Sustainability and Resilience Analysis in Supply Chain Considering Pricing Policies and Government Economic Measures

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***Abstract*—Sustainability and resilience are becoming increasingly critical in shaping supply chain pricing strategies. They ensure that supply chains can withstand disruptions while adhering to environmental and social standards, thereby securing long-term economic viability. Despite their importance, the integration of these two pillars with the promotion of domestic products remains under-explored, especially concerning their influence on the competitive dynamics within supply chains. This study seeks to bridge this gap by examining the influence of sustainability, resilience, and domestic product promotion on supply chain pricing strategies. We introduce a model that captures the interactions among a central supplier, multiple stores, and the government, focusing on strategies adopted by each stakeholder to maximize its profit while adhering to sustainability and resilience requirements. The study reveals that stores' pricing strategies are significantly influenced by their sustainability efforts, with the cost coefficient of these efforts and the elasticity of sustainability efforts directly affecting profit margins. It also finds that the supplier's resilience strategy involves allocating inventory reserves to manage wholesale pricing effectively. Governmental regulatory measures, through taxation and subsidies, are shown to play a crucial role in maintaining the balance between domestic and foreign products and providing flexibility to diversify product sources to cope with local disruptions. Finally, perspectives are provided to enrich the understanding of how sustainability and resilience can be considered and impact pricing policies of the whole network.**

Keywords—Supply chain management; pricing policies; sustainability; resilience; government regulation

I. Introduction

In today's interconnected world, supply chains stand as the backbone of global commerce, ensuring the seamless flow of goods and services across continents. However, as we navigate the challenges of the 21st century, from climate change and resource scarcity to geopolitical tensions and technological disruptions, the importance of sustainable and resilient supply chains has never been more pronounced [1]. Sustainability in supply chains ensures that operations are conducted in an environmentally conscious, socially responsible, and economically viable manner. On the other hand, resilience equips supply chains with the agility and adaptability to withstand unforeseen challenges, be they natural disasters, trade restrictions, or global pandemics. A supply chain that embodies both these qualities not only ensures business continuity and profitability but also plays a pivotal role in fostering a sustainable future for all.

This study embarks on a meticulous exploration of these twin pillars—sustainability and resilience—within the context of a supply chain of one supplier and several stores. It underscores the challenges tied to bolstering local production in an era dominated by transnational logistics networks. In today's interconnected world, gaining a nuanced understanding of how supply chains can optimize profitability while simultaneously fostering positive local and environmental impacts is imperative. Thus, the dual role of a supply chain—as a catalyst for economic gains and as an environmentally and locally attuned entity—warrants in-depth scrutiny [2], [3]. Firstly, it is a matter of drawing out the possible links between sustainability and resilience within the supply chain [3]. As such, the relationship between sustainability initiatives and the supply chain's ability to cope with disruption needs to be specifically addressed, exploring how sustainable practices can strengthen resilience. Next, it is necessary to know how a store can maximize profits while maintaining sustainable practices in its supply chain. This can encompass pricing strategies, operational efficiencies, and the integration of sustainable practices to ensure profitability [4]. Finally, the focus is on approaches to actively favor local products while meeting sustainability and resilience requirements. The main objective is to explore the measures needed to encourage local manufacturers, manage demand, and establish cooperation between the various players in the supply chain.

The interest of this research lies in several crucial aspects. Firstly, it is important to note that the issue of promoting domestic products while maintaining sustainability and resilience in supply chains remains relatively underexplored in the scientific literature. Very few studies to date have addressed this complex issue, despite its growing importance in a world where the globalization of supply chains is increasingly being called into question.

In addition, the recent crisis of supply chain disruption, exacerbated by unpredictable events such as the COVID-19 pandemic, has highlighted the urgency of rethinking and strengthening supply chain resilience [5]. This crisis has also raised key questions about the vulnerability of global supply chains and the importance of promoting local production to reduce this vulnerability [6].

Consequently, this research fills a gap in the literature by addressing these interrelated issues of sustainability, resilience, and the promotion of domestic products in supply chains. It thus offers innovative perspectives to address current and future challenges faced by companies and governments in supply chain management, helping to create more robust and environmentally friendly solutions in an ever-changing world. Practical implications of the findings are significant, as they empower stakeholders such as stores and suppliers to strategically choose pricing strategies that not only maximize profit but also promote sustainability and domestic products, enhancing resilience in the face of disruptive events. This study provides valuable insights for companies across various sectors, including textiles, mass-market retail, automotive, and more. The ability to navigate competitive dynamics, even within monopolistic scenarios, is crucial, especially when a company controls a substantial market share. In instances where a manufacturer (the monopolist) also owns distribution channels or outlets, competition with independent stores becomes a reality. Understanding this complexity, the study aims to provide answers to the following research questions.

Given this complexity, this study aims to answer the following research questions.

- What are pricing strategies to adopt by the store and the supplier to maximize their profits considering sustainability?
- How can the supplier comply with sustainability and resilience requirements?
- How can the government promote sustainability by encourage domestic products and resilience by offering the possibility of importing products?

The present research work will focus on a sustainable and resilient two-tier monopoly supply chain framework. Our supply chain management model examines the interactions between a central supplier, several stores and the government. The stores determine pricing and sustainability strategies, the supplier manages distribution and reserves, while the government regulates via taxes and subsidies, particularly with regard to domestic and foreign products. The key element is the resilience of the chain, with considerations such as inventories, the social burden of stores and the diversification of supply sources. The aim is to analyze supply chain dynamics with a focus on sustainability and local production.

The paper is structured as follows: Section II explores the literature related to supply chain pricing strategies, with a focus on promoting sustainability, resilience and domestic products with a government intervention. Section III concerns the model construction and analysis with three pricing strategies, the first one concern the store level, the second one concern the supplier level and finally the government. Section IV conducts a numerical analysis using examples to support the choice of pricing strategies adopted at each level. Moving to Section V, we present and meticulously discuss the findings derived from the developed model and the numerical analysis. Section VI encapsulates these findings in a comprehensive conclusion, elucidates the study's limitations and offers final observations and prospective directions.

II. Literature Review

Academic research is increasingly exploring these intersections between sustainability, resilience, performance, and competitiveness, seeking to define the ways in which companies can maintain efficient operations while being ecologically responsible and resilient to disruption.

This work is closely related to sustainability and resilience, domestic and foreign product and governmental intervention pricing strategies for supply chains.

A. Sustainability Pricing Strategies

The first focus of this paper is on the articulation and implementation of sustainability strategies. Firms are channeling resources into social and environmental programs to align with sustainability mandates, driven by a mix of governmental directives reflecting a heightened awareness [7]–[10]. In the study [11] authors investigated how inventory restocking and sustainability funding are influenced by three distinct regulatory environments. Similarly, the work in [12] investigated the best production practices for various products within the framework of cap-and-trade regulations, and in study [13] honed in on carbon emissions from warehouses, analyzing the inventory management and investment in eco-friendlier technologies in response to carbon emission limits set by cap-and-trade policies. While the study. Within the scope of this research, it's commonly acknowledged that environmental taxes significantly motivate corporate investment towards sustainable practices [14].

