Journal of Revenue and Pricing Management (2025) 24:12–29
https://doi.org/10.1057/s41272-023-00471-5

RESEARCH ARTICLE

Price optimization for manufacturers in a competitive retail market: imported products and online crowdfunding option

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Received: 4 October 2023 / Accepted: 20 December 2023 / Published online: 3 February 2024

Abstract

This study explores how manufacturers in the competitive supply chain can set prices and secure funding effectively. We use game theory to look at how competition between domestic and foreign manufacturers affects pricing decisions. Our research investigates how a domestic manufacturer can improve its market share by addressing financial challenges through modern financing methods. In this scenario, a domestic manufacturer competes with a foreign one to attract a retailer's market share and profits. The retailer decides what products to buy and how to price them based on bid prices and demand. We also consider that the domestic manufacturer will use online crowdfunding platforms to tackle its financial problem. Hence, our study sets up a supply chain where competition revolves around both operational and financial decisions. Mathematical models are developed to analyze how costs, finances, market potential, and price sensitivity impact various parts of the supply chain. The results reveal that decisions made on the crowdfunding platform significantly influence other supply chain decisions. Manufacturers and retailers need to pay attention to the financial decisions made on this platform to maximize profits. Also, domestic and foreign manufacturers should consider customer preferences for their products when setting prices. Finally, the results demonstrate that a domestic manufacturer can gain a competitive edge in the retail market by carefully considering both product pricing and financial decisions, including those made on the lending platform.

Keywords Optimal decision-making · Mathematical model · Pricing · Game theory · Supply chain finance · Crowdfunding platform

Introduction

The Internet and new technological innovations have facilitated trading around the world (Chen 2023; Muerza et al. 2023; Thaichon et al. 2019). The Internet and new technologies have expanded the trade between organizations and increased the focus on supply chains to compete in the global market (Xu et al. 2023). On the other hand, supply chain globalization issues will be accompanied by challenges, such as uncertainty (G. Li et al. 2022; Yeoman 2022), delay (Chen et al. 2020), and covid recovery challenges (Manishimwe et al. 2022). These opportunities and challenges have led to more investigation into supply chains (Tai et al. 2022; Teng et al. 2022).

Besides, the competition between domestic and international manufacturers has been increasing to take over the customer market. Indeed, each manufacturer must precisely adapt its conditions, such as expenses, due to the current competitive environment (Chen 2019; Liang et al. 2021). Hence, manufacturers have been paying attention to the components that increase their competitiveness against their competitors (Taleizadeh et al. 2022). One of the influential factors that can meet the above concern is setting appropriate prices for the product (Malekian and Rasti-Barzoki 2019; Schaefers et al. 2022; Larrosa et al. 2022). For instance, Intel endeavors to optimize its customer outreach and financial

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gains through the implementation of competitive pricing strategies, as elucidated by Li et al. (2019). Similarly, Nike adopts a pricing approach based on its competitors' decisions, thereby ensuring its sustained competitiveness in the market, a strategy addressed by Mahdi et al. (2015). Coca-Cola and Pepsi have also been evaluating the pricing strategies of their competitors frequently to make better decisions in this matter, as introduced by Singaram et al. (2019). Consequently, manufacturers are always keeping a close eye on their product expenses and analyzing the pricing strategies of their competitors in the industry. It is important to them to stay competitive while also keeping costs under control. Hence, industrial and academic researchers have increased investigations on the competitive pricing problem in recent decades. (Li et al. 2019; Huarng and Yu 2020; Hermel et al. 2021; Button 2022).

On the other hand, making bad choices when it comes to managing how products move through the supply chain and picking the wrong pricing strategies can cause domestic companies to go out of business. To avoid this and stay competitive against foreign companies, local businesses should pick the right prices for their products and smart ways to manage their financial issues. In the past, manufacturers used to be financed through banks usually subordinate to governments (Zhen et al. 2020). However, using this approach presents some challenging obstacles, such as the difficulties in obtaining loans from banks due to their high risk and the inability to support the entire financial requirements of the company. Hence, (1) providing more innovative and efficient methods of financing and (2) using the participation of venturous investors to complete the projects that lead to the development of the company seems inevitable.

Accordingly, an increasing number of lending platforms are becoming more preferred as there are more manufacturers in need of financial resources (Guo et al. 2016). These platforms, which are mainly online and are known as online crowdfunding platforms, seek the profitability of their organization by obtaining the right of service from the manufacturer. It should be noted that the investor and the manufacturer cannot communicate directly in this financing approach but will communicate with the lender and the borrower through the online platform (Chen et al. 2014). The main advantages of these platforms include their risk taking in investing in various projects and their flexibility in offering various service rates according to the manufacturer's conditions (Gao et al. 2018). Given the aforementioned instances and the significance of this topic, this research endeavor aims to address the inquiry regarding the impact of considering an online crowdfunding platform as a solution for mitigating financial deficits faced by domestic manufacturers within the supply chain. To be more precisely, this investigation seeks to discern how the inclusion of this novel element within supply chains influences manufacturers' decisions regarding pricing, their financial gains, and even, how it affects retailers which are the next stage of the chain process.

This research designed a supply chain that includes a domestic manufacturer, a foreign manufacturer, a retailer, and an online crowdfunding platform (lending platform) where the domestic and foreign manufacturers compete for more retail market share. The two manufacturers seek to maximize their profits by offering appropriate product pricing based on a game modeling framework. In contrast, the retailer purchases the manufacturers' products according to their competitive offered price and the willingness of their customers to buy domestic or imported products. This paper uses game theoretical approaches to track the interaction between manufacturers and the retailer. This approach is also observed between the domestic manufacturer and the lending platform.

In addressing these research inquiries, our study offers a substantial and multifaceted contribution to the existing body of knowledge. While extant literature has usually considered financial and physical flows within the supply chain separately, our research provides into the intricate interplay between an online crowdfunding platform and the pricing decisions of supply chain constituents. We employ game-theoretic frameworks to understand the competition among these entities, such as manufacturers and retailers, seeking to find strategies for enhancing the competitive edge of domestic manufacturers in contrast to imported goods. Finally, due to the proposed methodology, we do several sensitivity analyses on the significant parameters to examine the effects of various conditions and also extract valuable managerial insights. In sum, this study presents a holistic and insightful examination of the complex relationships between online crowdfunding, supply chain pricing, and domestic manufacturing competitiveness.

The rest of this paper is organized as follows. Section "Literature review" examines the literature and identifies research gaps. The problem definition of the proposed model is explained in Section "Problem definition and Assumptions". Section "Mathematical model and optimal decisions" presents the mathematical models and the optimal decisions of the supply chain's entities. In Section "Results and discussion", the results are analyzed, and managerial insights are provided. Finally, Section "Conclusion and future research direction" concludes the study and provides recommendations for future research.

Literature review

In this section, a review of recent research in the field of the global supply chain (global SC) and supply chain finance (SCF) is performed to find the research gap. First, the global

supply chain will be explored according to the evolution of the field literature over the years. Next, the finance of supply chains will be examined according to their evolution in the last decade.

Global supply chain

The first study in this field on the International plant location problem can be seen in Hodder and Jucker (1985). The authors studied the international plant location problem and developed a single-cycle model to determine the best location, material flow, and finance patterns. Breitman and Lucas (1987) then developed a global model to help General Motors make decisions on facility location, capacity planning, material sourcing, product allocation, and introducing new products. In this model, issues such as the export and import of products were also included. Cohen and Lee (1989) developed a global supply chain model and then evaluated a set of policy choices that the company could use to adopt a global manufacturing strategy. The objective function maximizes profits after tax. The authors also considered tariffs and duties, transportation costs, and exchange rates.

Additionally, Arntzen et al. (1995) developed a mixed-integer program to solve an electronics manufacturer's global supply chain design problem. The decision variables in this model were the choice of location and amount of production, inventory, and transportation. Dasu and de La Torre (1997) developed a model that performs the pricing and production allocation processes for multinational companies in the textile industry supported by a network of subsidiaries. The authors also used the game theory framework for their model. Next, Vidal and Goetschalckx (2001) developed a global SC model to examine the chain design issues associated with a multinational company that outsources part, not all, of its production to the supplier facilities. The authors also included transfer pricing in their model. Nagurney et al. (2003) tried to determine the optimum profit of each component of the supply chain according to the utility function of customers by designing a dynamic model in a global supply chain.

The proper pricing of products is one of the most important aspects of a sales strategy, as the price significantly impacts acquiring customers (Chen et al. 2022; Dockner 1984; Safari et al. 2022). This is especially the case of intense competition in the field of pricing of goods with global competition between domestic and foreign manufacturers (Choi 1991). Thus, the pricing and revenue management literature have experienced significant growth in the supply chain (Sepp¨al¨a et al. 2014; Wang and Song 2020). Xiao et al. (2014a, b) investigated the outsourcing decision model to a foreign company for two manufacturers competing on the retail price and product quality. They examined the influence of various factors, including production cost, on optimum outsourcing decisions. Then, in the same year, Xiao et al. (2014a, b) developed a game theory-based model that included competition between a domestic supply chain and a foreign manufacturer in such a way that the competition factors for customer acquisition were the price of products and their delivery time. Recently, Li and Chen (2018) developed a model based on the Stackelberg game by considering two manufacturers with different production qualities, one producing low-quality products and the other producing the same products with high quality and also considering a retailer. Hence, the retailer had three choices for backward integration. Integration with low-quality products, integration with the manufacturer with high-quality products, and/or no integration with either manufacturer. Parvasi and Taleizadeh (2021) proposed a bi-level mathematical model to consider the competition pricing problem between domestic and foreign manufacturers. Their model worked as a Stackelberg game, and they developed a hybrid solution approach based on the Lambert-W function and the Path-Following method to solve the problem. They also assumed that the markets' customers have different income levels that can be categorized as high, medium, and low income. Then, Parvasi et al. (2023) proposed a Stackelberg game model, wherein foreign and domestic manufacturers engage in competitive endeavors aimed at acquiring a greater share of the local retailer market. Within this framework, the domestic manufacturer strategically employs a dual-product approach, producing two distinct quality tiers of merchandise to effectively cater to a wider range of customer preferences. By offering such product diversity, the domestic manufacturer seeks to enhance its competitive edge and attain a superior market position.

