical economic production quantity model has been employed, relying on the two-stage assembly production system. The three parameters that contribute to the total profit formulation that have been considered consist of the social charity amount for per unit selling, the unit wholesale price of the manufacturer, and the return rate of used goods from the customer. The study has stressed that there is a significant impact from implementing CSR initiatives on the enterprise's inventory policy that leads to enhance the firm's financial performance.

Keywords: Two-stage production system; corporate social responsibility; supply chain; dairy industry; social charity; Vietnam

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1. Introduction

The idea of conducting corporate social responsibility (CSR) has undergone phenomenal growth in recent decades and has been rolled out in diverse sectors globally, such as the European banking industry [1], Vietnamese coffee sector [2], Jordanian pharmaceutical industry [3], the U.S. restaurant industries [4], Chinese food industry [5], and so on. Indeed, this positive signal has attracted increasing interest from corporations due to the advantages of adopting CSR into their business strategy [6–8]. Some recent studies have stated the critical role of CSR activities; for example, the positive effects of CSR on the firm's financial performance [9,10], the value perception by consumers is generated [11], corporate reputation, consumer's satisfaction, or competitive advantage of the company [12–14]. Thus, two major characteristics contribute to CSR simply understanding as follows: firstly, the relationship between corporate responsibility and the firm's stakeholders, including internal and external. Secondly, toward sustainable development, which obligation has divided into three major issues: enhancing the economy, protecting the environment, and contributing to local society. Hence, CSR initiatives have been conducted and considered an excellent tool to attain sustainability [15–17].

In terms of supply chain management (SCM), the structure starts from the first stage known as upstream suppliers to the last step known as downstream customers; thus, there are many relationships among stakeholders in the supply chain that must be solved and predicted [18–20]. Additionally, the positive signal from CSR initiatives can enhance SCM performance and may obtain a sustainable supply chain; thus, the number of studies integrating CSR initiatives into SCM has also been gradually becoming popular and diverse in many different industries worldwide [14,21,22]. Hence, adopting CSR initiatives into SCM may have been affected by various factors or barriers [18,19]. The customer is at the last stage of the supply chain but also plays a decisive role in the sales of products and impacts the economic responsibility of the firms. However, there are only a few studies concerning the relationship between customers and manufacturers, which have an influence on CSR ideas, especially the food supply chain [16,17]. The food supply chain has several particular characteristics compared to other sectors; thereby, research integration of CSR initiatives into the food SCM is attaining much attention due to its contribution to sustainability, particularly in transitional economies [23]. From some of the existing CSR-SCM studies about stakeholder theory, they have demonstrated that businesses' efforts to adopt CSR activities into corporate governance policies to satisfy the interests of shareholders and stakeholders because SCM plays a role as the critical interface with suppliers or agency services, for instance, logistics services, transport providers, service of yards and warehouses [24,25]. Unfortunately, only a few studies consider the optimal model related to SCM stakeholders; meanwhile, the excellent role of CSR programs in SCM sustainability has not been considered properly, particularly in transitional economies [21,22]. Thus, this research aims to propose an optimal model for the food supply chain, which can adopt CSR initiatives into the food SCM. In this way, supporting the food company has a social contribution as well as obtaining superior financial performance. This study has some research questions as follows:

RQ1. What is the optimal social charity amount for per unit product selling?

RQ2. What is the optimal production run time of the manufacturer?

RQ3. What is the optimal return rate of used products from the customer?

This study makes several contributions to the published literature regarding CSR and SCM. Firstly, this research develops the classical economic production quantity (EPQ) model to address the stakeholders' satisfaction under the two-stage assembly production system. An analysis between two supply chain members will be conducted, including midstream manufacturers and downstream buyers, whose members are witnessing the CSR adoption. Secondly, the proposed EPQ model's efficacy has been assessed through the Vietnamese dairy supply chain case study, which is among the critical sectors contributing to the sustainable development of a developing nation like Vietnam [26]. This is the unique research considering the relationship between CSR practices and food supply chain management in Vietnam; thus, the research findings provide useful information to SCM's managers. Moreover, this model's scope can also be expanded to various sectors to determine the proposed model's efficacy. The structure of this study as follows. The authors discussed the introduction in Section 1. The literature review and the methodology of this study will be described in Sections 2 and 3, respectively. The next section will outline the notation and model formulation for this research. A numerical example of this study will be shown in Sections 5 and 6. In the last part, Section 7 outlines the research implications and limitations of the study, as well as suggestions for new study directions in the future.

2. Literature Review

To date, the definition of CSR is still controversial about consistency, and there are many different perspectives on CSR definition [7,11]. In studies of the stakeholders' theory, the scholars agreed that businesses would enhance their profit; however, they must also assume responsibilities to the environment, community, and society where the company is operating [27]. Therefore, the CSR concept has been understood under three responsibilities dimensions: economic, social, and environmental responsibility [2,27]. Regarding supply chain management, this includes many different stages with several complex relationships between the company and other stakeholders. The role of stakeholders in sustainable supply chain management (SSCM) has been described in several previous studies, such as empirical research in India of Das (2018) [12]; a review research from Sodhi and Tang (2018) [18]; or Sarkar et al. (2018) who suggested a production model of the automobile SSCM related to environment protection [20]. Consequently, corporatations need to determine their responsibilities with goods from the first stage as forming ideas [28]. CSR initiatives have been employed as useful tools to incorporate with SCM to improve corporate decision-making effectiveness, as well as to accomplish SSCM targets [21,24,29]. In fact, the findings obtained have recently shown that various studies incorporating CSR and SCM have been increasing rapidly. For instance, Feng (2017) systematically reviewed the relationship between CSR and SCM among previous studies and pointed out that these studies are heavily concentrated in developed countries; meanwhile, just a few studies have been conducted in emerging economies [21]; Das (2018) evaluated the model to enhance SSCM performance of the Indian enterprises through competitiveness measurement that had been influenced by CSR practices [12]; Khalid et al. (2015) suggested employing three-aspect obligations to attain SSCM, however, they found a lack of attention on the social dimension of the SCM compared to other responsibilities [30]; Wu et al. (2017) indicated that supplier's CSR misconduct directly remarkably affects the economic performance in the SCM [25].