On the other hand, investing in sustainability initiatives is a strategic marketing proposition to enhance the company’s brand image, examines various factors that impact sustainability of supply chain. Consumers' environmental awareness, governmental regulations, sustainability investments, pricing, production quantities, and environmental constraints interact and influence each other within the context of sustainability and its impact on products and production processes [15]. Likewise, the investigation of retailers' investments in environmental R&D and manufacturers' proposed strategies for balancing and coordinating the supply chain through various joint R&D contracts. The study also reveals that consumer environmental awareness, while not always leading to increased demand for green products, systematically boosts the profits of green supply chains [16]. In the study [17] authors explores the impact of cooperative promotion on decisions and sustainability of service platform supply chains from different markets. Theoretical models suggest that joint promotion is advantageous, especially when independent promotional activities moderately impact demand. However, the benefit of cooperative promotion, influenced by demand sensitivity and adjustments in price and quality, may vary. Platforms with a high baseline demand typically derive more benefits from cooperation but might be less willing to invest more in cooperative promotions.

The examination of the relationship between sustainability efforts or investments and various aspects of product demand, production, or supply chain management, were explored in [18] where the manufacturer's incentive is considered to reduce carbon emissions in the presence of carbon taxes under revenue-sharing and cost-sharing contracts. Meanwhile, a comparison of optimal pricing and sustainability efforts was conducted in two scenarios in the study [19]: one where the manufacturer is a for-profit company driven by profit-seeking motives, and the other where the manufacturer is a nonprofit organization aiming to maximize demand realization and quantity. The same approach was made by [11], which examines sustainability investments made by retailers. Differing from this line of research, our paper considers both scenarios, where sustainability investments can be initiated by either the manufacturer or the retailer. Similarly, optimal decisions in pricing and ecological investment within competitive supply chains for electric vehicles were explored, focusing on the tension between the costs and revenues of green technologies. Manufacturers and retailers, in various market scenarios modeled via game theory approaches, navigate between investments in ecological technologies and consumer sensitivity to prices and ecology. The results offer insights to guide electric vehicle companies in developing optimal green investment and pricing strategies [20].

B. Resilience Pricing Strategies

The literature on resilience strategies in supply chain pricing is a dynamic and evolving field that addresses the crucial need for businesses to adapt and thrive in an increasingly uncertain and complex environment. Researchers and practitioners alike have recognized that pricing decisions are not just about setting optimal prices but also about fortifying supply chains against disruptions and unforeseen challenges.

Many studies underscore the critical importance of resilience in supply chain management and the diverse approaches to achieving it in the face of environmental, operational, and market challenges. A complex supply chain involving three manufacturers and a distributor managing complementary and substitute products which emphasizes the resilience of the chain against various possible disruptions. Using game theories to determine optimal prices at different levels of the supply chain, the developed model seeks to navigate efficiently through these potential interruptions, thereby ensuring order fulfillment and system stability despite environmental and operational challenges [21]. As well as, [22] where another strategy based on maintaining extra inventory at distribution centers is implemented and ensuring the reliability of distribution centers, which positively impacted the competitiveness and adaptability of supply chains investigated the influence of resilience strategies in supply chain management, particularly within the context of price competition and facility disruptions. In another context related to insufficient capacity, authors of the work [23] scrutinizes resilience in the maritime supply chain, specifically focusing on the "co-opetition" relationship between shipping companies and freight forwarders. Using a model based on game theory, it reveals that establishing a direct sales platform by shipping companies strengthens their competitive position and improves their price and profit compared to freight forwarders. Moreover, in the event of capacity shortage, the strategic implementation of capacity allocation and pricing strategies, especially through a spot market, can enhance the resilience of the supply chain. The examination of resilient agricultural supply chains in the post-COVID-19 era, as explored in [6], delves into the utilization of channel leadership strategies. This study emphasizes the critical need for selecting appropriate leadership tactics to ensure maximum profitability, optimal pricing, and high service quality in a volatile market. It also offers practical insights for the transition to e-commerce platforms in the aftermath of the pandemic.

By embracing both foreign and domestic products, businesses can diversify their portfolios, ensuring a balanced approach to sourcing and mitigating risks associated with supply disruptions. Studies in the literature delve into how these models can be leveraged to not only bolster the profitability of domestic enterprises but also strengthen their position in the increasingly competitive and complex market landscape. The optimization of prices and profits for a domestic company, along with the reduction of retailer costs, is the focus of the research [24]. By examining various scenarios, the research establishes that implementing an adapted pricing strategy can significantly enhance the profitability and market competitiveness of the domestic company in relation to imported products. Similarly, the pricing competition between national and foreign manufacturers on diversified market segments, using a Stackelberg game model was explored by [25] taking into account factors such as price and quality to influence customer purchasing trends, the study concludes that market segmentation by income levels can increase profits for the national manufacturer and improve its competitive advantage against the foreign manufacturer. Likewise, a cooperative strategy between national pharmaceutical manufacturers and foreign licensors to exclusively produce locally licensed branded drugs, with the aim of increasing the manufacturer's revenues and potentially offering government discounts [26]. Using a Nash bargaining solution and cooperative game theory to model tariff negotiations, the research reveals that the local market share of the licensor and the return on capital of national manufacturers positively influence the equilibrium price. If the price is too low, foreign entities might lack the incentive to join the coalition. On the other hand, in the context of supply disruption risk the study [27] examines the competitive dynamics between two closed supply chains, focusing on the management of product prices and recycling. One of the supply chains, a retailer, has the choice between a reliable but expensive domestic supplier and a cheaper but unreliable foreign supplier. The results indicate that in a dual supply situation, there is a direct correlation between sourcing from a foreign supplier and the return rate of used products, and that strategic use of return policies is essential to maintain competitiveness in the market.

C. Government Regulation

The government intervention strategies in various sectors are mainly focusing on subsidies, taxes, and regulations to promote environmentally friendly practices and sustainable development. To stimulate remanufacturing activities, governmental subsidies was explored, revealing that excessively high or low financial aids prompt remanufacturers to compete with producers [28]. A case study involving five European countries was highlighted by [29], unveiling how the evolution of the green economy is shaped by governmental intervention. Similarly, the price competition between green and non-green products is analyzed including government subsidies and the implementation of taxes to minimize carbon emissions [30]. Whereas, the influence of the government subsidy on the green supply chain system, exploring various chain leadership modes and how the subsidy policy impacts each chain member and the system's profit [31]. Meanwhile, the chain structure and pricing decisions for the producer and government subsidy strategy is studied, contrasting new and remanufactured products [32]. The impact of government incentive strategies, approaching eco-responsible products from a game theory-based perspective and comparing the benefits of each chain member, the level of eco-friendliness, and environmental improvement [9]. The assessment of the impact of governmental interventions on bioenergy and conventional energy supply chains is studied in [33], revealing that some support strategies, especially investment subsidies, can significantly optimize both profits and carbon emission reduction efforts while supporting sustainable development goals. In the research [7], authors utilized game theoretical models to refine pricing for energy sectors, aligning with government, societal, and ecological objectives. Findings reveal Nash strategies boost governmental and societal benefits, whereas cooperative approaches favor ecological results and energy producers' earnings. While the government regulation strategies are explored for promoting EV adoption and reducing CO_2 emissions through targeted tax reforms and subsidies, indicating that government policy adjustments are essential for achieving sustainability and market influence [34].