Supply chain finance

This section focuses on the articles published in recent decades. First, Wang et al. (2003) used budget constraints in facility location. The authors sought to minimize costs and to decide whether to open or close the facility due to budget constraints. Melo et al. (2006) designed a chain with budget constraints. In the strategic decisions of the proposed model, they paid attention to the capital required to relocate the facility. Next, Naraharisetti et al. (2008) examined a supply chain problem to finance the redesign of this supply chain and addressed issues such as asset management and the amount of capital required to maximize the supply chain profits.

Another critical problem in SCF is supply chain investment risk (de Melo et al. 2023). Investment risk can be directly related to the performance of that system in the past and present. Therefore, Pfohl and Gomm (2009) designed a model to mitigate the potential supply chain investment risk hazards. Next, Kouvelis and Zhao (2012) managed to reduce

the bankruptcy risk of a chain that included a retailer and a manufacturer by modeling game theory. Sodhi and Tang (2009) designed two distinct models in which they tried to optimize the financial flows between different members of the global supply chain and maximize the expected profit of the chain by considering uncertainty in the exchange rate and customer demand factors.

To solve the above financial problems, companies could use a variety of finance methods, such as banks, trade credits, and crowdfunding platforms (Wu et al. 2021). Banks are considered one of the oldest methods of finance. Nevertheless, this method is losing its appeal among companies every day more than before because of many reasons, such as the financial crisis in banks in 2008 and the potential difficulties of borrowing from banks (Randall and Theodore Farris 2009). Furthermore, although the use of bank resources can significantly help supply chains to advance their goals (Kouvelis and Zhao 2012), in some cases, the limited financial resources of supply chains to repay the received amount leads to the bankruptcy of that chain (Marquez et al. 2004). Hence, investigation to find alternative financial sources in companies seeking profitability has become popular among researchers (Gelsomino et al. 2016).

Recently, Wang et al. (2019) developed a new finance method called the electronic business (EB) platform to finance online retailers. They assume that retailers have the capital constraint and can provide their required capital from the EB platform and/or bank credit finance (BCF). Babich et al. (2021) examined the impact of crowdfunding-based methods on finance decisions by large entrepreneurs, banks, and investors. Next, Burtch et al. (2021) studied the success rate of crowdfunding-based capital acquisition methods in knowledge-based companies. Also, they finally tried to propose an optimum policy for using this method. By comparing the finance method based on the crowdfunding platform and the bank, Tang (2019) tried to examine the advantages and disadvantages of each according to the number of financial resources that companies need. Chakraborty and Swinney (2021) explored a reward-based investment problem. They found that entrepreneurs could better represent their products to investors through this investment method. As a result, entrepreneurs can more easily attract investment from investors. Fatehi and Wagner (2019) proposed a crowdfunding model in which the platform and the company in need of capital enter into a revenue-sharing contract. Given the characteristics of this type of contract, the authors showed that not only is the profit of the platform and the company in need of capital higher than other finance methods, including the bank, but also the company's bankruptcy risk is reduced. Taleizadeh et al. (2022) analyzed a supply chain with two capital-constrained manufacturers producing high- and low-quality goods. Manufacturers of high-quality products borrow capital through online lending platforms, while manufacturers of low-quality products pre-sell their products.

Table 1 presents a concise review of the related literature. The literature review shows that in the last decade, researchers have significantly increased to the study of the integrated financial and physical flows in supply chains. However, little research has looked at the two areas of competitive pricing in the global supply chain and finance methods simultaneously. Most of this research has focused on the supply chain network design, and less attention has been paid to competitive pricing. Given that we are observing the increasing competition between companies, paying attention to these two flows simultaneously in the chains to get out of the local optimum is necessary because financial constraints significantly affect companies' pricing decisions. In finance methods, researchers consider using bank resources or, in some cases, using commercial credits in their models to overcome the financial shortage of chains. However, these assumptions do not seem to align with the current decade's needs, given the rapid growth of companies and their different needs in the finance area. There are many new finance methods, such as Internet mutual funds and online platforms, which, by working more closely with organizations in need of funding, can reduce investment risk and increase the profitability of both parties. Therefore, this study tries to fill this research gap by considering an online crowdfunding platform in a supply chain.

Problem definition and Assumptions

With the prosperity of the global market, several international manufacturers have entered the local markets. But on the other hand, domestic manufacturers are often financially weaker than their foreign competitors. Therefore, the proper pricing decisions on goods and meeting the financial issues suitably to obtain maximum profit and customer share seem inevitable for them.

The game theory approach is often used to tackle problems where actors' decisions interact. This approach provides a theoretical framework for how decision-makers interact and what they can and are trying to achieve through interaction. Since this paper aims to learn the interaction between decision-makers and then determine the structure of optimal decisions based on those interactions, this study uses of game theoretical approaches.

Generally, this study investigates the competition between a domestic and a foreign manufacturer in a retail market. As shown in Fig. 1, these two manufacturers compete to set appropriate pricing in a Nash game structure. On the other hand, the retailer buys the products according to the demand and the offer price of the imported and local products. Indeed, the retailer decides the appropriate pricing on the manufacturers' goods to sell to the customers with

Table 1 A brief review of the literature

Global SC					SCF						
Author(s)	Global scale	Competitive pricing	Different brands	Game model	Author(s)	Material flow	Financial flow	Financial methods			
								Bank	Trade credit	Crowdfunding	Others
Choi (1991)		✓		✓	Wang et al. (2003)		✓				
Xiao et al. (2014a, b)		✓	✓	✓	Melo et al. (2006)	✓	✓				
Xiao et al. (2014a, b)		✓	✓	✓	Randall and Farris (2009)		✓	✓			
He and Xiao (2009)	✓	✓			Jing and Seidmann (2014)	✓	✓	✓	✓		
Seppälä et al. (2014)	✓	✓			Gao et al. (2018)	✓	✓			✓	
Nagurney and Li (2015)	✓	✓	✓		Fatehi and Wagner (2019)		✓	✓		✓	✓
Li and Chen (2018)		✓	✓	✓	Wang et al. (2019)		✓	✓	✓		
Gandomi and Zolfaghari (2018)		✓	✓	✓	Babich et al. (2021)		✓	✓	✓	✓	
Huang et al. (2019)	✓	✓	✓	✓	Burtch et al. (2021)		✓			✓	
Parvasi and Taleizadeh (2021)	✓	✓	✓	✓	Chakraborty and Swinney (2021)		✓			✓	
Parvasi et al. (2023)	✓	✓	✓	✓	Taleizadeh et al. (2022)	✓	✓			✓	✓
This paper	✓	✓	✓	✓		✓	✓			✓	

maximum profit. Figure 1 shows that the retailer interacts with the manufacturers in the Stackelberg game framework. This type of game seems logical and acceptable since manufacturers set the price on their goods (first move) before the retailer buys the goods concerning the set price (reciprocal action or influence).

A capital constraint is assumed for the domestic manufacturer to make a problem more practical and an online crowdfunding platform is used to address this issue. In other words, the domestic manufacturer uses an online crowdfunding platform to eliminate the lack of financial resources to compete with the international manufacturer and increase its competing advantages. Conversely, the crowdfunding platform seeks to increase profitability as well as pay investors' interests by determining a proper service rate. As a result, competition in the form of the Stackelberg game can be seen between the online crowdfunding platform and the domestic manufacturer. More specifically, the domestic manufacturer decides on the amount of financing from the platform (reciprocal action or influence) after determining the service rate by the platform (first move). The study of Gao et al. (2018) can be referred to for more information.

Furthermore, it is important to note that the domestic manufacturer purchases its raw materials from a foreign supplier, and this supplier's selling price (φ_f) is considered an exogenous factor (Fig. 1). In fact, this assumption is taken into account to avoid over-complicating the mathematical models and to fulfill the article's aim, which is to examine the various aspects and changes in the purchase price of raw materials as a cost factor in the objective function of the domestic manufacturer. In addition, the interest rate of investors (i_m) in the online crowdfunding platform is also considered an exogenous factor in this study.