In terms of the food supply chain sector, which is always a difference between the food industry and other industries since the characteristics of food products such as food quality, safety, storage condition, and shelf life as well as the process of transporting between warehouses, and stores to end customers [5,31]. These are factors that can easily occur in incidents related to food goods. Moreover, it also may impact food supply chain management and make them more difficult and complicated, although the companies have applied risk mitigation strategies in the supply chain [5,31,32]. Evaluation of the correlation between CSR issues and the food SCM has been indicated as a hot topic and given much attention by some scholars in recent years [21]. For instance, Chkanikova and Mont (2015) highlighted some drivers and barriers for food retailers in conducting CSR in their supply chains [33]; Prakash (2018) indicated the rise of CSR and SCM studies; however, it is not really significant and worthy of research potential [34]. Hence, there has been a gap in sustainability efforts and outcomes between developed nations and emerging nations in attaining a sustainable food supply chain. The comparison research between two types of countries has been conducted and claims that in developed countries' conditions where mature supply chains already exist, the industry can adopt risk mitigation strategies and achieve the effectiveness. They also suggested that the future of research should clarify which conditions in transitional economies are needed to achieve a sustainable supply chain [35]. However, their similar findings suggested that companies should pay attention to the different stages and their roles from up-stream to down-stream [28,36].

Regarding SCM in the developing country context, especially in the perishable food supply chain, no company wants to suffer the risk of damage because of perishable products such as meat, seafood, or other perishable goods. The relationship between manufacturers and retailers is very complicated and mainly focused on their economic benefits. There are two aspects, including the price markdown costs and it is related to some parameters such as potential customer quantity and market price fluctuations. These two factors affect the optimal choice of pricing strategy of the enterprises in the perishable food supply chain [37]. Meanwhile, the perceived consumer in developing countries has changed significantly in recent years. Huang et al. (2019) stressed that Vietnamese consumers have more interest and are willing to spend more money on products from socially responsible companies [11]. In terms of the dairy SCM, the dairy quality was the top priority of all stakeholders as well as stages in the SCM; thus, the biggest issue is dairy quality assurance across the entire supply chain because the specificity of dairy products is highly perishable and it is very costly to preserve refrigeration and collect it continuously. Previous studies have shown that manufacturers and stakeholders such as farmers, logistic services, and suppliers have mutual responsibility related to dairy quality [23,38–41]. Hence, studying the optimal model of integrating CSR into SCM in the food industry context will enrich the CSR and SCM literature and suggest more new promising ideas for other scholars in the future.

3. The Research Methodology

3.1. The EPQ Model

The classical economic production quantity model is developed based on the single product and single-stage production system; furthermore, it has been widely employed in various SCM studies [42–45]. In fact, the manufacturing process's complexity recently has witnessed more involvement with different components, from raw materials procurement to distribution systems for finished products. Therefore, several articles have been interested in studying how the end product is manufactured through a multi-stage production system [46–48]. Several studies have noted that multi-component production strategies adopt opportunistic maintenance policies [49–52]. However, only a little literature has been published on the impact of CSR in the inventory field. Those recommendations have mentioned that the impact of CSR on the manufacturing process as well as the supply chain would be given new opportunities to explore. For instance, Modak et al. (2019) have considered the effect of selling price and social work donation on demand for three-channel structures [53].

The authors will illustrate the optimal model to enrich the findings of Chang et al. (2012), who have conducted that model in the automation industry. They have also suggested that other scholars may evaluate their model in various industries or another country context [47]. Consequently, many scholars have been conducting the two-stage production system approach to point out the most suitable EPQ model for their examples. This example can be demonstrated by Gupta and Mohanty (2015), Dey et al. (2019), or Sabbaghnia and Taleizadeh (2020); they have argued the two-stage production system perspective through their research [48,54,55], particularly SCM integration with CSR similarly to Nematollahi et al. (2017), and Jokar and Hosseini-Motlagh (2020) [56,57]. Furthermore, they have recommended evaluating this approach's applicability to different sectors in the real world. From these suggestions include relying on different characteristics related to the dairy industry and the emerging economy; thus, the author has employed the proposed model of Chang et al. (2012) to evaluate concordance through a case study in the Vietnamese dairy industry. Moreover, it has also contributed to filling the literature gap in theoretical inventory management in the dairy supply chain.

3.2. The Research Context

Vietnam is a transitional economy with agriculture as a majority development sector [58,59]. The Vietnamese dairy industry is one of the priority sectors for sustainable development targets and receives attention from government policies and enterprises, and the community [26]; furthermore, the Vietnamese dairy industry represents a typical case study in the Vietnamese supply chain (be presented in Figure 1). However, only a few dairy firms are involved in CSR programs and attempt to commit to stakeholders, the community, and society. Hence, their CSR programs' undeniable efforts over the years related to shareholders, employees, local-residents, environment protection, and others, have had a phenomenal contribution to the sustainability of a transitional economy like Vietnam [11]. Furthermore, the perception of Vietnamese consumers for products is also increased when they pay more attention to the origin of the products as well as the responsibilities of those companies to society instead of only being interested in price and quality [11]; therefore, it has given a positive sign and become the dynamic for Vietnamese dairy firms to CSR adoption.

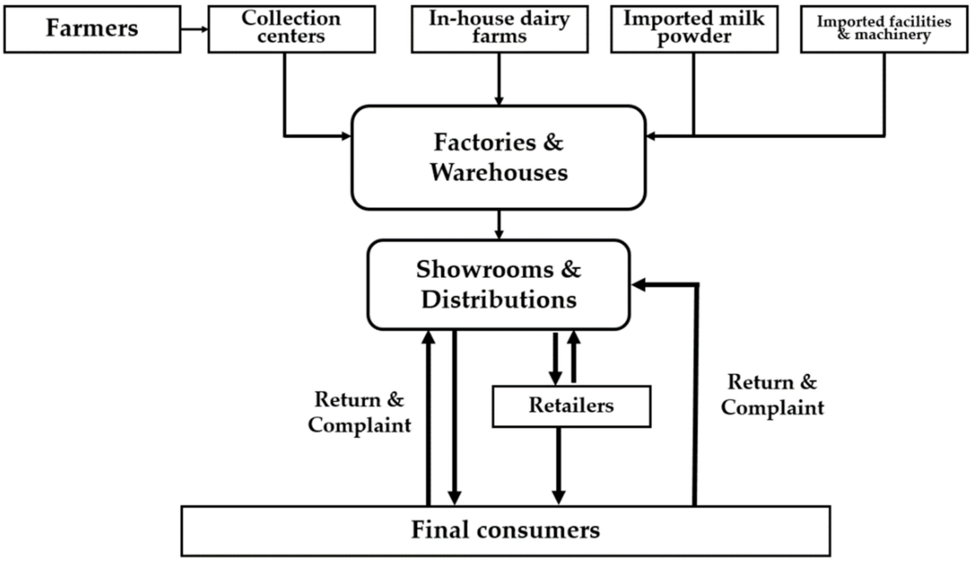

Figure 1. Simplified Vietnam's Dairy Supply Chain. (Source: The authors).