III. Modeling Formulation and Analysis

A. Model Description and Assumptions

In our supply chain model, we consider a configuration, as illustrated in Fig. 1, where the actors in this system are the stores, the supplier and the government. Each of these actors has an impact on the supply chain through specific strategies. The central supplier provides multiple stores with foreign and domestic products. The stores, as the final sale points, make significant strategic decisions regarding prices, sustainability efforts, and demand management. The supplier, although not directly involved in the production of products, plays a central role in distribution, negotiating unit prices and managing security stock (ψ_i) with each store. The government steps in by imposing custom fees (τ) on foreign products and by granting subsidies (ν) to promote domestic products as presented in the Table I. It also plays a regulatory role by influencing tariff policies and sustainability practices.

Integrating sustainability and resilience into supply chains combines environmental responsibility, operational robustness, and market competitiveness. This research paper primarily focuses on sustainability strategies, which are incorporated into our model at various levels. At the store level, sustainability efforts (s_i) involve demanding durable products and undertaking sustainability actions and investments, such as sustainable product refurbishment, the requirement for sustainable packaging, recycling, and more [35]. At the supplier level, it includes contributing to the reduction of carbon footprint through the integration of CO_2 emissions cost (η_i) during product transportation. Additionally, at the government level, the social charge (λ) paid by the store contributes to fostering a more socially sustainable business environment [35] across the supply chain.

Moreover, the proposed model takes into account the resilience of the supply chain, through the integration of parameters that attempt to express said resilience, such as the security stock and the diversification of supply sources. Indeed, the supplier reinforces supply chain resilience through inventories that play a key role by implementing a dedicated extra inventory (ψ_i) for each store i, that is essential to deal with potential disruptions [22]. Additionally, diversifying supply sources is also a crucial aspect of resilience. The supplier can choose to diversify the supply chain, whether they are national or foreign. On one hand, importing products allows flexibility and reduce risks of supply chain disruption and increase their resilience in the face of uncertainty. On the other hand, encouraging domestic products reduce dependence on international markets, secure jobs and bolster economic security within a country. This paradox stems from the conflicting goals of achieving supply chain flexibility and resilience by depending on imports, and simultaneously encouraging local manufacturing.

The government plays a critical role in navigating this paradox through various regulatory mechanisms. In this sense, government by offering subsidies (ν) to actively promotes domestic products ($1-\theta$), while imposing custom fees (τ) to foreign products (θ) can them more expensive. Furthermore, the government maintains the option to import foreign products (θ). This dual approach not only provides flexibility but also serves as a valuable contingency plan in the face of disruptive events, significantly enhancing the supply chain's ability to endure and recover from disruptions. These two key options are considered, each with clear financial implications:

Import Foreign Products: The supplier is considering importing a large volume of foreign products, such as manufactured goods or raw materials, for resale on the local market. However, this decision requires careful cost management. For example, when importing these products, you need to take into account customs costs, which vary according to the type of product and the country of origin. Customs costs can represent a significant proportion of import expenditure. A relevant example is Canada, where a survey of 635 men and women revealed positive attitudes towards Canadian-made products, particularly among women. However, it is important to note that customs costs can vary from country to country. Therefore, the supplier must calculate these costs accurately to assess the economic viability of this option.

Purchase of domestic products: In addition to importing, the supplier plans to purchase local products. A concrete example might be the purchase of locally manufactured products for resale on the domestic market. The government encourages this approach by offering economic benefits, such as subsidies to support local businesses or tax breaks for domestic products. These financial incentives support the purchase of local products and can reduce procurement costs. Suppliers must therefore integrate these advantages into their local purchasing strategy to maximize the economic benefits.

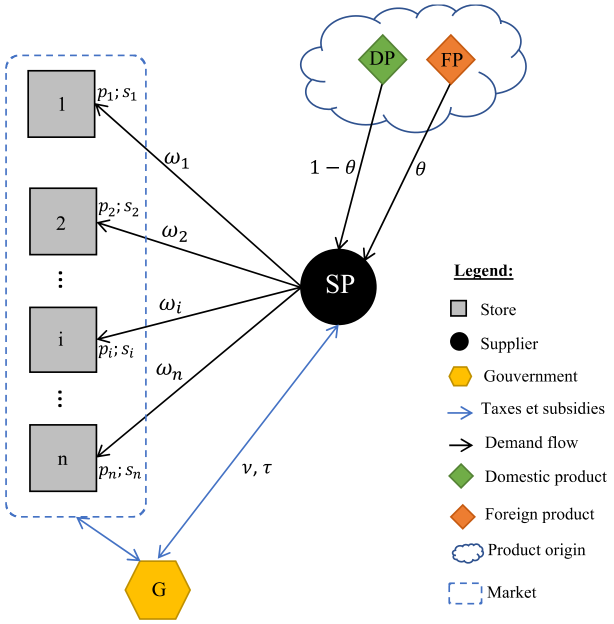

Fig. 1. Theoretical model of a network of stores and one supplier with a government regulation.

Profits within the supply chain are determined by the pricing and sustainability strategies set up by each store. Each store must decide the selling price of its products, taking into account various factors such as operational costs (c_i), negotiated purchase prices (ω_i) with the supplier, sustainability efforts (s_i) deployed, and other parameters. The government intervenes by imposing taxes on CO_2 emissions related to product transportation, while subsidies may be granted to encourage sustainability.

In this model, each store i negotiates the purchase price (ω_i) individually with the supplier, allowing for significant flexibility and customization in business relationships. This freedom to negotiate creates a competitive situation where the supplier and each store i strategically compete to achieve an optimal purchase price (ω_i), considering the competing interests of each actor within the supply chain.

This supply chain model aims to understand interactions and dynamics between actors, configurations, profits, and resilience in a context of promoting local production and sustainable concerns.

1) Assumptions: Within the framework of our supply chain pricing model, several fundamental assumptions are established to simplify and define the context of our analysis. These assumptions define the parameters, relationships and basic conditions governing our system. They are essential for framing our study precisely and rigorously:

- $\mathrm{a, b, k}, \alpha > 0$
- $p_i > (c_i + \omega_i)$
- $\frac{k^2}{2\alpha} > b$
- We consider a monopolistic market configuration at store level;
- A store i is supplied by a single supplier;
- We assume uniform operator numbers for all stores, as we also assume they employ the same value of d_m, So $\forall\, i, A_i = A$;
- The supplier applies different selling prices negotiated with each store i;
- The supplier keeps a reserve quantity (ψ_i) for each store i;
- Each store has fixed costs that are independent of demand (wages, rent, electricity bills, ...);
- The Supplier transports the products to the stores. This transport generates CO_2 emissions, which are taxed by the government;
- It is assumed that all planned requests have been met. In this case, we won't deal with profit expectations, and the model is considered deterministic;
- Products are assumed to have the same quality preference for the customer.