The notations for the proposed mathematical models are shown in Table 2:

Case setting (1)

The present study assumes that there is a market demand for both local and imported goods. Hence, the retailer decides to buy from these manufacturers with respect to the maximum market potential of the producers (α_d, α_f), the manufacturers' price of goods (W_d, W_f), and the sensitivity coefficient of the price of manufacturers' goods (β_d, β_f). For instance, when society becomes patriotic or loyal toward domestically produced goods, a natural increase and decrease can be observed in α_d and α_f, respectively. Also, when the average community has a lower-income level, the retailer will be more sensitive to the price offered by the manufacturers and an increase can be seen in β_d and β_f. According to the idea of arbitrage, when two similar products are available and the price of one product goes up, people tend to choose a similar product that costs less (Zhang et al. 2021). In our

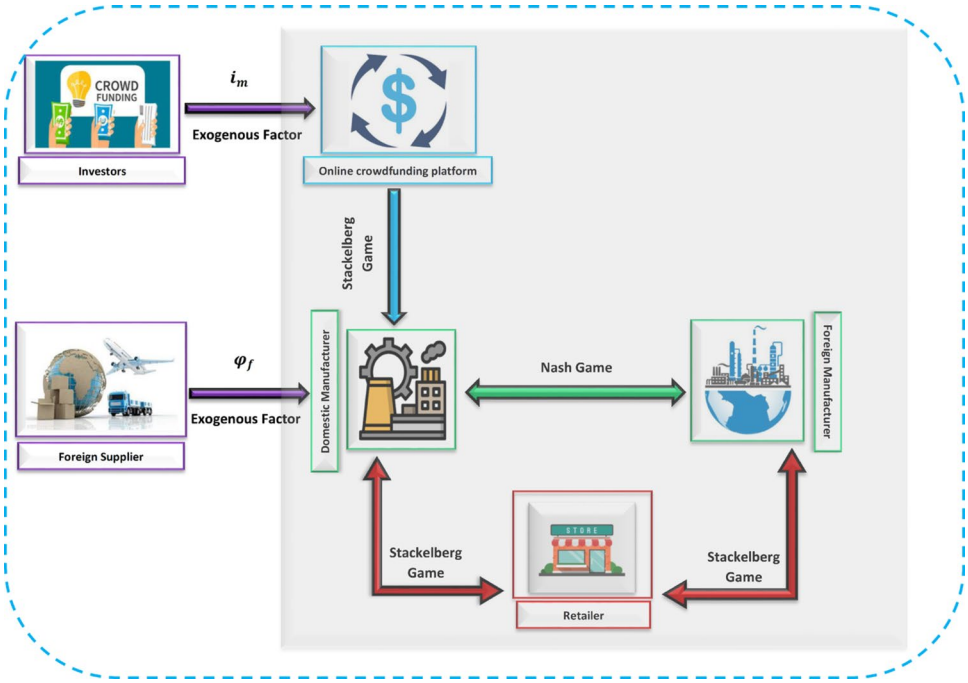

Fig. 1 The perceptual structure of this study

Table 2 Notations

Parameters	
φ_{f}	Selling price of the foreign supplier
C_{d}	Unit cost of producing one product by the domestic manufacturer
C_{G}	The costs of globalization for the domestic manufacturer
C_{f}	Unit cost of producing one product by the foreign manufacturer
C_{g}	The costs of globalization for the foreign manufacturer
α_{d}	Market potential of the domestic manufacturer
α_{f}	Market potential of the foreign manufacturer
β_{d}	Retailer sensitivity to the price of the domestic manufacturer's product
β_{f}	Retailer sensitivity to the price of the foreign manufacturer's product
β_{d}'	Market price sensitivity to the domestic manufacturer's product
β_{f}'	Market price sensitivity to the foreign manufacturer's product
γ	Substitutability degree between two types of products
B_{m}	Initial capital of the domestic manufacturer
i_{m}	Interest rate of investor
Decision variables	
W_{d}	Selling price of the domestic manufacturer
W_{f}	Selling price of the foreign manufacturer
P_{d}	Retailer's unit retail price of the domestic manufacturer's product
P_{f}	Retailer's unit retail price of the foreign manufacturer's product
S_{m}	Service rate of the online crowdfunding platform
D_{d}	Demand of the retailer for the domestic manufacturer
D_{f}	Demand of the retailer for the foreign manufacturer
D_{d}'	Demand of the market for the domestic manufacturer
D_{f}'	Demand of the market for the foreign manufacturer
$\Pi(W_{\mathrm{d}})$	Profit of the domestic manufacturer
$\Pi(W_{\mathrm{f}})$	Profit of the foreign manufacturer
$\Pi(P_{\mathrm{d}}, P_{\mathrm{f}})$	Profit of the retailer
$\Pi(S_{\mathrm{m}})$	Profit of the online crowdfunding platform

study, we're looking at the competition between two products, wherein the product offering lower price levels tends to draw a larger customer base. To make our proposed model more realistic, we also take into account the degree of substitutability between these two products (γ) based on their prices (Modak and Kelle 2019). More precisely, with the increase in the price of each manufacturer, the retailer can see increased demand for its competitor's product. More precisely, with the increase in the price of each manufacturer, the retailer can see increased demand for its competitor's product. The retailer demand functions for both manufacturers proposed in Eqs. (1) and (2).

$$D_{\mathrm{d}} = \alpha_{\mathrm{d}} - \beta_{\mathrm{d}} W_{\mathrm{d}} - \gamma(W_{\mathrm{d}} - W_{\mathrm{f}}) \tag{1}$$

$$D_{\mathrm{f}} = \alpha_{\mathrm{f}} - \beta_{\mathrm{f}} W_{\mathrm{f}} - \gamma(W_{\mathrm{f}} - W_{\mathrm{d}}) \tag{2}$$

Case setting (2)

Since the number of products the retailer sells to customers usually differs from the amount it buys from manufacturers (Taleizadeh et al. 2022), this paper distinguishes between customer demand from the retailer and retail market from manufacturers. In other words, in an ideal situation, the retailer would manage to sell all of their products to customers. However, this does not always happen in real environment. Sometimes, the retailer might choose a price that does not lead to the sale of all their products, leaving some unsold. While this approach might result in a reduction in customer demand, it can actually lead to higher profits (Kuiper and Meulenberg 2005). In this study, the retailer sales of the goods of each manufacturer depend on two factors, such as the product price and the sensitivity of market customers to the price of domestically produced and imported goods ($\beta_{\mathrm{d}}\prime, \beta_{\mathrm{f}}\prime$). The market demand function for manufacturers' products is described below.

$$D_{\mathrm{d}}\prime = D_{\mathrm{d}} - \beta_{\mathrm{d}}\prime P_{\mathrm{d}} \tag{3}$$

$$D_{\mathrm{f}}\prime = D_{\mathrm{f}} - \beta_{\mathrm{f}}\prime P_{\mathrm{f}} \tag{4}$$

Case setting (3)

In this paper, the cost relationships of domestic and foreign manufacturers are calculated as Eqs. (5) and (6).

$$C_{\mathrm{DT}} = \varphi_{\mathrm{f}} + C_{\mathrm{d}} + C_{\mathrm{G}} \tag{5}$$

$$C_{\mathrm{FT}} = C_{\mathrm{f}} + C_{\mathrm{g}} \tag{6}$$

As can be seen in Eq. (5), the cost of a domestically manufactured product depends on three factors: the cost of purchasing raw materials from a foreign supplier, the cost of production, and the cost of globalization of the product.

The costs of globalization for the domestic manufacturer include the transportation costs of raw materials purchased from foreign suppliers and customs duties, taxes, and insurance. But on the other hand, two charges can be seen in the price of the foreign manufacturer product in Eq. (6), which includes the product's production price and the product's globalization price for export. This globalization costs for a foreign manufacturer's product might include terminal handling costs, insurance costs, customs costs, and taxes, which are assumed as parameters in this study.

Mathematical model and optimal decisions

According to the above case settings and the mentioned competitive supply chain space, including four components of the retailer, domestic and foreign manufacturers, and an online crowdfunding platform, this section presents the objective functions of these components and the optimal solution to their decision variables.

Retailer objective function and optimal decision

Since the retailer directly affects the profitability of manufacturers by determining the number of purchases from each manufacturer, it is considered one of the main components of the supply chain in this study. The retailer competes in the form of a Stackelberg game in which it is the follower, and the manufacturers are the leaders. In fact, the retailer buys from the manufacturers according to the price offered on their goods. Then, it determines the appropriate pricing on these goods to obtain maximum profit based on the price sensitivity coefficient of the customers toward local and imported products. The objective function of the retailer is presented in Eq. (7).

$$\Pi(P_{\mathrm{d}}, P_{\mathrm{f}}) = \{P_{\mathrm{d}} D_{\mathrm{d}}\prime - W_{\mathrm{d}} D_{\mathrm{d}}\} + \{P_{\mathrm{f}} D_{\mathrm{f}}\prime - W_{\mathrm{f}} D_{\mathrm{f}}\} \tag{7}$$

As observed, the objective function of the retailer consists of two parts. The first and the second part are related to the retailer's profit from the sale of locally manufactured goods and the sale profit from imported goods, respectively. In other words, the retailer in each part earns its profit based on its bid price on the goods ($P_{\mathrm{d}}, P_{\mathrm{f}}$) and the number of sales of products purchased from each manufacturer.

To solve the problem according to the existing case settings and the type of competition between retailers and manufacturers, first, the optimal selling price of products to customers by the retailer is obtained in terms of the

manufacturers' offered price and the retail demand function, which is illustrated in Theorem 1.

Lemma 1 *According to Eq.* (7), *the objective function of the retailer is concave*; *therefore*, *it has optimal coordinates to maximize the profit of the objective function* (*see Appendix A*1 *for proof*).