4. Model Formulation

4.1. Notation

In this study, the authors proposed an EPQ model for a two-stage assembly production system throughout one cycle. The system illustrates the relationship for all returned products in Stage 1 (manufacturing process) and end product in Stage 2 (assembly process). The manufacturer also directly collects the returned goods through a closed-loop supply chain with a reverse dual-channel. To ease readability, the authors will adopt the same notation in the production system and formulation from Chang et al. (2012) for this paper. The notation used in this paper, including system parameters and decision variables, has been listed in Tables 1 and 2, respectively.

Table 1. System parameters of this study.

m	The number of return points at retailer stage.
n	The number of raw material sourcing at the manufacturing stage.
p_i	Production rate of the return source i at retailer stage, where $i = 1, 2, \ldots, n$ and $p_1 > p_2 > \ldots > p_n$
D	Demand rate.
k	Setup cost.
c_1	The unit price of a returned product that the manufacturer paid to the customer.
c_0	The unit cost of the manufacturer paid to customers for a returned unit.
r	The return rate of used goods from the customer ($0 \leq r \leq 1$)
h_i	Holding cost of the source i for raw materials at the manufacturer stage, with $i = 1, 2, \ldots, n$.
h_e	Holding cost of an end product at retailer stage.
θ_i	The defective rate of the source i for raw material at the manufacturer stage, with $i = 1, 2, \ldots, n$.
θ_e	The defective rate of an end product at retailer stage.
d_i	Disposal cost for a defective source i for raw materials at the manufacturer stage, with $i = 1, 2, \ldots, n$.
d_e	Disposal cost for a defective end product at retailer stage.
d_{re}	Disposal cost for a returned product at retailer stage.
t_{id}	The time period when the inventory of source i for raw materials depletes, with $i = 1, 2, \ldots, n$.
t_{rdi}	Return period for an inventory of the used product at i retailer, with $i = 1, 2, \ldots, m$.
I_r	Investment in collection activities at the retailer stage.
I_s	Investment in CSR activity at the manufacturing stage.
T	The amount of cycle time.
Z_i	The maximum inventory level of source i for raw material at the manufacturer stage, with $i = 1, 2, \ldots, n$.
Z_e	The maximum inventory level of the end product at the retailer stage.
Z_{re}	The maximum inventory level of the returned product at the retailer stage.
p_w	The unit wholesale price of the manufacturer.

Table 2. Decision variables.

s	Social charity (SC) amount for per unit selling.
t_i	Production run time for the raw material of resource i, where i = 1, 2, . . . , n.
r	The return rate of used goods from the customer.

4.2. Assumptions

The aim is to determine the effects of an optimal model for this study, therefore, the authors have adopted four assumptions as below.

(1) The production cycle repeats infinitely.

(2) Following the line of Savaskan et al. (2004), the total collection cost : $C(r) = I_r + c_0 rD = \alpha r^2 + c_0 rD$, where rD was the total amount of goods which will be returned from customers; besides, $D = a - bp_w + \delta s$; moreover, $a > 0$, is the entire size of the market, b is the price sensitivity of demand, δ is the social charity of demand.

(3) The return rate for used products from the customers to the manufacturer in the reverse channel, where $r = \sqrt{I_r/\alpha}$ and α is a scaling parameter.

(4) Based on Ma et al. (2013) and Hosseini-Motlagh et al. (2018), MI is the investment function of the manufacturer which is illustrated as follows $MI = \sqrt{I_s/\varepsilon}$, where ε is a scaling parameter [46,60].

(5) The authors consider forward and reverse dual-channel in reverse logistics with a manufacturer and a retailer. In the forward dual-channel, the manufacturer sells a product on the market through the retailer through reverse logistics. In reverse dual-channel, the manufacturer collects the returned products; additionally, they also conduct CSR activities.

4.3. Model Formulation

From the notation and assumptions illustrated above, the graph of production system during the time period from 0 to T [0,T] will be demonstrated in the two-stage production system (reference in Figure A1 of Appendix A). The total profit function will be established; the model of research is a perfect cyclic process. The demands of customers with amounts of dairy products in a cycle will be met by the right number of goods from manufacturers (i.e., $p_i t_i = p_n t_n = DT$).

Therefore, t_i and T can be presented in turn as follows:

$$t_i = \frac{p_n t_n}{p_i}, \tag{1}$$

with i = 1, 2, . . . , n and

$$T = \frac{p_n t_n}{D}, \tag{2}$$

Hence, the maximum level of inventory for raw material i at retailer stage is

$$Z_i = (p_i - p_e)t_i, \tag{3}$$

with i = 1, 2, . . . , n.

Therefore, the period when the inventory of raw material i depletes can be determined as:

$$t_{id} = \frac{Z_i}{p_e} = \frac{(p_i - p_e)t_i}{p_e} = \left(\frac{p_i}{p_e} - 1\right)t_i, \tag{4}$$

with i = 1, 2, . . . , n.

$$\begin{aligned} H_e &= (p_e - D)(t_n + t_{nd}) \\ &= (p_e - D)\left[t_n + \left(\tfrac{p_n}{p_e} - 1\right)t_n\right] \\ &= (p_e - D)\tfrac{p_n}{p_e}t_n. \end{aligned} \quad (5)$$

However, the maximum inventory level of return used product as

$$Z_{re} = rt_{rdi} \quad (6)$$

where $i = 1, 2, \ldots, m$.

Based on six Equations (1)–(6), with the influence of these components, the total profit function will be established as follows:

(1) Sales revenue (SR)

$$SR = (p_w - s)$$

(2) Setup cost

$$C_s = k$$

(3) Holding the cost of the end product (HC_e)

$$HC_e = \frac{h_e Z_e T}{2} = \frac{h_e(p_e - D)}{2Dp_e}{p_n}^2{t_n}^2$$

(4) Holding the cost of all materials (HC_c)

$$HC_c = \frac{{p_n}^2{t_n}^2}{2}\left[\sum_{i=1}^{n} h_i\left(\frac{1}{p_e} - \frac{1}{p_i}\right)\right]$$

(5) Disposal costs of the defective end product/all raw materials per cycle (DC)

$$DC = \left(d_e\theta_e + \sum_{i=1}^{n} d_i\theta_i\right)DT + \left(T - \sum_{i=1}^{m} t_{rdi}\right)rd_{re}$$

(6) Return costs for used products at retailer stage (RC).

$$RC = c_1 r \sum_{i=1}^{m} t_{rdi}.$$

(7) Based on Giri's proposed model in 2005 [61], the production cost *(PC)* as:

$$PC = \left(\beta_0 + \frac{\beta_1}{p_e} + \beta_2 p_e\right)p_n t_n.$$

In the integrated supply chain system, all upstream manufacturers are willing to conglomerate resources. In an organizational decision-making process involving the manufacturer and the retailer, a product is manufactured in a single batch. Thus, making capital investment decisions on CSR activities is given by I_s and collecting the used products for recycling is given by I_r. Based on Savaskan et al. (2004), both investment costs are $I_s = \beta s^2$ and $I_r = \alpha r^2$, where α and β are scaling parameters, respectively [62]. Therefore, the objective function of the proposed model consisting of seven parts to maximize the total profit per unit of time is given by optimizing $s,\ t_n,$ and r.