However, in the realm of supply chain and inventory management, the supplier's decision to reserve a specific quantity of goods ψ_i for each order from a store i reflects a strategic approach to ensure the supplier's resilience in the face of market uncertainties. This quantity acts as a buffer, allowing the supplier to respond efficiently to variations in demand and unforeseen disruptions in the supply chain.

Based on the above assumptions, the objective functions of the problem to be modeled are as follows:

- Maximize store profit
- Maximize supplier profit
- Maximize government revenues according to tax/subsidy policies

Table I, presented below, succinctly encapsulates the key sustainability, resilience, and economic parameters employed in the formulated model, serving as a valuable aid for comprehension.

TABLE I. SUSTAINABILITY, RESILIENCE AND ECONOMIC PARAMETERS OF THE MODEL

	Sustainability	Resilience	Economic
Store	s_i, k, α, A_i	θ, ψ_i	p_i , π_i
Supplier	η_i	θ, ψ_i , γ	$\omega_i, \pi_{i,s}$, π_s
Government	λ	θ, ψ_i	τ , ν , π_g

2) Model parameters and variables

d_i : demand quantity at store i
p_i : unit price at store i
s_i : sustainability efforts for store i
a : basic market demand
b : price elasticity
k : elasticity of sustainability effort

c_i : operating unit cost of store i
c : operating unit cost of supplier
F_i : fixed expenses of store i
α : cost coefficient of sustainability effort for store i
d_m : average demand estimated by store i
A_i : number of operators needed to satisfy d_m
λ: social charge per operator to be remitted to the government by a store
y_i : unit cost to be paid to the operator to satisfy d_m
γ : inventory security sensitivity
ψ_i : inventory quantity reserved for store i
η_i : unit cost of CO_2 emission
θ : ratio of quantity of foreign products, $\theta \epsilon [0,1]$
τ : custom fees
ν : government subsidy
ω_i : wholesale price negotiated between supplier and store i
$w_i{}^s$: wholesale price negotiated considering the whole network
π_i : profit of store i
$\pi_{i,s}$: profit of the supplier considering the whole network
π_s : total supplier profit
π_g : total government profit

B. Model Construction and Analysis

In economic analysis, the inverse demand function emerges as a pivotal tool, offering a distinct perspective compared to the conventional demand function, which typically represents quantity demanded as a function of price [36]. This inverse approach articulates the price as contingent upon the quantity demanded, essentially inverting the traditional relationship. For companies, this analytical approach is indispensable for formulating sophisticated pricing strategies.

Similar to the work of [37], [38] the inverse demand equation is given as follows:

$$d_i = a - bp_i + ks_i \quad (1)$$

Based on the work of [39], [40] $C(s_i) = \frac{\alpha s_i{}^2}{2}$, corresponds to the cost of the sustainability effort.

1) Store i strategies: In this sub-section, the store's profitability is studied. So, it can be divided into two components: the first part comprises gains, represented by the product of the price (p_i) and demand (d_i), while the second part encompasses expenses. Among these expenses, some are variable, such as operational costs (c_i) and the negotiated wholesale price between the supplier and store i (ω_i), while others are fixed, such as overhead expenses (F_i), the employee payroll ($A_i y_i$), and sustainability efforts (s_i).

The profit Eq. (2) for store i is given as follows.

$$\pi_i = d_i(-c_i + p_i - \omega_i) - F_i - \frac{\alpha s_i{}^2}{2} - A_i y_i \quad (2)$$

By replacing Eq. (1) in Eq. (2) we get:

$$\pi_i(p_i, s_i) = -bp_i{}^2 + p_i(a + ks_i + b\omega_i) - \frac{\alpha s_i{}^2}{2} - c_i(a - bp_i + ks_i) - (a + ks_i)\omega_i - F_i - A_i y_i \quad (3)$$

According to this equation, a store has two strategies: The price to apply and the sustainability effort to adopt.

Assuming now that the store focuses only on the price strategy. The price to achieve maximum profit is:

$$p_i{}^* = \frac{1}{2}\left[\frac{a+ks_i}{b} + (c_i + \omega_i)\right] \quad (4)$$

It can be seen that the selling price increases as the sustainability effort increases. It is also influenced by the purchase price ω_i and operating costs.

Price elasticity tends to eliminate the effect of sustainability effort. For this reason, we assume that $k > b$.

Proof. Maximum profit is sought by deriving the profit function π_i.

$$\frac{d\pi_i}{dp_i} = -2bp_i + a + b(c_i + \omega_i) + ks_i$$

We have: $\frac{d^2\pi_i}{d^2p_i} = -2b \leq 0$ thus, the function admits a maximum. This maximum is obtained by solving $\frac{d\pi_i}{dp_i} = 0$

Since $p_i{}^*(s_i)$ has the equation of a straight line and $\frac{dp_i{}^*}{ds_i} = \frac{k}{2b} > 0$. Then the function is increasing with respect to s_i.

Furthermore, assuming that the store wishes to use the sustainability strategy to attract more demand. The sustainability effort to achieve maximum profit is:

$$s_i{}^* = \frac{k(p_i - (c_i + \omega_i))}{\alpha} \quad (5)$$

According to this result, an increase in price has an impact on the sustainability effort. The sustainability effort cancels out in the case where the sustainability effort coefficient α is equal to the sustainability elasticity K. In this case, s_i will correspond to the marginal profit.

The purchase price to be negotiated affects the sustainability effort. The store has no interest in having a purchase cost ω_i, zero.

Proof. Maximize profit by seeking the value of s_i

$\frac{d\pi_i}{ds_i} = -kc_i + kp_i - \alpha s_i - k\omega_i$;

Since $\frac{d^2\pi_i}{d^2s_i} = -\alpha \leq 0$ o the function admits a maximum, obtained when $\frac{d\pi_i}{ds_i} = 0$.

Since $s_i{}^*(p_i)$ has the equation of a line and $\frac{ds_i{}^*}{dp_i} = \frac{k}{\alpha} > 0$. Then the function is increasing with respect to s_i.

In the model shown, the store actually has two strategies to apply to improve profit. In this case, $s_i{}^*$, and $p_i{}^*$are always profit-maximizing solutions.

Proof. The hessian matrix is as follows:

$$\boldsymbol{H}\,[\pi_i(p_i, s_i)] = \begin{pmatrix} -2b & k \\ k & -\alpha \end{pmatrix}$$

$\boldsymbol{Det}(\boldsymbol{H}) = -k^2 + 2b\alpha$
$\boldsymbol{Tr}(\boldsymbol{H}) = -(2b + \alpha)$

Since $\boldsymbol{Det}(\boldsymbol{H}) > \mathbf{0}$ **et** $\boldsymbol{Tr}(\boldsymbol{H}) < 0$, then $\pi_i(p_i, s_i)$ admits a maximum in:

$$\begin{cases} {p_i}^* = \dfrac{1}{2}\left[\dfrac{a + ks_i}{b} + (c_i + \omega_i)\right] \\ {s_i}^* = \dfrac{k[p_i - (c_i + \omega_i)]}{\alpha} \end{cases}$$

Maximum profit can therefore be written as:

$$\max(\pi_i) = -\frac{k^2 p_i^2}{2\alpha} - \frac{k^2 s_i^2}{4b} - \frac{k^3 s_i(c_i + w_i)}{2b\alpha} + \frac{1}{2b\alpha} p_i\left(k^3 s_i + k^2\left(a + b(c_i + w_i)\right)\right) + \frac{\alpha(a^2 + b^2 c_i^2) - 2c_i(a(k^2 + b\alpha) - b^2\alpha w_i) + w_i(-2a(k^2 + b\alpha) + b^2\alpha w_i)}{4b\alpha} - (F_i + A_i y_i)$$

We'll try to analyze the price that store i will negotiate with the supplier so that the store ensures maximum profit. In this case, we assume that the store is the leader.