Theorem 1 *The optimal price for domestic and imported goods by the retailer is as follows* (*see Appendix A*2 *for proof*):

$$p_{\mathrm{d}}^{*}=\frac{\alpha_{\mathrm{d}}-\left(W_{\mathrm{d}}\beta_{\mathrm{d}}\right)+\gamma(W_{\mathrm{f}}-W_{\mathrm{d}})}{2\beta_{\mathrm{d}}\prime} \tag{8}$$

$$p_{\mathrm{f}}^{*}=\frac{\alpha_{\mathrm{f}}-\left(W_{\mathrm{f}}\beta_{\mathrm{f}}\right)+\gamma(W_{\mathrm{d}}-W_{\mathrm{f}})}{2\beta_{\mathrm{f}}^{\prime}} \tag{9}$$

As observed in Eqs. (8) and (9), the optimal price of each commodity depends on the size of their market, the difference in the offered price of manufacturers ($\left|W_{\mathrm{f}}-W_{\mathrm{d}}\right|$), and the market price sensitivity of the customers. In other words, as the values of $\beta_{\mathrm{d}}\prime$ and $\beta_{\mathrm{f}}\prime$ increase, retailers are forced to lower the prices for increasing their profitability and gaining the maximum market share.

Manufacturers objective functions and their optimal decisions

This section assumes that manufacturers' products compete in a Nash equilibrium game to meet the retail market demand. This competition is for adopting the right pricing decisions for the goods to be able to use their full market capacity and make the maximum profit. In summary, the market capacity of each manufacturer indicates the maximum demand or desire their customers have for their product. According to case setting 1, each manufacturer wants to prevent its customers from using the goods of the rival company and encourage customers of the rival company to use their products by setting the right pricing decision. Accordingly, the objective functions of these manufacturers are written as follows:

$$\begin{aligned}\Pi\left(W_{\mathrm{d}}\right)=&\{W_{\mathrm{d}}D_{\mathrm{d}}-C_{\mathrm{DT}}D_{\mathrm{d}}\}\\&-\mathrm{Max}\{0,(\left[C_{\mathrm{DT}}D_{\mathrm{d}}-B_{\mathrm{m}}\right]\\&\times\left(i_{\mathrm{m}}+S_{\mathrm{m}}+1\right))\}\end{aligned} \tag{10}$$

$$\Pi\left(W_{\mathrm{f}}\right)=W_{\mathrm{f}}D_{\mathrm{f}}-C_{\mathrm{FT}}D_{\mathrm{f}} \tag{11}$$

As seen in Eq. (10), the objective function of the domestic manufacturer consists of two parts. The first part is related to the producer's profit from selling the products to retailers. In the second part, the manufacturer has to pay a share of its profit to the company from which it has financed. Because as stated in the definition of the problem, the domestic manufacturer uses a crowdfunding platform to provide the necessary financial resources to compete with the foreign manufacturer. This payment includes the interest on the received loan and the original amount ($C_{\mathrm{DT}}D_{\mathrm{d}}-B_{\mathrm{m}}$). However, this expense is applied to the domestic manufacturer when it needs financial resources to compete with the foreign manufacturer, otherwise, the second part of the objective function is considered zero.

On the other hand, the revenue of the foreign manufacturer is equal to the number of sales of its products to retailers minus the cost of the product, which includes the cost of production and costs associated with product globalization (Eq. (11)).

The optimal decision variables of these two supply chain elements are expressed according to the aforementioned and the objective function of the manufacturers in Theorem 2.

Lemma 2 *According to Eq.* (10), *the objective function of the domestic manufacturer is concave*; *therefore*, *it has an optimal point to maximize the profit of the objective function* (*see Appendix A*3 *for proof*).

Lemma 3 *According to Eq.* (11), *the objective function of the foreign manufacturer is concave*; *therefore*, *the optimal point of its decision variable maximizes the profit of the objective function* (*see Appendix A*4 *for proof*).

Theorem 2 *The optimal price offered to the retailer by manufacturers with respect to their objective function*, *the type of competition between them*, *and the best retailer response function are as follows* (*see Appendix A*5 *for proof*):

$$\begin{cases} cW_{\mathrm{d}}^{*}=\dfrac{\left[\begin{array}{c}2\alpha_{\mathrm{d}}\left(\gamma+\beta_{\mathrm{f}}\right)+\gamma^{2}\left[C_{\mathrm{FT}}+2C_{\mathrm{DT}}\right]\\+\gamma\left[\alpha_{\mathrm{f}}+C_{\mathrm{FT}}\beta_{\mathrm{f}}++2C_{\mathrm{DT}}\left(\beta_{\mathrm{d}}+\beta_{\mathrm{f}}\right)\right]+2\beta_{\mathrm{d}}\beta_{\mathrm{f}}C_{\mathrm{DT}}\end{array}\right]}{4\beta_{\mathrm{d}}\beta_{\mathrm{f}}+4\gamma\left(\beta_{\mathrm{d}}+\beta_{\mathrm{f}}\right)+3\gamma^{2}}, \\ \left(C_{\mathrm{DT}}D_{\mathrm{d}}-B_{\mathrm{m}}\right)<0 \\ W_{\mathrm{d}}^{*}=\dfrac{\left[\begin{array}{c}2\alpha_{\mathrm{d}}\left(\gamma+\beta_{\mathrm{f}}\right)+\gamma^{2}\left[C_{\mathrm{FT}}+2C_{\mathrm{DT}}\left(i_{\mathrm{m}}+S_{\mathrm{m}}+1\right)\right]\\+\gamma\left[\alpha_{\mathrm{f}}+C_{\mathrm{FT}}\beta_{\mathrm{f}}++2C_{\mathrm{DT}}\left(i_{\mathrm{m}}+S_{\mathrm{m}}+1\right)\left(\beta_{\mathrm{d}}+\beta_{\mathrm{f}}\right)\right]+2\beta_{\mathrm{d}}\beta_{\mathrm{f}}C_{\mathrm{DT}}\left(i_{\mathrm{m}}+S_{\mathrm{m}}+1\right)\end{array}\right]}{4\beta_{\mathrm{d}}\beta_{\mathrm{f}}+4\gamma\left(\beta_{\mathrm{d}}+\beta_{\mathrm{f}}\right)+3\gamma^{2}}, \\ \left(C_{\mathrm{DT}}D_{\mathrm{d}}-B_{\mathrm{m}}\right)>0 \end{cases} \tag{12}$$

$$\begin{cases} cW_{\mathrm{f}}^{*} = \dfrac{\left[\begin{array}{c} 2\alpha_{\mathrm{f}}(\gamma+\beta_{\mathrm{d}}) + \gamma^{2}\left[2C_{\mathrm{FT}} + C_{\mathrm{DT}}\right] \\ +\gamma\left[\alpha_{\mathrm{d}} + C_{\mathrm{DT}}\beta_{\mathrm{d}} + 2C_{\mathrm{FT}}(\beta_{\mathrm{d}}+\beta_{\mathrm{f}})\right] + 2\beta_{\mathrm{d}}\beta_{\mathrm{f}}C_{\mathrm{FT}} \end{array}\right]}{4\beta_{\mathrm{d}}\beta_{\mathrm{f}} + 4\gamma(\beta_{\mathrm{d}}+\beta_{\mathrm{f}}) + 3\gamma^{2}}, \\ (C_{\mathrm{DT}}D_{\mathrm{d}} - B_{\mathrm{m}}) < 0 \\ W_{\mathrm{f}}^{*} = \dfrac{\left[\begin{array}{c} 2\alpha_{\mathrm{f}}(\gamma+\beta_{\mathrm{d}}) + \gamma^{2}\left[2C_{\mathrm{FT}} + C_{\mathrm{DT}}(i_{\mathrm{m}} + S_{\mathrm{m}} + 1)\right] \\ +\gamma\left[\alpha_{\mathrm{d}} + C_{\mathrm{DT}}\beta_{\mathrm{d}}(i_{\mathrm{m}} + S_{\mathrm{m}} + 1) + 2C_{\mathrm{FT}}(\beta_{\mathrm{d}}+\beta_{\mathrm{f}})\right] + 2\beta_{\mathrm{d}}\beta_{\mathrm{f}}C_{\mathrm{FT}} \end{array}\right]}{4\beta_{\mathrm{d}}\beta_{\mathrm{f}} + 4\gamma(\beta_{\mathrm{d}}+\beta_{\mathrm{f}}) + 3\gamma^{2}}, \\ (C_{\mathrm{DT}}D_{\mathrm{d}} - B_{\mathrm{m}}) > 0 \end{cases} \tag{13}$$

It is noteworthy that S_{m}, in the function of the best responses of the price, plays a role in Eqs. (12) and (13) when the domestic manufacturer uses the lending platform to cover their lack of budget ($(C_{\mathrm{DT}}D_{\mathrm{d}} - B_{\mathrm{m}}) > 0$). In other words, this service rate is even an influencing factor in the optimal price of a foreign manufacturer. As a result, it can increase or decrease the competitive pricing power of a domestic manufacturer against a rival manufacturer.