Thus, the total profit per unit time (denoted by $TP(s,\ t_n,\ r)$) is given by

$$\begin{aligned} TP(s,t_n,r) &= (SR-SC-HC_e-HC_c-DC-RC-PC) \\ &= (p_w-s+c_1r)(a-bp_w+\delta s) \\ &\quad -\left[\frac{h_e[p_e-(a-bp_w+\delta s)]}{(a-bp_w+\delta s)p_e}+\left[\sum_{i=1}^{n}h_i\left(\frac{1}{p_e}-\frac{1}{p_i}\right)\right]\right]\frac{{p_n}^2t_n^2}{2} \\ &\quad -\left[\left(d_e\theta_e+\sum_{i=1}^{n}d_i\theta_i\right)+\left(\beta_0+\frac{\beta_1}{p_e}+\beta_2p_e\right)+\frac{rd_{re}}{a-bp_w+\delta s}\right]p_nt_n \\ &\quad +(d_{re}-c_1)r\sum_{i=1}^{m}t_{rdi} \\ &\quad -\beta s^2-\alpha r^2-k. \end{aligned} \tag{7}$$

Aiming to address this nonlinear programming issue, the authors first ignore the restriction and take the first-order derivation of $TP(s,t_n,r)$ with respect to s,t_n,r, respectively. We obtain

$$\begin{aligned} \frac{\partial TP(s,t_n,r)}{\partial s} &= [\delta c_1r+(b-\beta)p_w+(\beta+\delta)(p_w-2s)-a] \\ &\quad -(p_nt_nh_e+2rd_{re})\left[\frac{\delta}{(a-bp_w+\delta s)^2}\right]\frac{p_nt_n}{2}, \end{aligned} \tag{8}$$

$$\begin{aligned} \frac{\partial TP(s,t_n,r)}{\partial t_n} &= -\left\{\frac{h_e[p_e-(a-bp_w+\delta s)]}{(a-bp_w+\delta s)p_e}+\left[\sum_{i=1}^{n}h_i\left(\frac{1}{p_e}-\frac{1}{p_i}\right)\right]\right\}{p_n}^2t_n \\ &\quad -\left[\left(d_e\theta_e+\sum_{i=1}^{n}d_i\theta_i\right)+\left(\beta_0+\frac{\beta_1}{p_e}+\beta_2p_e\right)+\frac{rd_{re}}{a-bp_w+\delta s}\right]p_n, \end{aligned} \tag{9}$$

and

$$\frac{\partial TP(s,t_n,r)}{\partial r}=c_1(a-bp_w+\delta s)+(d_{re}-c_1)\sum_{i=1}^{m}t_{rdi}-2\alpha r. \tag{10}$$

To find the optimal solution of (s,t_n,r), let $\partial TP(s,t_n,r)/\partial s=0$, $\partial TP(s,t_n,r)/\partial t_n=0$, and $\partial TP(s,t_n,r)/\partial r=0$, simultaneously. Solving these three equations, we obtain

$$\delta c_1r+(b+\delta)p_w=\left[\frac{p_nt_nh_e+2rd_{re}}{2(a-bp_w+\delta s)^2}\right]\delta p_nt_n+a+2s(\delta+\beta), \tag{11}$$

$$\begin{aligned} &\left\{\frac{h_e[p_e-(a-bp_w+\delta s)]}{(a-bp_w+\delta s)p_e}+\left[\sum_{i=1}^{n}h_i\left(\frac{1}{p_e}-\frac{1}{p_i}\right)\right]\right\}{p_n}^2t_n+\frac{rd_{re}}{a-bp_w+\delta s}p_n \\ &=-\left[\left(d_e\theta_e+\sum_{i=1}^{n}d_i\theta_i\right)-\left(\beta_0+\frac{\beta_1}{p_e}+\beta_2p_e\right)\right]p_n, \end{aligned} \tag{12}$$

and

$$r=\frac{c_1(a-bp_w+\delta s)+(d_{re}-c_1)\sum_{i=1}^{m}t_{rdi}}{2\alpha}. \tag{13}$$

From Equations (11)–(13), it is clear that s and r can be uniquely determined as functions of t_n. To analyze the inventory problem, we will show that for any given feasible (s^*,r^*), the optimal production run time also exists and is unique. For given s^* and r^*, the first-order necessary condition for $TP(t_n|s^*,r^*)$ to be maximum is

$$\begin{aligned}\frac{dTP(t_n|s^*,r^*)}{dt_n} &= -\left\{\frac{h_e[p_e-(a-bp_w+\delta s)]}{(a-bp_w+\delta s)p_e} - \left[\sum_{i=1}^{n} h_i\left(\frac{1}{p_e}-\frac{1}{p_i}\right)\right]\right\}{p_n}^2 t_n \\ &\quad -\left[\left(d_e\theta_e+\sum_{i=1}^{n} d_i\theta_i\right)+\left(\beta_0+\frac{\beta_1}{p_e}+\beta_2 p_e\right)+\frac{rd_{re}}{a-bp_w+\delta s}\right]p_n \\ &= 0.\end{aligned} \tag{14}$$

Let $G(t_n)$ be the left-hand side of Equation (14), i.e.,

$$\begin{aligned}G(t_n) = & -\left\{\frac{h_e[p_e-(a-bp_w+\delta s^*)]}{(a-bp_w+\delta s^*)p_e} - \left[\sum_{i=1}^{n} h_i\left(\frac{1}{p_e}-\frac{1}{p_i}\right)\right]\right\}{p_n}^2 t_n \\ & -\left[\left(d_e\theta_e+\sum_{i=1}^{n} d_i\theta_i\right)+\left(\beta_0+\frac{\beta_1}{p_e}+\beta_2 p_e\right)+\frac{r^*d_{re}}{a-bp_w+\delta s^*}\right]p_n.\end{aligned} \tag{15}$$