So, we replace Eq. (5) in Eq. (4). We then obtain the negotiated price $\widehat{w_i}$**:**

$$\widehat{w_i} = \frac{a\alpha + (k^2 - 2b\alpha)p_i}{k^2 - b\alpha} - c_i \tag{6}$$

2) Supplier strategies: In this sub-section, we focus on the supplier's profit in the supply chain. Firstly, we study the supplier's profitability in relation to store i, then the profitability in the whole network.

The profit function is as follows:

$$\pi_s = \sum_{i=1}^{n} \pi_{i,s} - C(\tau) + I(\nu) \tag{7}$$

With $\sum_{i=1}^{n} d_i = D, C(\tau) = \tau.\theta D, I(\nu) = (1 - \theta)\nu D$

$C(\tau)$ corresponds to the customs fees that the supplier pays to the government for the percentage θ of the quantities imported. On the other hand, the supplier receives a government subsidy $I(\nu)$ for the percentage $(1 - \theta)$ of quantities made from local suppliers.

a) The supplier's strategy, considering its profit in relation to a store i

The supplier's profit is written as follows:

$$\pi_{i,s} = d_i(\omega_i - c - \eta_i) - \gamma\omega_i\psi_i \tag{8}$$

Replacing Eq. (1) in Eq. (8) gives the following equation:

$$\pi_{i,s} = -a(c + \eta_i) - \gamma\omega_i\psi_i + bp_i(c + \eta_i - \omega_i) + a\omega_i - ks_i(c + \eta_i - \omega_i)$$

The supplier focuses solely on the pricing strategy. Always considering that the store is the leader and the supplier is the follower, we obtain the price that allows us to reach the maximum as follows:

$${\omega_i}^* = \frac{(c_i + c + \eta_i)}{2} + \frac{a}{2b} + \frac{k^2(ks_i - \gamma\psi_i - 2bc_i)}{2b(k^2 + b\alpha)} \tag{9}$$

To be able to offer a price, the supplier needs to have information on the sustainability effort of store i. It is also influenced by the cost of emissions CO_2 η_i.

Proof. To find the maximum profit, we derive the profit function π_s

$$\frac{d\pi_s}{d\omega_i} = a + bc + \frac{ab\alpha}{k^2} + \frac{b^2 c\alpha}{k^2} - bc_i + \frac{b^2\alpha c_i}{k^2} + ks_i + 2(-b - \frac{b^2\alpha}{k^2})w_i + b\eta_i + \frac{b^2\alpha\eta_i}{k^2}$$

We have: $\frac{d^2\pi_i}{d^2\omega_i} = -2(b + \frac{b^2\alpha}{k^2}) \leq 0$, then the function admits a maximum. This maximum is obtained by solving $\frac{d\pi_i}{d\omega_i} = 0$

Since ${\omega_i}^*(s_i)$ has the equation of a straight line and $\frac{d{p_i}^*}{ds_i} = \frac{k}{2b} > 0$. Then the function is increasing with respect to s_i.

To calculate the Supplier's profit, we first calculate the profit for each store i.

$$\frac{d\pi_i}{dp_i} = -2bp_i + a + b(c_i + \omega_i) + ks_i$$

The Eq. (9) aims to determine the wholesale price ${\omega_i}^*$ negotiated by the supplier in the context of sustainability, the supply chain, and operational costs. Two key parameters, k (sustainability effort elasticity) and α (the cost coefficient of sustainability effort), play a crucial role.

Thus, k measures how consumers respond to the sustainability efforts undertaken by store i. A high k value indicates a strong consumer response to sustainability, meaning they are willing to purchase more sustainable products. Consequently, the supplier may consider raising the wholesale price ${\omega_i}^*$ without compromising demand. Consumers are willing to pay a premium for sustainable products, which can increase the supplier's profit margin. However, α quantifies the costs associated with the sustainability initiatives of store i. A high α indicates higher costs to implement sustainable practices, such as using environmentally friendly materials or reducing carbon emissions. These additional costs can exert upward pressure on the wholesale price ${\omega_i}^*$ negotiated by the supplier. The supplier must offset these costs to maintain profit margins.

b) The supplier's strategy, considering the whole network: In this section, it is necessary to focus on the overall profit of the supplier of the whole network, which will incorporate other elements not directly dependent on the store's demands. Thus, we will attempt to break down the overall profit of the supplier, as provided in Eq. (7). The total demand is expressed as follows:

$$\mathrm{D} = an - b\sum_{i=1}^{n} p_i + k\sum_{i=1}^{n} s_i \tag{10}$$

Based on the work of [41], it is possible to consider φ as an endogenous decision variable, with: $\varphi = \frac{p_i - w_i}{p_i}$ where $\varphi \in [0,1]$. Therefore, we can write $p_i = \frac{w_i}{(1-\varphi)}$.

Similarly, and based on the results obtained during the analysis of store-level strategies, we know that sustainability efforts s_i directly impact the price offered p_i by the store. Therefore, we can propose a simple linear equation to express sustainability effort as a function of price, thus creating an equation as follows: $s_i = \Omega p_i,\ \Omega > 0$

When we substitute, Eq. (7) will be then expressed in the following form:

$$\pi_s = anU + (a-b)\sum_{i=1}^{n} w_i - bU\sum_{i=1}^{n}\frac{w_i}{1-\varphi} - k\left(U\sum_{i=1}^{n}\frac{\Omega w_i}{1-\varphi} + \sum_{i=1}^{n}\frac{\Omega w_i(w_i-\eta_i)}{1-\varphi}\right) - a\sum_{i=1}^{n}\eta_i + b\sum_{i=1}^{n}\frac{w_i\eta_i}{1-\varphi} - \gamma\sum_{i=1}^{n} w_i\psi_i \quad (11)$$

With, $U = c - \nu + \theta(\nu - \tau)$

Based on this equation, we will attempt to examine potential strategies for the supplier, including the wholesale price and the inventory quantity reserved for store i (ψ_i), to improve supply chain resilience.

$$w_i{}^s = \frac{1}{2k\Omega}[(a-b-\gamma\psi_i)(1-\ \varphi) + (b+k\Omega)(-U+\eta_i)]$$

$$w_i{}^s = \frac{1}{2k\Omega}[(a-b-\gamma\psi_i)(1-\ \varphi) + (b+k\Omega)(-c+\nu-\theta(\nu-\tau)+\eta_i)] \quad (12)$$

Proof. To find the maximum profit, we derive the profit function π_s

$$\frac{d\pi_s}{d\omega_i} = a - b - \frac{bU}{1-\varphi} - \frac{b\eta_{\mathrm{i}}}{-1+\varphi} - k(-\frac{U\Omega}{-1+\varphi} + \frac{2\Omega w_{\mathrm{i}} + \Omega\eta_{\mathrm{i}}}{1-\varphi}) - \gamma\psi_{\mathrm{i}}$$

We have: $\frac{d^2\pi_i}{d^2\omega_i} = -k\frac{2\Omega w_{\mathrm{i}}}{1-\varphi} \leq 0,$ then the function admits a maximum. This maximum is obtained by solving $\frac{d\pi_i}{d\omega_i} = 0$

c) Resilience and wholesale price analysis: First and foremost, it is essential to emphasize that the chosen model in this article involves the incorporation of imports to meet a portion of the store's demand from overseas. This strategic decision is made with the primary aim of enhancing the resilience of the supply chain. Consequently, it becomes crucial to examine the wholesale price concerning this resilience concept.