Online crowdfunding platform objective function and optimal decisions

Another essential element is the online crowdfunding platform, which pays a loan to the domestic manufacturer. This platform practically seeks to maximize the monetization of its company by determining the service rate for the domestic manufacturer. Specifically, this platform should be looking for an optimal point of service rate. A service rate can convince the domestic manufacturer to cover its lack of financial resources from the company and can maximize the profits of the company itself based on the rate of interest it pays to its customers. Since this platform competes with the domestic manufacturer in the form of a Stackelberg game, the i_{m} and S_{m} factors that are determined by investors and the investment platform, respectively, highly contribute to the success rate of the domestic manufacturer toward competing with the foreign manufacturer for retail market share. It should be noted that this member of the supply chain could be considered when the domestic manufacturer needs financial support ($\left(C_{\mathrm{DT}}D_{\mathrm{d}} - B_{\mathrm{m}}\right) > 0$), otherwise, it would be zero ($\Pi\left(S_{\mathrm{m}}\right) = 0$). The objective function of this platform can be observed in Eq. (14).

$$\Pi\left(S_{\mathrm{m}}\right) = \mathrm{Max}\{0, [\left(C_{\mathrm{DT}}D_{\mathrm{d}} - B_{\mathrm{m}}\right) \times (i_{\mathrm{m}} + S_{\mathrm{m}} + 1)]\} \times S_{\mathrm{m}} \tag{14}$$

Theorem 3 *The optimal service rate of the online investment platform, with respect to other goals of the supply chain components and its objective function, is as follows (see Appendix A6 for proof)*:

$$\begin{cases} S_{\mathrm{m}}^{*} = 0, (C_{\mathrm{DT}}D_{\mathrm{d}} - B_{\mathrm{m}}) < 0 \\ S_{\mathrm{m}}^{*} = \dfrac{\psi}{4C_{\mathrm{DT}}(\beta_{\mathrm{d}}+\gamma)\left[2\beta_{\mathrm{d}}\beta_{\mathrm{f}}+2\gamma(\beta_{\mathrm{d}}+\beta_{\mathrm{f}})+\gamma^{2}\right]}, (C_{\mathrm{DT}}D_{\mathrm{d}} - B_{\mathrm{m}}) > 0 \end{cases} \tag{15}$$

where ψ equals to

$$\left\{\begin{array}{l} c - C_{\mathrm{DT}}\gamma^{3}\left[C_{\mathrm{DT}}(i_{\mathrm{m}}+1) - C_{\mathrm{FT}}\right] + C_{\mathrm{DT}}\gamma^{2}\left[2(\alpha_{\mathrm{d}}+\alpha_{\mathrm{f}})\right. \\ \left. +C_{\mathrm{FT}}(\beta_{\mathrm{d}}+\beta_{\mathrm{f}})\right] - \gamma^{2}\left[{C_{\mathrm{DT}}}^{2}(3\beta_{\mathrm{d}} + 2\beta_{\mathrm{f}})(i_{\mathrm{m}}+1) + 3B_{\mathrm{m}}\right] \\ -\gamma\left[(4B_{\mathrm{m}} - 2C_{\mathrm{DT}}\alpha_{\mathrm{d}})(\beta_{\mathrm{d}}+\beta_{\mathrm{f}}) + (2{C_{\mathrm{DT}}}^{2}\beta_{\mathrm{d}}(\beta_{\mathrm{d}} + 2\beta_{\mathrm{f}}))(i_{\mathrm{m}}+1)\right. \\ \left. -C_{\mathrm{DT}}\beta_{\mathrm{d}}(\alpha_{\mathrm{f}} + C_{\mathrm{FT}}\beta_{\mathrm{f}})\right] - 2\beta_{\mathrm{d}}\beta_{\mathrm{f}}\left[{C_{\mathrm{DT}}}^{2}\beta_{\mathrm{d}}(i_{\mathrm{m}}+1) + 2B_{\mathrm{m}} - C_{\mathrm{DT}}\alpha_{\mathrm{d}}\right] \end{array}\right\}$$

As can be seen in Eq. (15), S_{m}^{*} is highly dependent on C_{DT} and B_{m}. Specifically, the number of financial resources required by the domestic manufacturer ($C_{\mathrm{DT}} - B_{\mathrm{m}}$) will significantly impact the lending platform's decision to determine S_{m}^{*}.

Results and discussion

This section aims to study the problem's different aspects according to the proposed mathematical models. In other words, it seeks to investigate the behavior of the supply chain components to obtain managerial insights by numerically changing the main parameters of the problem. Hence, a sensitivity analysis is performed for four main parameters: cost related, financial, market size related, and price sensitivity. Additionally, to solve the models, the codes were written in Matlab 2019a and run on a computer equipped with a 2/90 GHz Intel Core i5 CPU, 8 GB of 1333 MHz DDR3 RAM, and Windows 10.

Random samples are created in this study due to the lack of real data for creating a numerical example for the proposed model. It should be noted that part of the sample data mostly related to the online crowdfunding platform is taken from the article by Gao et al. (2018). In addition, the authors of this study believe that the proposed model can be used in the auto parts industry and the electronic home appliances industry due to the nature of this study, domestic and foreign manufacturers, and the type of retailer decisions. For example, in some countries, such as Iran, domestic auto parts manufacturers have a financial problem competing with imported products to gain market share for their products, so foreign companies have largely taken over the market (Minaee et al. 2021). Hence, they need to implement the models of this research based on their parameters to increase their competitive advantages and offer attractive prices to customers. As another example, the Coronavirus epidemic caused a significant drop in revenue for the Bosch firm. To address this dilemma, it was considered that pricing tactics needed to alter (Bosch stays on course through the coronavirus crisis to achieve a positive result., 2021). To compete

Table 3 Computational result for the proposed model

Decision variables	W_d	W_f	P_d	P_f	S_m
Values	2175	2652	9704	10,328	0.0515
Objective functions	$\Pi(W_d)$	$\Pi(W_f)$	$\Pi(P_d, P_f)$	$\Pi(S_m)$	
Values	1,891,593	1,365,381	5,192,611	282	

with its international rivals, notably LG, who had a lower price, Bosch made significant efforts to enhance competition and cut costs. By altering their price approach, they were able to keep their place in the market.

The following settings are used to evaluate the model: $\alpha_d = 2000$, $\alpha_f = 1500$, $\beta_d = 0.45$, $\beta_f = 0.20$, $\beta_d\prime = 0.06$, $\beta_f\prime = 0.04$, $\gamma = 0.3$, $i_m = 0.08$, $B_m = 635000$, $C_G = 100$, $C_d = 300$, $\varphi_f = 150$, and $C_{FT} = 1000$. As observed in Table 3, all decision variables and the objective function of each of the considered competition's components are expressed according to the created sample in the proposed model. Table 3 also shows that the retailer has been able to make the most profit in the competitive environment as the last decision-maker in the proposed model. Also, the domestic manufacturer has been able to make a considerable profit by making the right pricing decisions and providing the required financial resources optimally.

Sensitivity analysis according to the cost

This section investigates the effect of changes in φ_F, C_G, and C_{FT} cost parameters on the profit of supply chain components and the decision variables of the problem. In the beginning, two factors that affect the production costs of the domestic manufacturer are discussed. Since φ_F is an exogenous factor offered by the foreign supplier, this section analyzes the change of this parameter in the profit of the foreign supplier according to Eq. (16).

$$\Pi(\varphi_f) = D_d \times (\varphi_f - c_f\prime) \tag{16}$$

$c_f\prime$ is the cost of supplying a unit of raw material by a foreign supplier, which is considered equal to 20. In this section, first, all other parameters of the problem are considered fixed for an accurate analysis of the model behavior. Besides, all changes are recorded in the proposed supply chain's decision variables and objective functions by changing the two parameters of φ_F and C_G, shown in Table 4, respectively.

The profit of the domestic manufacturer decreases with the increase of φ_F; in contrast, the profit of the foreign manufacturer increases. On the other hand, due to the increase in costs, the domestic manufacturer's need for financial resources also increases to compete with the imported product. As a result, an increase can be seen in the profit of the online crowdfunding platform. Also, with the increase of φ_F, a decrease can be observed in the price difference between domestic and foreign products. This is because, by increasing the costs of the domestic manufacturer, its pricing power decreases against the foreign manufacturer. On the contrary, with the reduction of competitive advantages, an increase can be seen in the chances of the sales of the foreign manufacturer in the market; therefore, the retailer has to reduce its prices to sell to its customers. This will reduce the retailer's profit from domestically manufactured products and increase the profit from the sale of imported products.

All of the above-mentioned can happen with the increase in C_G. The difference is that the profit of the foreign supplier decreases with the increase of C_G, but this profit increases with the increase of φ_F. In fact, in the state of Table 4, the foreign supplier did not increase the price of its products, and with the increase of C_G, the domestic manufacturer has less chance to sell its products to retailers. As a result, it buys fewer raw materials from the supplier, reducing the supplier's profit.

Figures 2 and 3 illustrate the lending platform's and retailer's profit functions, while the φ_F and C_G parameters are changed simultaneously. Notably, an initial increase and then a significant decrease can be observed in the profit of the lending platform by increasing the costs of the domestic manufacturer in the profit function of this platform (Fig. 2). This is because the domestic manufacturer uses this platform to cover the lack of financial resources with increased costs. However, since the manufacturer faces increased expenses, such as purchasing raw materials and globalization, it loses its competitiveness with foreign manufacturers. As a result, it does not use the platform, which reduces the profit of the platform. In contrast, customers' desire to buy domestically manufactured products decreases as the costs increase. Hence, the retailer loses the domestically manufactured product market, which also reduces the retailer's profit (Fig. 3).

The competitiveness of the foreign manufacturer decreases against the domestic manufacturer by increasing the costs of this manufacturer to enter the local market. Therefore, as shown in Table 4, the foreign manufacturer is experiencing a higher price increase than the domestic manufacturer in selling its product to the retailer. As can be observed in Fig. 4, the foreign manufacturer's price increase slope is steeper than the domestic manufacturer's ($|82.5| > |25.2|$). Hence, given that the competitiveness of the foreign manufacturer is decreased in the market, the retailer is forced to reduce its prices to sell its products. As a result, the retailer is less inclined to buy foreign manufacturers' products due to the high purchase and low selling costs, which also reduces the manufacturer's profit.