We first rewrite Equation (14) and have

$$\begin{aligned}&\left[\left(d_e\theta_e+\sum_{i=1}^{n} d_i\theta_i\right)+\left(\beta_0+\frac{\beta_1}{p_e}+\beta_2 p_e\right)+\frac{r^*d_{re}}{a-bp_w+\delta s^*}\right]p_n \\ &= -\left\{\frac{h_e[p_e-(a-bp_w+\delta s^*)]}{p_e(a-bp_w+\delta s^*)} - \left[\sum_{i=1}^{n} h_i\left(\frac{1}{p_e}-\frac{1}{p_i}\right)\right]\right\}{p_n}^2 t_n.\end{aligned} \tag{16}$$

Because of the left-hand side of Equation (16)

$$\left[\left(d_e\theta_e+\sum_{i=1}^{n} d_i\theta_i\right)+\left(\beta_0+\frac{\beta_1}{p_e}+\beta_2 p_e\right)+\frac{r^*d_{re}}{a-bp_w+\delta s^*}\right]p_n > 0,$$

then we have $\Delta > 0$, where

$$\Delta \equiv \left\{\left[\sum_{i=1}^{n} h_i\left(\frac{1}{p_e}-\frac{1}{p_i}\right)\right] - \frac{h_e[p_e-(a-bp_w+\delta s^*)]}{p_e(a-bp_w+\delta s^*)}\right\}{p_n}^2 t_n.$$

Next, taking the first-order derivative of $G(t_n)$ with respect to t_n, we obtain

$$\frac{dG(t_n)}{dt_n} = \left\{\left[\sum_{i=1}^{n} h_i\left(\frac{1}{p_e}-\frac{1}{p_i}\right)\right] - \frac{h_e[p_e-(a-bp_w+\delta s^*)]}{(a-bp_w+\delta s^*)p_e}\right\}{p_n}^2 = \frac{\Delta}{t_n} > 0. \tag{17}$$

Therefore, $G(t_n)$ is a strictly increasing function $t_n \in (0,\infty)$.

Theorem 1. *For any given $t_n \geq 0$, we consider the interval $t_n \in (0,\infty)$,*

(a) If $G(t_n) < 0$, then the solution (s^*, t_n^*, r^*) which maximizes $TP(s,t_n,r)$ not only exists but also is unique, and $t_n^* \in (0,\infty)$.

(b) If $G(t_n) \geq 0$, then the optimal value of t_n is $t_n^* \to 0$. The production system should not be opened.

Proof.

(a) Firstly, we consider the interval $t_n \in (0,\infty)$. Because $\lim_{t_n\to\infty} G(t_n) = \infty$ and $\lim_{t_n\to 0} G(t_n) < 0$, from the Intermediate Value Theorem, we can find a unique solution $t_n^* \in (0,\infty)$ such that $G(t_n^*) = 0$. Substituting t_n^* into Equations (8)–(10), the corresponding s^* and r^* can be determined. Furthermore, we also calculate that

$$\mathbf{H}_{11} = \left.\frac{\partial^2 TP(s,r|t_n)}{\partial s^2}\right|_{(s,r)=(s^*,r^*)} = 2\left\{\left[\frac{\delta^2 p_n t_n(h_e p_n t_n + rd_{re})}{(a-bp_w+\delta s)^3}\right] - (\beta+\delta)\right\},$$

$$\mathbf{H}_{22} = \left.\frac{\partial^2 TP(s,r|t_n)}{\partial r^2}\right|_{(s,r)=(s^*,r^*)} = -2\alpha < 0,$$

and

$$\mathbf{H}_{12} = \mathbf{H}_{21} = \left.\frac{\partial^2 TP(s,\ r|t_n)}{\partial s \partial r}\right|_{(s,r)=(s^*,r^*)} = 0.$$

Therefore, the determinant of the Hessian matrix at the stationary point (s^*, r^*) is

$$\begin{aligned} \det(H) &= \mathbf{H}_{11} \times \mathbf{H}_{22} - \mathbf{H}_{12} \times \mathbf{H}_{21} \\ &= -4\alpha\left\{\left[\frac{\delta^2 p_n t_n (h_e p_n t_n + r d_{re})}{(a - b p_w + \delta s)^3}\right] - (\beta + \delta)\right\} < 0. \end{aligned}$$

(b) From Equation (9), we obtain that $\frac{\partial TP(s,t_n,r)}{\partial t_n} < 0$, which implies that t_n causes a higher value $TP(s,t_n,r)$. Hence, the maximum value $TP(s,t_n,r)$ occurs at the point $t_n^* \to 0$. It seems reasonable to conclude that the production system will not be opened. This completes the proof. □

Summarizing the above results, the Algorithm 1 was used to obtain the optimal solution to our problem.

Algorithm 1 Calculating the optimal solution

Step 1:	Start with $i = 1$ and $t_i \to t_n$.
Step 2:	Put t_i into Equation (12) to obtain the corresponding value of t_n, i.e., $t_n{}'$.
Step 3:	*If* $G(t_n{}') < 0$, go to Step 4. Otherwise, set the optimal solutions $r^* = 0$, $s^* = 0$, and $t_n^* = 0$ (i.e., the manufacturer will not adopt CSR initiatives), then stop the Algorithm.
Step 4:	Find the optimal value $t_n{}'$ such that $G(t_n{}') = 0$.
Step 5:	If the difference between t_i and t_{i+1} is sufficiently small, set $t_n^* = t_{i+1}$, then go to Step 6.
Step 6:	The maximum total profit per unit time $TP(s^*, t_n{}^*, r^*)$ can be obtained by substituting s^*, t_n^*, and r^* into Equation (7).

5. Application Example

The empirical research context is Vietnam's dairy supply chain to demonstrate the utility and feasibility of the proposed model. ABC dairy corporation was chosen, which is currently the largest dairy company in Vietnam [63]. The ABC company currently has a complete supply chain with several farms, factories, and its own distribution system; moreover, their products have been distributed to nearly all supermarkets and retail points all over Vietnam. Towards sustainable development, ABC dairy firm's orientation would invest heavily in CSR initiatives and be directed to the five major objectives, including community development support; environment and energy; responsibility for employees; responsibility for products; and local economic development. Regarding the ABC dairy company's commitment to the stakeholders, they are committed to providing safe products to consumers with top quality and appropriate prices. Moreover, this company also declares complying with environmental regulations and integrating social responsibility into business strategies. Food products' characteristics are easily broken for many different reasons before reaching customers, combined with the ABC company's product quality assurance policy. Thus, the case study selected as the ABC dairy corporation would help the authors better assess the proposed model in the empirical research.