Now, let's explore how the wholesale price behaves within the context of government subsidies, customs fees, and the supplier's flexibility in adjusting φ to impact wholesale prices. This analysis will provide a comprehensive understanding of the dynamics at play in the supply chain and its price regulation.

The Eq. (12) represents the wholesale price offered by the supplier as a function of the level of imported quantities $w_i{}^s(\theta)$, taking into account government subsidies ν and custom fees τ. When ν is high, meaning that the government offers generous subsidies for local products, the function tends to decrease with an increase in ν (i.e., an increase in imports). In other words, government subsidies reduce the wholesale price to encourage local production and reduce dependence on imports.

However, when τ is high, indicating substantial custom fees imposed on imports, the function $w_i{}^s(\theta)$, tends to increase with an increase in θ,. Additional customs fees raise the cost of imports, which can result in higher wholesale prices for imported products.

This means that the government plays a significant role in market price regulation. Furthermore, the supplier can adjust φ to slightly lower or raise wholesale prices, but with a limited variation.

Proof. The expression for the slope of the line in the Eq. (12) is as follows: $m = \frac{1}{2\mathrm{k}\Omega}(\tau - \nu)$. So, when $\nu > \tau$ (government subsidies exceed customs fees), $(\tau - \nu)$ is negative.

This results in a positive slope (m > 0), indicating a positive incline of the line.

Conversely, when $\nu < \tau$ (government subsidies are less than customs fees), $(\tau - \nu)$ becomes positive.

This yields a negative slope (m < 0), signifying a negative incline of the line

d) Sustainability effort elasticity impact on wholesale prices: Furthermore, an analysis regarding the elasticity of sustainability effort (k) highlights that with a high k, the function becomes more responsive to variations in θ. An increase in θ (more imports) can lead to a more significant rise in wholesale prices when sustainability effort is high. This indicates that an increased commitment to sustainability can have a greater impact on the supplier's pricing decisions. On the other hand, for a low value of (k), indicating low elasticity of sustainability effort, the wholesale price will be less sensitive to variations in (θ). An increase in (θ) may have a less significant impact on wholesale prices when sustainability effort is low. In this case, other factors, such as government subsidies and customs fees, may play a more prominent role in determining wholesale prices.

3) Government strategies: The government derives its profit from the taxes it imposes on the quantities of products imported from abroad. In this government profit formulation, we must include not only the total quantities ordered by the stores but also the safety quantities planned by the supplier to ensure resilience. Furthermore, within the context of government profit analysis and sustainability considerations, we take into account social charges. These charges, directed towards essential programs such as healthcare and pensions, play a crucial role in bolstering stability, alleviating poverty, supporting employment, and promoting social equity, thereby contributing to a more sustainable and equitable society.

The profit equation for the government is given as follows:

$$\pi_g = [\theta(\tau+\nu) - \nu]\sum_{i=1}^{n}(d_i + \psi_i) + \lambda\frac{A}{d_m}\sum_{i=1}^{n} d_i \quad (13)$$

When examining government strategies, the focal point is the calibration of tax rates and subsidies to boost the consumption of domestic products, all the while taking into account the challenges associated with sustainability and resilience. To conduct this analysis and streamline the study, we will rely on the wholesale price of the supplier examined in the preceding section.

Pour faciliter l'analyse, nous allons tenir compte de des subventions.

The government profit function can be written as follows:

$$\pi_g(\nu) = ((-1+\theta)\nu + \theta\tau)(an + \frac{k\Omega - b}{1-\varphi}\sum_{i=1}^{n} w_i + \frac{n(b+k\Omega)(-c+\nu-\theta(\nu-\tau))}{2k\Omega} + \frac{(b+k\Omega)}{2k\Omega}\sum_{i=1}^{n}\eta_i + \frac{(1-\varphi)}{2k\Omega}[n(a-b) - \gamma\sum_{i=1}^{n}\psi_i]) + \frac{\alpha A n\lambda}{d_m} + \frac{A\lambda(-b+k\Omega)}{d_m\ (1-\varphi)}\sum_{i=1}^{n} w_i \quad (14)$$

To simplify the analysis, we will only consider the government subsidy parameter. Indeed, addressing the government profit function has allowed us to obtain an optimal government subsidy that maximizes this profit function. So, Eq. (15) provides the government subsidy that maximizes the profit function $\pi_g(\nu)$.

$$\nu^* = \frac{n^2(c-\overline{\eta})}{2(1-\theta)} + \frac{1}{2(b+\mathrm{k}\Omega)(1-\theta)}\left[2\mathrm{k}\Omega\left(1 - n^2\frac{(b-\mathrm{k}\Omega)}{-1+\varphi}\overline{w}\right) + (n^2\gamma\overline{\psi} + a - b)(1-\varphi)\right)\Big] \quad (15)$$

With,

$$\sum_{i=1}^{n}\eta_i = n\overline{\eta}, \sum_{i=1}^{n} w_i = n\overline{w}, \sum_{i=1}^{n}\psi_i = n\overline{\psi}$$

Proof. To find the maximum profit, we derive the profit function $\pi_g(\nu)$.

We have: $\frac{d^2\pi_g}{d^2\nu} = -\frac{(b+\mathrm{k}\Omega)n(-1+\theta)^2}{\mathrm{k}\Omega} \leq 0$, then the function admits a maximum. This maximum is obtained by solving $\frac{d\pi_g}{d\nu} = 0$

The Eq. (15) suggests that the government subsidy ν is determined based on a combination of factors related to the number of stores, operating costs, sustainability sensitivity, price elasticity, and various parameters associated with sustainability efforts and costs. The quotient (Ω) highlights the importance of sustainability efforts relative to the price of the product, indicating that the government subsidy is influenced by the sustainability quotient.

Moreover, the government subsidy (ν) reveals a nuanced relationship with the parameter θ, representing the ratio of the quantity of foreign products in the market. The presence of (θ) in the equation underscores the government's strategic approach to balancing the consumption of domestic and foreign products. As (θ) increases, indicating a higher reliance on imported goods, the government subsidy adjusts to incentivize and support domestic product consumption. This reflects the government's commitment to fostering economic resilience by promoting a balance between local and international products.