Table 4 Sensitivity analysis

φ_F	Sensitivity analysis for φ_F									
	W_d	W_f	P_d	P_f	S_m	$\Pi(W_d)$	$\Pi(W_f)$	$\Pi(P_d, P_f)$	$\Pi(S_m)$	$\Pi(\varphi_f)$
140	2155	2647	9809	10,292	0.0063	1,902,035	1,355,943	5,293,285	4	141,249
145	2165	2650	9756	10,310	0.0292	1,896,903	1,360,695	5,242,322	89	146,342
150	2175	2652	9704	10,328	0.0515	1,891,593	1,365,381	5,192,611	282	151,384
155	2184	2655	9652	10,345	0.0728	1,886,116	1,370,003	5,144,109	575	156,376
160	2193	2658	9602	10,363	0.0934	1,880,482	1,374,563	5,096,776	961	161,321
C_G	Sensitivity analysis for C_G									
	W_d	W_f	P_d	P_f	S_m	$\Pi(W_d)$	$\Pi(W_f)$	$\Pi(P_d, P_f)$	$\Pi(S_m)$	$\Pi(\varphi_f)$
90	2155	2647	9809	10,292	0.0063	1,902,035	1,355,943	5,293,285	4	153,020
100	2175	2652	9704	10,328	0.0515	1,891,593	1,365,381	5,192,611	282	151,384
110	2193	2658	9602	10,363	0.0934	1,880,482	1,374,563	5,096,776	961	149,797
120	2211	2663	9504	10,396	0.1320	1,868,788	1,383,503	5,005,462	1987	148,258
130	2228	2668	9408	10,429	0.1675	1,856,585	1,392,212	4,918,378	3316	146,763
C_{FT}	Sensitivity analysis for C_{FT}									
	W_d	W_f	P_d	P_f	S_m	$\Pi(W_d)$	$\Pi(W_f)$	$\Pi(P_d, P_f)$	$\Pi(S_m)$	
700	2124	2487	9604	11,171	0	1,815,259	1,597,555	5,854,781	0	
850	2150	2570	9654	10,750	0.0205	1,853,378	1,479,190	5,513,795	45	
1000	2175	2652	9704	10,328	0.0515	1,891,593	1,365,381	5,192,611	282	
1150	2200	2735	9754	9906	0.0825	1,929,903	1,256,126	4,891,230	723	
1300	2225	2817	9803	9484	0.1135	1,968,308	1,151,427	4,609,652	1368	
B_m	Sensitivity analysis for B_m									
	W_d	W_f	P_d	P_f	S_m	$\Pi(W_d)$	$\Pi(W_f)$	$\Pi(P_d, P_f)$	$\Pi(S_m)$	
615,000	2202	2660	9552	10,379	0.1457	1,890,854	1,379,072	5,050,478	2254	
625,000	2188	2656	9628	10,353	0.0986	1,891,584	1,372,218	5,121,057	1032	
635,000	2175	2652	9704	10,328	0.0515	1,891,593	1,365,381	5,192,611	282	
645,000	2161	2648	9780	10,302	0.0044	1,890,880	1,358,561	5,265,141	2	
655,000	2147	2644	9855	10,276	0	1,889,447	1,351,758	5,338,646	0	
i_m	Sensitivity analysis for i_m									
	W_d	W_f	P_d	P_f	S_m	$\Pi(W_d)$	$\Pi(W_f)$	$\Pi(P_d, P_f)$	$\Pi(S_m)$	
0.06	2172	2651	9720	10,322	0.0615	1,891,244	1,363,931	5,207,934	402	
0.07	2173	2652	9712	10,325	0.0565	1,891,417	1,364,655	5,200,267	339	
0.08	2175	2652	9704	10,328	0.0515	1,891,593	1,365,381	5,192,611	282	
0.09	2176	2652	9696	10,330	0.0465	1,891,771	1,366,106	5,184,966	229	
0.10	2178	2653	9688	10,333	0.0415	1,891,952	1,366,831	5,177,332	183	
α_d	Sensitivity analysis for α_d									
	W_d	W_f	P_d	P_f	S_m	$\Pi(W_d)$	$\Pi(W_f)$	$\Pi(P_d, P_f)$	$\Pi(S_m)$	
1900	2063	2619	9482	10,119	0	1,722,482	1,310,800	5,022,571	0	
2000	2175	2652	9704	10,328	0.0515	1,891,593	1,365,381	5,192,611	282	
2050	2230	2669	9814	10,432	0.1204	1,976,856	1,393,088	5,278,510	1539	
2100	2286	2685	9925	10,536	0.1892	2,062,590	1,421,074	5,364,995	3804	
2150	2341	2702	10,036	10,640	0.2581	2,148,796	1,449,338	5,452,066	7076	

Table 4 (continued)

α_f	Sensitivity analysis for α_f								
	W_d	W_f	P_d	P_f	S_m	$\Pi(W_d)$	$\Pi(W_f)$	$\Pi(P_d, P_f)$	$\Pi(S_m)$
1300	2108	2432	9571	8953	0	1,789,900	1,026,002	4,539,001	0
1400	2141	2542	9637	9640	0.0102	1,840,661	1,189,640	4,852,948	12
1500	2175	2652	9704	10,328	0.0515	1,891,593	1,365,381	5,192,611	282
1600	2208	2762	9770	11,015	0.0928	1,942,694	1,553,223	5,557,989	915
1700	2241	2872	9837	11,703	0.1341	1,993,965	1,753,167	5,949,081	1911
β_d	Sensitivity analysis for β_d								
	W_d	W_f	P_d	P_f	S_m	$\Pi(W_d)$	$\Pi(W_f)$	$\Pi(P_d, P_f)$	$\Pi(S_m)$
0.40	2335	2700	9792	10,629	0.1147	2,096,405	1,446,292	5,231,852	1298
0.425	2252	2675	9747	10,473	0.0816	1,989,986	1,404,000	5,212,254	682
0.45	2175	2652	9704	10,328	0.0515	1,891,593	1,365,381	5,192,611	282
0.475	2103	2630	9661	10,193	0.0240	1,800,356	1,329,986	5,172,844	63
0.50	2036	2610	9619	10,067	0	1,715,528	1,297,436	5,152,898	0
β_f	Sensitivity analysis for β_f								
	W_d	W_f	P_d	P_f	S_m	$\Pi(W_d)$	$\Pi(W_f)$	$\Pi(P_d, P_f)$	$\Pi(S_m)$
0.16	2238	2860	9829	10,696	0.1299	1,988,236	1,591,859	5,285,760	1782
0.18	2205	2751	9763	10,509	0.0888	1,937,613	1,472,676	5,240,882	836
0.20	2175	2652	9704	10,328	0.0515	1,891,593	1,365,381	5,192,611	282
0.22	2147	2561	9649	10,151	0.0174	1,849,576	1,268,351	5,141,638	32
0.24	2122	2478	9598	9979	0	1,811,063	1,180,245	5,088,529	0

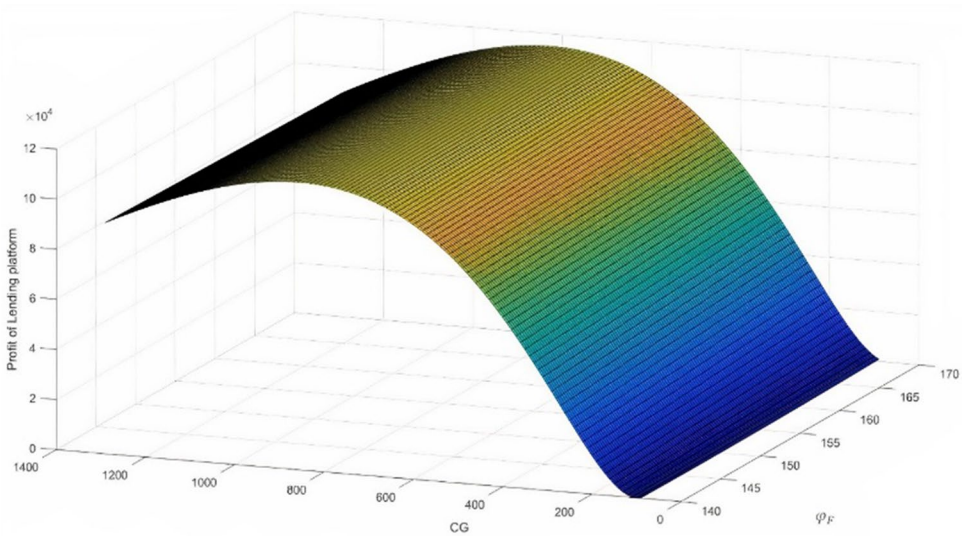

Fig. 2 Profit of online crowdfunding platform under Sensitivity analysis for φ_F and C_G

This study also suggests that an exponential increase can be witnessed in the lending platform's profit with the increase in the potential of the domestic manufacturer market. Since the chances are increased for domestic products, the need for financial resources is also increased for this manufacturer, which increases the profitability of the lending platform. According to the above-mentioned information, local governments can increase the costs of foreign manufacturers for entering their market by imposing contractionary policies on them (such as rising customs and tax rates) if they seek to strengthen the competitiveness of domestic manufacturers. However, an extreme implementation of this approach can lead to a monopoly in the market; therefore, customers will not have a considerable choice in buying various products. In addition, as the cost of the foreign manufacturer increases, the retailer loses the market