The authors considered an application example of CSR initiatives to demonstrate the proposed model and verify the obtained analytical results. The real data were collected from ABC dairy firm and employed for the numerical analysis as following: $k = \$80/cycle$, $\beta_0 = 0.1$, $\beta_1 = 0.03$, $\beta_2 = 0.025$, $p_w = \$10$, $a = 15$, $b = 9$, $\alpha = 7$, $\beta = 2$, $\delta = 4$.

Raw material source 1: p_1 = 100/per unit time, h_1 = \$0.01/per unit, θ_1 = 0.03, d_1 = \$0.01/per unit.

Raw material source 2: p_2 = 200/per unit time, h_2 = \$0.02/per unit, θ_2 = 0.02, d_2 = \$0.02/per unit.

Raw material source 3: p_3 = 300/per unit time, h_3 = \$0.375/per unit/per unit time, θ_3 = 0.01, d_3 = \$0.03/per unit.

End product in showrooms: p_e = 60/per unit time, h_e = \$2/per unit/per unit time, θ_e = 0.05, d_e = \$0.04/per unit.

Then, we find the outcome as s^* = 9.58943; t_n^* = 0.495389; r^* = 0.0595798 and $TP(s^*, t_n{}^*, r^*)$ = 287.392.

In the finding of this section, the authors evaluate the impact of implementing CSR practices on the company's inventory policy. Thus, the effect of changes in various parameters of the model, for example (in Table A1 of Appendix B), was indicated that the effects of h_e, β_2, and θ_e on total profit are significant. These imply that the quality of the end product is essential for the ABC dairy enterprise.

Thus, maintaining high-quality products secures a high level of demand by end customers whereas poor quality products affect the customer's confidence, reputation, and sales of the company. Aim to create a positive brand image through CSR activities of the enterprise towards the community. Hence, the dairy company was aware of the importance of the public, especially their target customers, having a positive perception of them. As Figure 2 indicated, the concave function of the total economic profit based on per unit time.

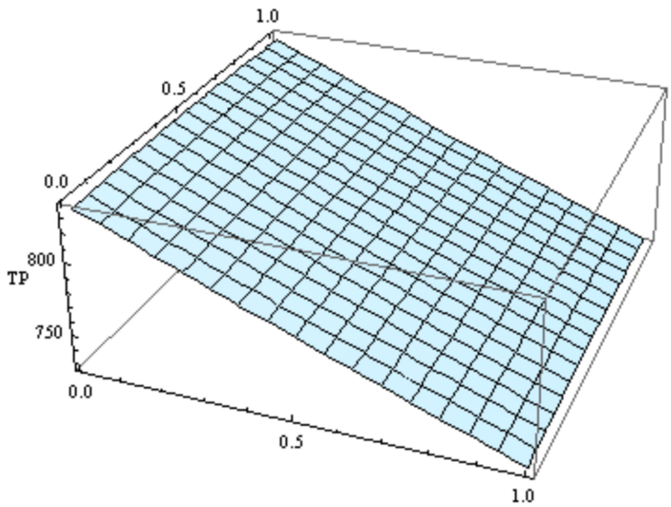

Figure 2. The total profit per unit time $TP(s^*,\ t_n^*\ ,\ r)$ for application example.

6. Discussion of Research Findings

Toward sustainable development targets that lead to ABC dairy company's CSR programs being conducted to solve the comprehensive enterprise issue, which has a profit-sharing obligation to society beyond making a profit. In fact, to contribute the profit-sharing to the nation's target through charitable activities or community development, the ABC dairy firm has an obligation that implements financial responsibilities before other duties. Therefore, it requires the ABC dairy firm to ensure their accountability to stakeholders, especially shareholders' interests. A numerical example in the above subsection is considered to study the effects of changes in the system parameters (h_1, h_2, h_3, h_e, θ_1, θ_2, θ_3, θ_e, d_1, d_2, d_3, d_e, β_0, β_1, and β_2) on the optimal values of s^*, t_n^* , r, and $TP(s^*,\ t_n^*\ ,\ r)$. The result indicated that the effects of h_e, β_2 and θ_e on total profit are significant. These imply that the quality of the end product is essential for the ABC dairy enterprise. Thus, maintaining high-quality products aims to secure a high demand by end customers while struggling with the risk that poor quality products affect customers' confidence, reputation, and sales. Brand image, reputation, as well as financial performance can be significantly enhanced through CSR activities of the enterprise towards the community; hence, ABC dairy company must be aware of the local community's importance, especially their target customers. For the present, it may be useful to look more closely at some of the more important features of the sensitivity analysis performed by changing each of the parameters by +50%, +25%, −25%, and −50%; taking one parameter at a time and keeping the remaining parameters unchanged. The analytical results were clearly demonstrated in Table A1 of Appendix B.

From the Table A1 in Appendix B, the following the management implications have been very positive as follows:

(1) When the values of parameters (h_1, h_2, h_3, h_e, θ_1, θ_2, θ_3 and θ_e) are decreased, it leads to the growth for $TP(s^*,\ t_n^*,\ r)$. It indicates that the firm cooperation with manufacturers is based on these factors, including inventory turnover and the quality of raw material or end products. The total profit has been enhanced, leading to the firm's social donation fund also increasing. Thus, it positively directs on the ABC dairy enterprise's brand and its reputation from the local community.

(2) With decreases in the value of parameter β_0, then $TP(s^*,\ t_n^*,\ r)$ increases. If the processing cost of raw materials from different sources could be reduced effectively, the total profit would be enhanced. This implies that the ABC dairy firm should invest more in new employee orientation to improve productivity.

(3) With decreases in the value of parameter β_1, then $TP(s^*,\ t_n^*,\ r)$ increases. This implies that the ABC dairy firm should decrease the labor costs per unit of time (i.e., wage or salary) to increase total profit.

(4) With decreases in the value of parameter β_2, then $TP(s^*,\ t_n^*,\ r)$ increases. This implies that the ABC dairy firm should decrease the tool or idle cost per unit of time to increase total profit. Furthermore, the β_2 parameter will have an influence rather than β_0 and β_1 on the total profit per unit time.

(5) With decreases in the value of parameters as d_1, d_2, d_3, then $TP(s^*,\ t_n^*,\ r)$ can be increased. This implies that the firm should decrease scrape costs per unit of time to increase total profit.