IV. Numerical Analysis

In this part, numerical analysis is employed to validate the conclusions drawn in the preceding section. The focus is on exploring sustainability and resilience within logistics supply chains concerning pricing strategies and sustainability efforts. Additionally, government interventions in the logistics system are addressed, considering the constraints previously outlined in this paper. The numerical values chosen for this analysis are derived from a comprehensive examination of existing literature, ensuring alignment with established methodologies. Moreover, these values are thoughtfully selected based on the specific assumptions outlined in our study, thereby enhancing the overall validity and reliability of our numerical approach.

A. Price, Sustainability, and Profit Analysis on the Store Side

To assess the optimal price for a store concerning sustainability parameters, the analysis highlights a positive correlation between the store's price and its sustainability effort, as illustrated in Fig. 2. This positive relationship remains consistent across different scenarios of sustainability effort elasticity (k), suggesting that higher values amplify the price (p_i) response to changes in sustainability initiatives (s_i). Practically, as the store strengthens its commitment to sustainability increases, there is a notable rise in product prices, with this response being particularly pronounced with higher values. Additionally, the wholesale price (ω_i) plays a crucial role in determining the baseline cost and influencing the overall pricing structure.

However, in analyzing the store's profit through optimal sustainability efforts as illustrated in Fig. 3, one can also observe the correlation of sustainability (s_i) with the price (p_i) set by the store. Nevertheless, the cost coefficient of sustainability effort (α) for store plays a crucial role in adjusting this correlation.

Furthermore, concerning the store's profit, sustainability effort elasticity (k) affects this profit. It can be observed in Fig. 4 that a small variation in profit is guaranteed when the sustainability effort elasticity coefficient (k) is small. Conversely, when this coefficient (k) is large, it is noticeable that it increases profit with a significant variation relative to the price.

$a = 100, b = 1, F = 30, A = 50, y = 2, \alpha = 0.2,$

$w = 40, c_i = 10, s_i = 11$

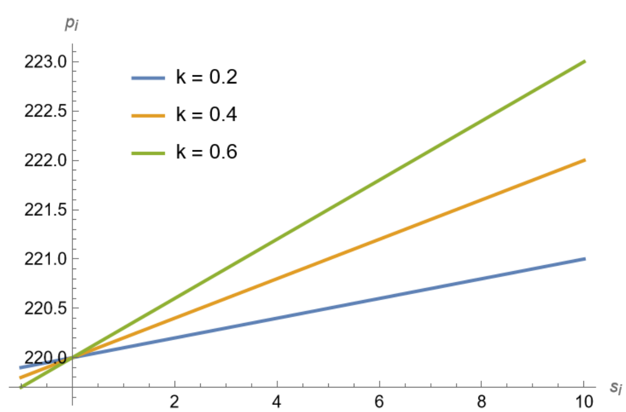

Fig. 2. Correlating Optimal store prices with sustainability parameters.

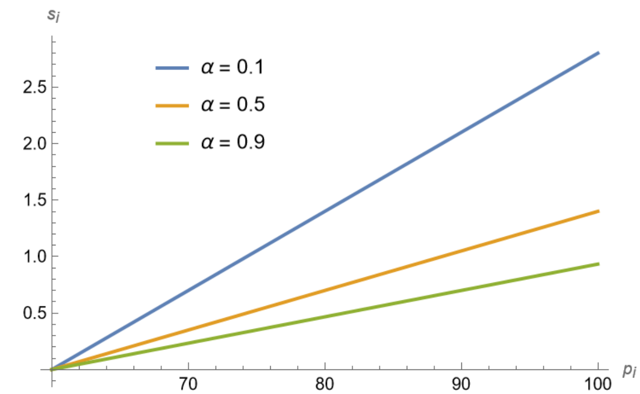

Fig. 3. Correlating Optimal sustainability effort store price.

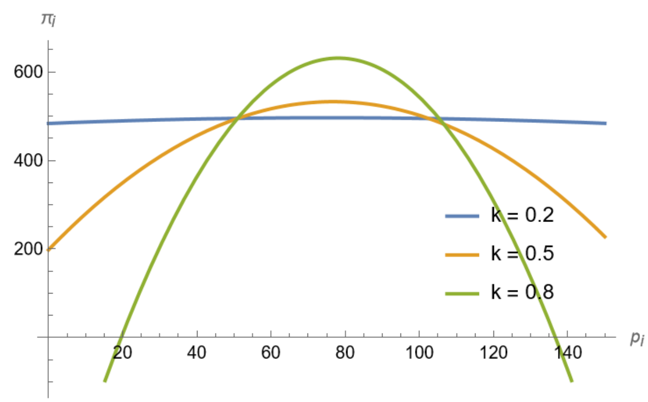

Fig. 4. Influence of sustainability effort elasticity on store profit.

In the same context, the store is tasked with determining the purchase price (p_i) for negotiation with the supplier. Our analysis delves into the interplay between this purchase price (p_i) and two pivotal parameters: (α), the cost coefficient of sustainability effort for the store, and (k), the elasticity of sustainability effort. This investigation is illustrated in Fig. 5, where specific values for α (0.01, 0.2, and 0.4) were selected to explore the nuanced dynamics of sustainability and pricing strategies.

The graph in Fig. 5 demonstrates that as sustainability sensitivity (k) increases, reflecting a greater commitment to sustainability, the store encounter a corresponding upward trend in optimal negotiation costs ($\widehat{w_i}$). This implies that striving for higher sustainability standards may necessitate the store to allocate additional resources to negotiation processes, potentially incurring higher expenses. The impact of this relationship varies based on the sustainability cost coefficient (α), with lower (α) values resulting in a relatively moderate increase in negotiation costs as sustainability sensitivity rises. This suggests that stores with lower sustainability costs may find it economically feasible to invest more in negotiations for enhanced sustainability.

B. *Partial Supplier Profit Case*

The relevant parameters are assigned as:

$c = 10, \eta = 2, a = 50, b = 0.2, \gamma = 5, \psi = 4, c_i = 2$

Sustainability Coefficient (α) and Optimal Price (ω_i): The graph in the Fig. 6 depicts the variation in the optimal price ω_i as a function of the sustainability coefficient (α) for different values of the elasticity of sustainability effort (k). This illustrates how the optimal price of a product or service changes in response to variations in the sustainability coefficient, which can be interpreted as a measure of a company's commitment to sustainable practices. The different curves for k = 0.1, 0.5 and 0.9 show how the elasticity of sustainability effort affects the sensitivity of the optimal price to changes in sustainability.

Impact of Sustainability Effort Elasticity (k): The curves reveal that the optimal price reacts differently to changes in the sustainability coefficient (α) depending on the value of the elasticity of sustainability effort (k). For instance, a higher value of k (k = 0.9) demonstrates a greater responsiveness of the optimal price to sustainability variations compared to a lower value of k (k = 0.1). This suggests that, in this model, an increased commitment to sustainability (increasing α) has a more significant impact on price when the elasticity of sustainability effort is higher.

Profit Optimization and Sustainability: The model appears to seek a balance between profit maximization (represented by the optimal price formula) and the promotion of sustainable practices (embodied by the sustainability coefficient α). Price variations in response to changes in α and k may indicate how a company can adjust its prices to achieve its economic objectives while promoting sustainability, which has significant implications for decision-making in a business context.