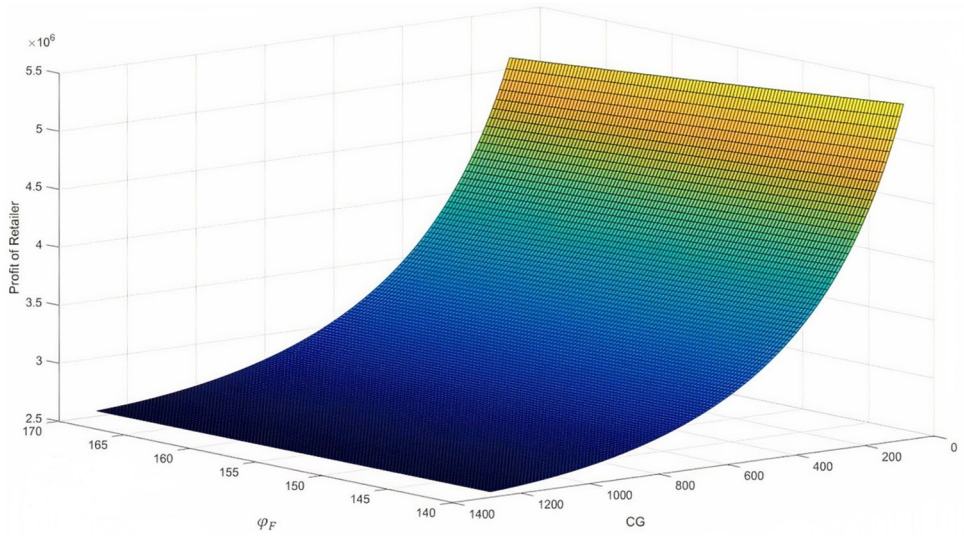

Fig. 3 Profit of retailer under Sensitivity analysis for φ_{F} and C_{G}

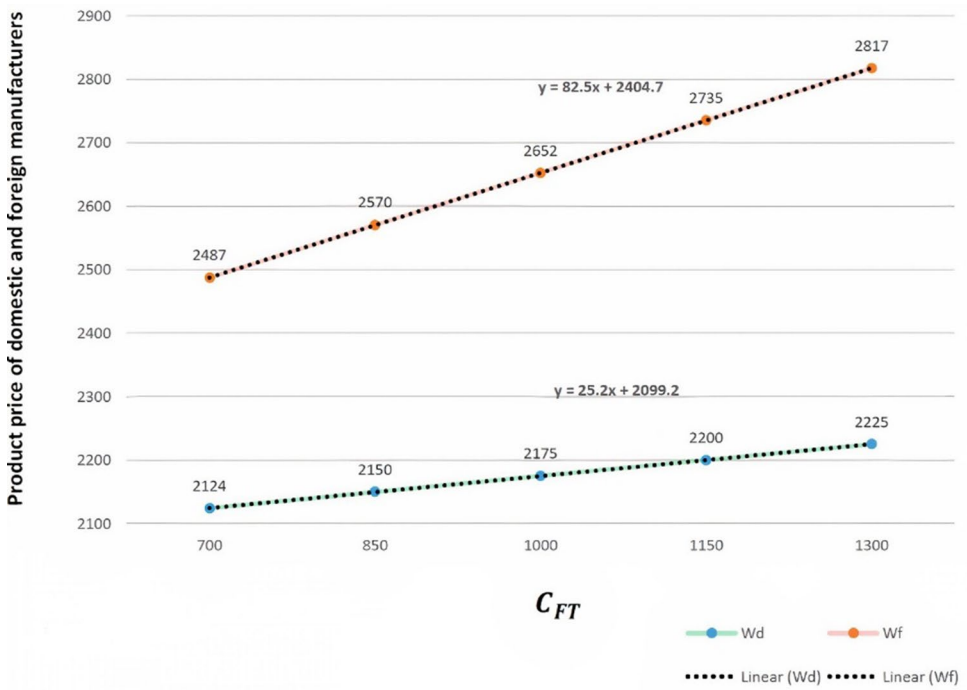

Fig. 4 Sensitivity analysis for C_{FT}

for foreign products, which reduces the retailer's profit (Table 4). In fact, governments' contractionary policies may increase domestic manufacturers' profitability. However, it may also cause severe damage to the retail industry of these governments.

Sensitivity analysis according to the financial parameters

This section examines the effect of B_{m} and i_{m} parameters on the supply chain components and the decision variables. For this purpose, the model components' behavior changes are first discussed according to the individual differences in the parameters mentioned (Table 4).

As the initial capital of the domestic manufacturer increases, the lending platform seeks to maintain its profitability by reducing its service rate to encourage this manufacturer. However, since the manufacturer will need fewer financial resources for production, the profit of this platform will naturally decrease. It is also notable that the retailer's profit is raised sharply. More specifically, the competitiveness of the domestic manufacturer is increased against the foreign manufacturer due to the increase in B_m. Hence, the competition between the two manufacturers is intensified

over the pricing of their products. This leads to a reduction in the bid price to the retailer by these two manufacturers. As a result, retailers have better conditions for pricing the products for sale and can make better profits.

Furthermore, an initial increase and a subsequent decrease are observed in the profit of the domestic manufacturer by increasing B_m. This indicates that attracting large amounts of initial capital will not always bring more profit for a company and can even impose costs on the company. Hence, a company needs to attract optimal capital according to the existing competitive environment and the size of its market to make the most profit. In addition, a decrease can be seen in the profitability of the foreign manufacturer. The chances of selling imported products to retailers decrease as the competitive pricing power of the domestic manufacturer increases; as a result, a continuous decline can be seen in the foreign manufacturer's profits. According to Table 4, a decrease can be observed in the profit of the lending platform with an increase of i_m. More precisely, since investors' confidence is low in the platform's success in making a profit, they increase the investor's interest rate to reduce a part of the investment risk. Hence, the platform has to decrease s_m to encourage manufacturers in need of capital to use their company and keep $i_m + S_m$ at a constant level, leading to a reduction in the profit of this platform. On the other hand, no significant change can be observed in the profit of the domestic manufacturer with an increase of i_m. This is because the online lending platform has to reduce the level of its service rate to attract domestic manufacturers and meet the needs of its investors.

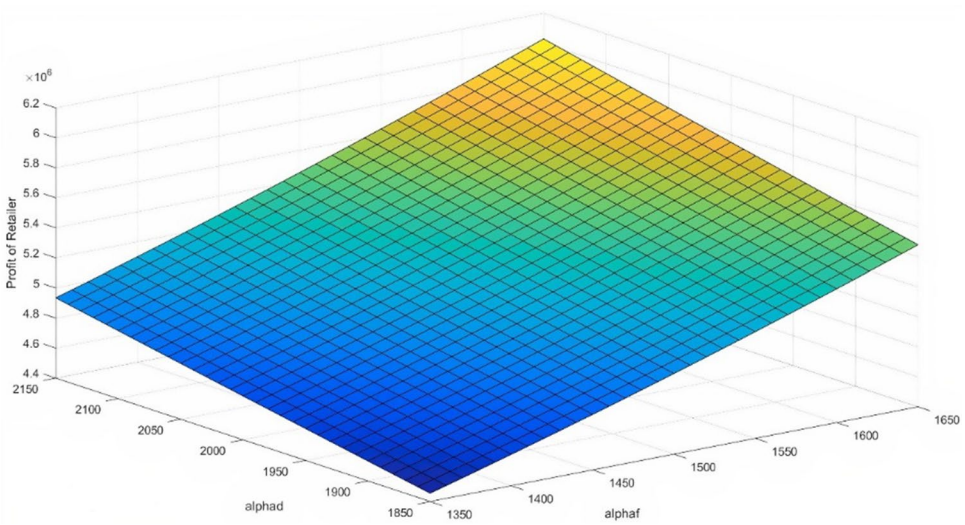

Fig. 5 Profit of retailer under Sensitivity analysis for α_d and α_f

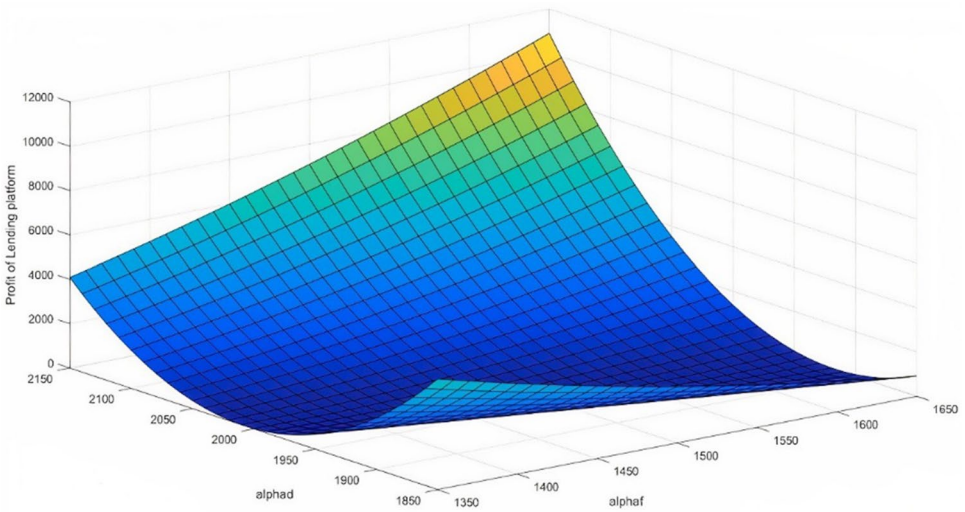

Fig. 6 Profit of online crowdfunding platform under Sensitivity analysis for α_d and α_f

Sensitivity analysis according to the market potential of the market

This section examines the effect of the individual (Table 4) and simultaneous (Figs. 5 and 6) changes of the α_d and α_f parameters on the decision variables and objective functions of the problem. Each manufacturer increases the prices with the increase in the market potential of their products. Since more potential customers are in the market for each manufacturer's products, the competition between manufacturers is reduced for market share. As a result, the mentioned manufacturers can apply higher pricing to their products to make more profit.