Apart from complying with laws related to the environment and workers, improving the quality of end products and reducing their holding costs to enhance financial performance are the firms' priority targets. Based on the proposed model of Chang et al. (2012), the authors have developed and evaluated this suggestion to the Vietnamese food supply chain via collected data from the ABC dairy firm case study; thereby, the suitability and positive results have been clarified. These research findings are consistent with other studies related to evaluating the EPQ model under the two-stage assembly production system, such as Dey et al. (2019) and Sabbaghnia and Taleizadeh (2020). They indicated that relationships between SCM members could be comprehensively evaluated to point out the best decision-making; hence, an application example along with sensitivity analysis has been conducted to support this argument. In particular, the relationship between CSR initiatives and SCM of some studies has supported our findings, and the research examples can be seen by Nematollahi et al. (2017); Modak et al. (2019); and Jokar and Hosseini-Motlagh (2020). They have similar conclusions in terms of the vital role as well as the CSR initiatives that could affect decision-making and various SCM performances. Furthermore, to increase donations to local society, the economic performance would be impacted by these activities; however, there is a positive signal from the final customers, whose willingness to buy green products [11,53], or think they are making a small contribution to society generates the enhancing of economic obligation for corporations.

Although the implementation of social activities affects the economic benefits of ABC dairy enterprise, its total profits still increase, which ensures its commitment to its economic responsibility with shareholders and employees. Thus, ABC dairy corporation is a particular example for the EPQ model's suitability, which can point out some practical implications for the top managers in decision-making related to CSR programs under SCM. They need to establish a risk management mechanism to control any potential risks that may affect their operations and profits. With such an arrangement, they can significantly lower the company's operational risk, damage, and impact.

7. Conclusions

This study is unique considering integrating CSR initiatives into the food supply chain in Vietnam, which considered some critical decision parameters together and linked the ideas and conclusions based on a particular case study. The noteworthy contributions of Vietnam's dairy firms and their CSR programs are significant to the sustainable development goal of an agricultural country like Vietnam. Aiming to demonstrate the efficiency of the proposed EPQ model, ABC dairy corporation was chosen, which is a typical example that can represent the Vietnam dairy industry in both the main issues of this study as CSR and SCM. Thus, the authors demonstrated the proposed model and clarified how to integrate CSR initiatives into the food SCM. A two-stage assembly production system involving the return rate of used goods from the customer was suggested, which has impacted the CSR policy and top manager decision-making in the dairy supply chain. The research findings are consistent with several prior studies in terms of the CSR initiatives' role, which is considered an excellent tool that may obtain a sustainable supply chain by enhancing social responsibility and the firm's financial performance. Furthermore, total profits per unit of time have been influenced by these critical parameters leading to the following research implications.

(1) Based on theories regarding the relationship between CSR and SCM, these results have contributed to the existing literature on developing the classical economic production quantity model under the two-stage assembly production system.

(2) The findings will help the top managers of dairy corporations in Vietnam better understand the integrating approach and the efficiency of adopting CSR programs into SCM.

(3) The production costs will be effectively controlled, such as material and operating costs. Hence, the firms have more dynamics to devote more money to charitable donations, which positively impacts consumer perception, and then economic performance will be enhanced.

The supply chain management includes all relationships from upstream suppliers to downstream consumers; unfortunately, in this study, the author has just focused on evaluating the relationship between producer ABC and their final customer through social activities, total profits of the dairy company, and the return of the goods issue of the customer. Thus, the authors suggested that further research might extend to different relationships between manufacturers and stakeholders based on CSR activities and SCM nexus. Considering the relationship between manufacturers and suppliers, the linkage effect between the dairy company and retailers in the dairy supply chain of an emerging economy is a promising idea for other scholars. Moreover, aiming to reduce their holding costs and enhance financial benefits, this proposed model could be conducted in various sectors to broaden and enrich the knowledge of the CSR initiatives' usefulness.

Author Contributions: M.-H.D. and Y.-F.H. developed conceptualization; methodology was developed by M.-W.W. and T.-S.C.; data curation and resources were undertaken by M.-H.D. and T.-S.C.; Y.-F.H. and M.-W.W. analyzed the data; wrote the manuscript, M.-H.D., M.-W.W., and T.-S.C.; writing—review and editing, T.-S.C., M.-H.D., and M.-W.W.; visualization, Y.-F.H.; supervision, Y.-F.H.; project administration, Y.-F.H. All authors have read and agreed to the published version of the manuscript.

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Appendix A

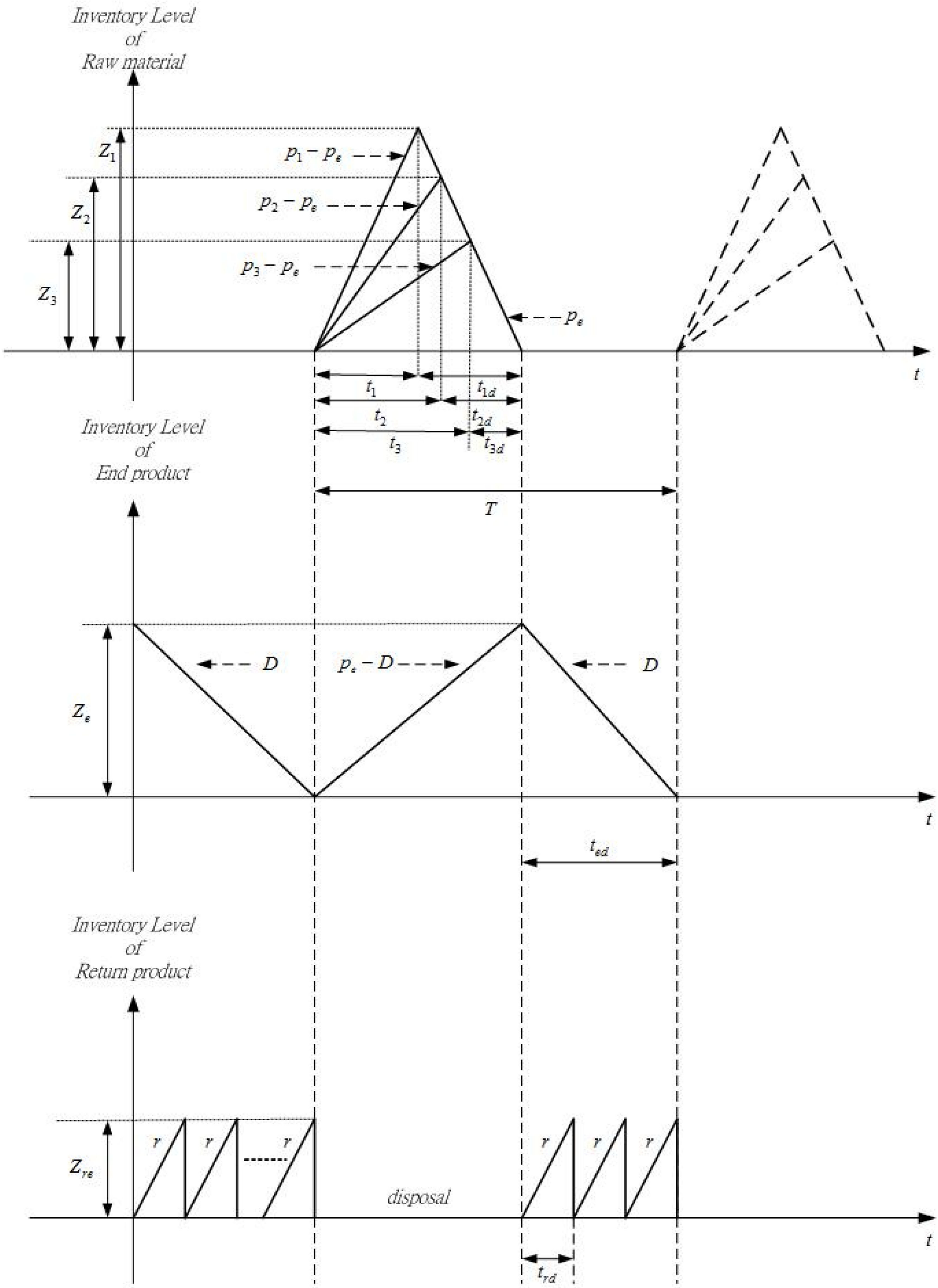

Figure A1. The graph of production system during time period [*0*, *T*].

Appendix B

Table A1. Effect of changes in various parameters of the model for application example.

Parameter	Change (%)	Optimal Solutions			
		s^*	t_n^*	r^*	$TP(s^*, t_n^*, r^*)$
h_1	−50%	0.85486	0.15500	0.02282	287.395
	−25%	9.58942	0.49506	0.05962	287.395
	0	9.58942	0.49538	0.05957	287.392
	25%	9.58943	0.49572	0.05954	287.389
	50%	9.58944	0.49605	0.05950	287.386
h_2	−50%	9.58939	0.49401	0.05975	287.404
	−25%	9.58941	0.49470	0.05966	287.398
	0	9.58942	0.49538	0.05957	287.392
	25%	9.58944	0.49608	0.05950	287.386
	50%	9.58946	0.49678	0.05941	287.380
h_3	−50%	9.58883	0.47072	0.06271	287.627
	−25%	9.58977	0.50912	0.06115	287.506
	0	9.58942	0.49538	0.05957	287.392
	25%	9.58977	0.50912	0.05797	287.283
	50%	9.59015	0.52394	0.05633	287.181
h_e	−50%	9.59251	0.85894	0.03436	289.676
	−25%	9.59027	0.61039	0.04835	288.211
	0	9.58942	0.49538	0.05957	287.392
	25%	9.58898	0.42676	0.06916	286.836
	50%	9.58872	0.38024	0.07762	286.421
θ_1	−50%	9.58942	0.49535	0.05959	287.393
	−25%	9.58943	0.49537	0.05958	287.392
	0	9.58943	0.49538	0.05957	287.392
	25%	9.58944	0.49541	0.05957	287.391
	50%	9.58944	0.49543	0.05957	287.391
θ_2	−50%	9.58942	0.49533	0.05958	287.393
	−25%	9.58943	0.49536	0.05958	287.392
	0	9.58943	0.49538	0.05957	287.392
	25%	9.58943	0.49542	0.05957	287.391
	50%	9.58943	0.49545	0.05957	287.391
θ_3	−50%	9.58942	0.49535	0.05959	287.393
	−25%	9.58943	0.49537	0.05958	287.392
	0	9.58943	0.49538	0.05957	287.392
	25%	9.58943	0.49541	0.05957	287.391
	50%	9.58943	0.49543	0.05957	287.391
θ_e	−50%	9.58907	0.48082	0.04808	287.643
	−25%	9.58925	0.48806	0.04880	287.517
	0	9.58943	0.49538	0.05957	287.392
	25%	9.58961	0.51027	0.05870	287.269
	50%	9.58981	0.51028	0.05784	287.148
d_1	−50%	9.58942	0.49535	0.05959	287.391
	−25%	9.58943	0.49536	0.05958	287.391
	0	9.58943	0.49538	0.05957	287.392
	25%	9.58943	0.49541	0.05957	287.392
	50%	9.58943	0.49543	0.05957	287.393
d_2	−50%	9.58942	0.49533	0.05959	287.391
	−25%	9.58943	0.49536	0.05958	287.391
	0	9.58943	0.49538	0.05957	287.391
	25%	9.58943	0.49542	0.05957	287.392
	50%	9.58943	0.49545	0.05957	287.393

Table A1. *Cont.*

Parameter	Change (%)	Optimal Solutions			
		s^*	t_n^*	r^*	$TP(s^*, t_n^*, r^*)$
d_3	−50%	9.58942	0.49535	0.05959	287.391
	−25%	9.58943	0.49536	0.05958	287.391
	0	9.58943	0.49538	0.05957	287.391
	25%	9.58943	0.49541	0.05957	287.392
	50%	9.58943	0.49543	0.05957	287.393
d_e	−50%	9.58943	0.49535	0.05959	287.391
	−25%	9.58943	0.49537	0.05958	287.391
	0	9.58943	0.49538	0.05958	287.391
	25%	9.58943	0.49541	0.05958	287.391
	50%	9.58943	0.49543	0.05957	287.391
β_0	−50%	9.58907	0.48082	0.02282	287.643
	−25%	9.58925	0.48806	0.05962	287.517
	0	9.58943	0.49538	0.05958	287.391
	25%	9.58961	0.50279	0.06047	287.269
	50%	9.58981	0.51027	0.06138	287.148
β_1	−50%	9.58942	0.49495	0.05963	287.399
	−25%	9.58942	0.49516	0.05960	287 396
	0	9.58943	0.49538	0.05958	287.391
	25%	9.58943	0.49561	0.05955	287.388
	50%	9.58944	0.49583	0.05953	287.384
β_2	−50%	9.58858	0.45958	0.06422	288.035
	−25%	9.58899	0.47723	0.06185	287.707
	0	9.58943	0.49538	0.05958	287.391
	25%	9.58989	0.51405	0.05742	287.088
	50%	9.59039	0.53319	0.05536	286.795

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