In addition, by the simultaneous increase of the market potential of the manufacturers, the retailer can sell more products at higher prices to customers, which leads to enhancing the retailer's profit (Fig. 5). The profitability of the online crowdfunding platform also increases with the increase of α_d and α_f parameters (Fig. 6). Indeed, since the potential increases for the produced products, the domestic manufacturer has to meet the needs of their financial resources from this platform, resulting in more profit for the platform.

Notably, by decreasing α_d and α_f, an initial decrease and a subsequent increase can be seen in the lending platform's profit. The initial decrease in the platform profit is due to the decrease in the level of the potential market of the domestic manufacturer. However, suppose the market potential of manufacturers decreases more than a specific level. In that case, the domestic manufacturer will be forced to use more financial resources to compete with the foreign manufacturer successfully. This is due to the sharp increase in the competitive environment between the two manufacturers for the maximum market share. As a result of this policy, a

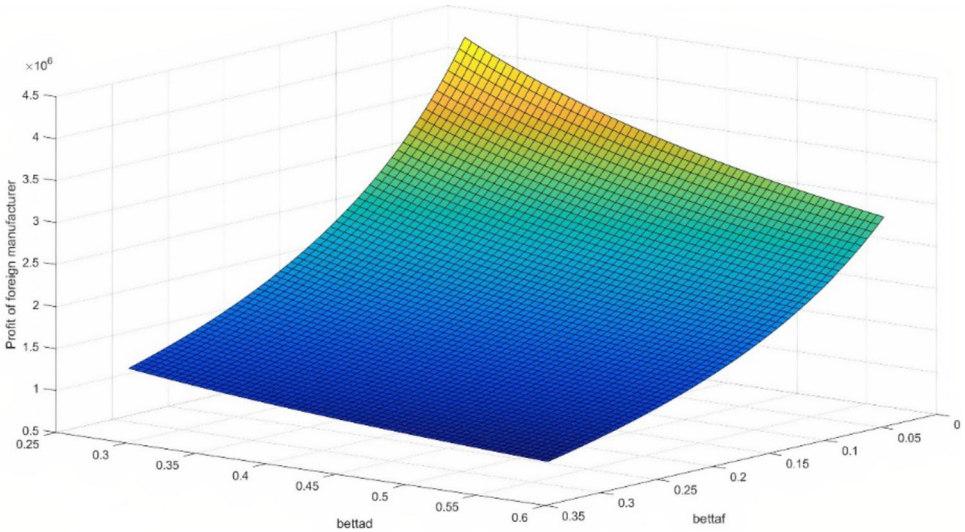

Fig. 7 Profit of foreign manufacturer under Sensitivity analysis for β_d and β_f

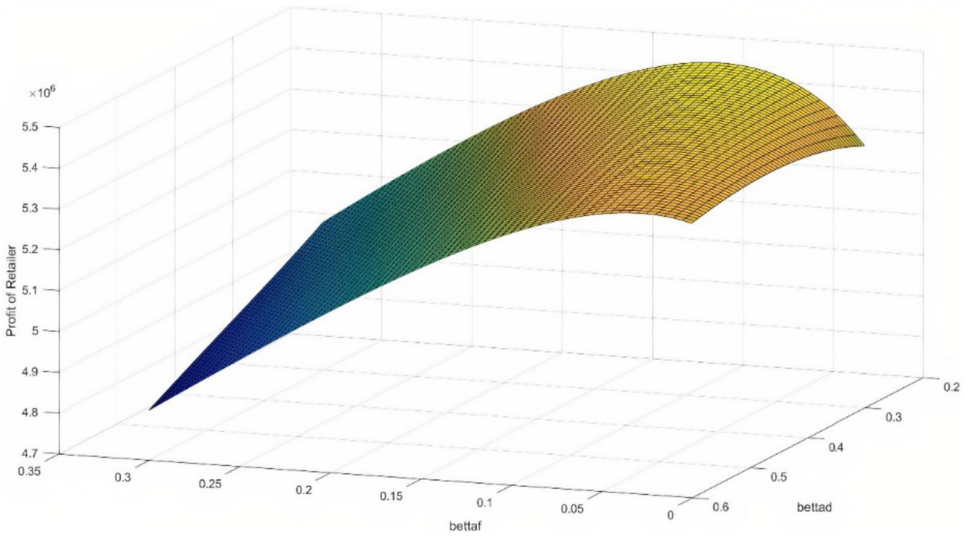

Fig. 8 Profit of retailer under Sensitivity analysis for β_d and β_f

subsequent increase can be observed in the profitability of the lending platform.

Sensitivity analysis according to price sensitivity

The β_d and β_f parameters are examined in this section. First, all other parameters are fixed, and each mentioned parameter is changed individually (Table 4). Then, a more comprehensive study of their effects on the supply chain components is studied by changing these parameters simultaneously (Figs. 7 and 8).

With the increases of β_d, the domestic manufacturer has to impose lower prices on its products to maintain its market share. Hence, the foreign manufacturer also has to reduce the prices of their products to compete with domestic products. However, the decrease in W_f is lower than W_d. Similarly, according to Table 4, the decrease in W_f is greater than W_d by increasing β_f.

As shown in Fig. 7, a significant decrease can be observed in the profit of the foreign manufacturer if the society shows a sense of patriotism toward the domestic products (i.e., less β_d and more β_f). It is also notable that as β_d and β_f decrease, the retailer's profit increases first and then decreases from a certain level (Fig. 8). This is because manufacturers can meet more demand at the beginning by reducing β_d and β_f; therefore, the retailer sells more products to customers and gains more profit. However, after a specific level, since manufacturers offer higher prices to sell their products to retailers, the retailer will be restricted from applying an appropriate pricing policy to sell to customers, reducing the retailer's profits. In other words, manufacturers increase the prices of their goods while the retailer needs to control the prices to sell more products, and as a result, the retailer loses profit.

Conclusion and future research direction

The main contributions of this article are divided into three main categories. First, limited papers have considered the physical and financial procedures of the supply chain simultaneously. In addition, the issues of financing methods are mainly combined with the network design of the supply chain. However, problems such as an appropriate pricing strategy in the supply chain and novel financing methods have not been considered. Hence, this paper examined the pricing competition between supply chain components by designing a supply chain via an online crowdfunding platform. Second, despite the increase in the number of foreign manufacturers that compete with domestic manufacturers in local market share in the recent decade. Limited studies have been conducted on the issue of competitive pricing on a global scale. Thus, this study considers a globally competitive environment and product pricing competition between domestic and foreign manufacturers. Third, this paper conducted several sensitivity analyses on supply chain components to gain managerial insights, ultimately leading to remarkable results.

For this purpose, the two domestic and foreign manufacturers compete in a game theory framework to execute appropriate pricing for their products for sale to a retailer. On the other hand, the retailer competes with the manufacturers in a Stackelberg game way to buy their products. Also, the domestic manufacturer that faces capital constraints is financed by a lending platform. This platform also competes with the domestic manufacturer in the form of the game structure to determine the optimal service rate and maximize its profit from the executed investment.

A sensitivity analysis is performed on the cost, financial, market potential, and price sensitivity parameters to study the behavior of different supply chain components in different conditions and gain managerial insights. The analyses revealed that the service rate of the lending platform and the financial resources that the domestic manufacturer requires to compete with the foreign manufacturer substantially affect the profitability of all supply chain components. Many manufacturers produce and sell their products regardless of their competitor's capital constraints problem and its solution. However, the results of this study show that manufacturers and retailers must consider these types of financial constraints to make an appropriate decision for entering the market and earning maximum profit. Furthermore, the parameters related to the sensitivity coefficient of the price of domestic and foreign products are among other concerns that are very influential in the profitability of the proposed supply chain components. In other words, this study showed that domestic and foreign manufacturers must also consider the inclination of customers toward foreign or domestic products (patriotism) to price them.

This study has a few inherent limitations. The present study only considered the financial constraints of the domestic manufacturer. It is suggested that further researches also consider the financial constraints of retailers to make the problem more realistic. It is also possible to create a competitive environment in the lending platform. In fact, the large number of investment companies around the world practically leads to competition between these platforms for investment. Therefore, more comprehensive models can be created in future research by considering various lending platforms that compete to satisfy companies in need of financial resources. Furthermore, in this article, the domestic manufacturer and the lending platforms compete as separate components. It appears that the problem can be more realistic in future studies by examining the contracts that can be signed between these two to compete with a foreign manufacturer. Moreover, exploring the results of the proposed

model with data is another direction for future studies to increase the practicality of our research.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1057/s41272-023-00471-5.

Funding Open Access funding enabled and organized by CAUL and its Member Institutions.

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