$a = 100$, $b = 1$, $\Omega = 3$, $\gamma = 0.5$, $\phi = 0.2$, $\psi = 0.7$, $c = 20$, $\nu = 10$, $\theta = 0.4$, $\tau = 0.8$, $\eta = 0.5$, $\alpha = 0.01$

Exploring equilibrium wholesale prices involves an examination of the negotiated purchase price ($\widehat{w_i}$) by the store to optimize its profit and the selling price (${w_i}^s$) set by the supplier for store i. The graph in Fig. 7 reveals the intersection, indicating an equilibrium price where the curves representing both prices meet. Additionally, we underscore the significance of the sustainability sensitivity coefficient (k) in this analysis.

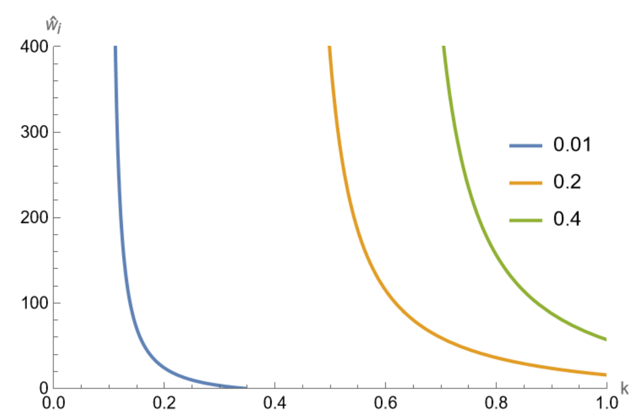

Fig. 5. Comparative analysis of optimal negotiation price and sustainability parameters.

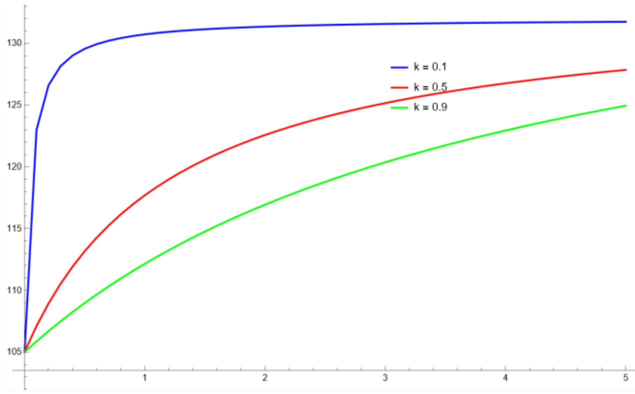

Fig. 6. Wholesalse price in function of sustainability coefficient k.

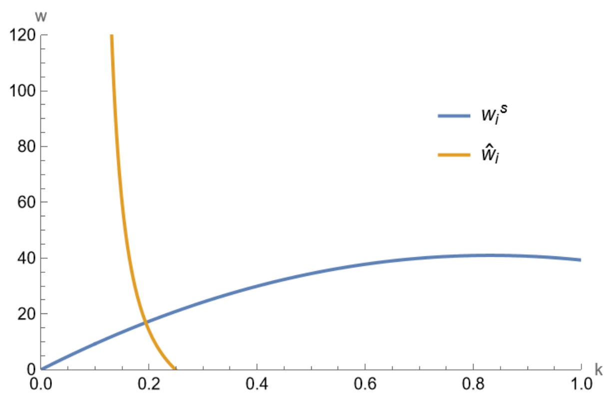

Fig. 7. Equilibrium wholesale prices.

C. Supplier Chain Resilience

In an effort to investigate the resilience of the supply chain, we have constructed a set of numerical values given in Table II. The objective is to analyze the profits of both the government and the supplier. The numerical data within the table offers a comprehensive view of how variations in parameters, such as the rate of foreign products (θ) and inventory security sensitivity (γ), impact the financial outcomes for both key stakeholders in the supply chain. This analysis provides valuable insights into the resilience of the supply chain under different conditions and aids in decision-making related to supply chain management strategies.

TABLE II. IMPACT OF SUSTAINABILITY AND RESILIENCE PARAMETERS ON GOVERNMENT AND SUPPLIER PROFITS

θ	λ	π_s	π_g
0.39	0.3	1101.00	40291
0.39	0.54	1065.29	38371
0.39	0.78	1029.59	36451
0.59	0.3	5530.22	39956.7
0.59	0.54	5368.52	38036.7
0.59	0.78	5206.82	36116.7
0.79	0.3	9981.19	39622.4
0.79	0.54	9693.49	37702.4

V. RESULTS AND DISCUSSION

In this section, our attention is directed towards a comprehensive examination of the outcomes derived from the implemented model and numerical analyses. Subsequently, the ensuing discourse will meticulously explore the findings pertaining to profit maximization for each stakeholder, specifically, the store, the supplier, and the government.

Within this framework, stores wield authority over pricing and sustainability strategies, while the supplier assumes responsibility for distribution and inventory management. Simultaneously, the government plays a crucial role by enforcing regulations, particularly through taxation and subsidies, with an emphasis on both domestic and foreign products. Central to our investigation is the resilience of this supply chain, where we take into account various factors such as security stock, the social impact of stores, and the diversification of supply sources. Our primary objective was to comprehensively analyze the dynamic interplay within this supply chain, with a particular emphasis on sustainability, resilience and the promotion of domestic production.

Each stakeholder of the supply chain; namely the store, the supplier, and the government, adopt strategies to maximize their profits. Regarding the store i, the model presents two strategies for improving profit, with $s_i{}^*$and $p_i{}^*$as always profit-maximizing solutions. From the supplier's perspective, the first strategy centers on calibrating the optimal wholesale price ($\omega_i{}^*$) in a manner that harmonizes sustainability commitments with supply chain. The second strategy expands this focus to encompass the broader network, seeking to establish a wholesale price ($w_i{}^s$) that incorporates resilience metrics, thus ensuring profit maximization across the network. On the governmental front, the strategies revolve around custom fees (τ) on international imports and subsidies (ν) to bolster the competitiveness of domestic products, balancing international trade with local economic encouragement.

Sustainability emerges as a key point in the main conclusions of this study, particularly in its influence on pricing strategies within supply chains. Firstly, a store's pricing strategy is closely linked to its sustainability efforts (s_i), with the cost coefficient of these efforts (α) playing a significant role in shaping pricing (p_i). The elasticity of sustainability efforts (k) is found to directly impact profit margins (π_i) where a lower elasticity results in smaller profit variations, and a higher elasticity leads to more substantial profit fluctuations relative to price changes. Additionally, as a store intensifies its commitment to sustainability, it incurs higher negotiation costs ($\widehat{w_i}$), though this is less burdensome for stores with lower associated sustainability costs (α). The optimal price ($\omega_i{}^*$) of a product is thus affected by the company's sustainability commitment (α) and its responsiveness to sustainability efforts (k), with more responsive companies experiencing more significant pricing effects. This indicates a strategic imperative for businesses to align pricing with sustainability objectives, balancing environmental considerations with the aim of profit optimization.

Resilience in the model is a keystone of the supplier's strategy, by allocating reserved inventory quantities (ψ_i) in wholesale prices for each store i. This approach ensures that pricing and stock level decisions are in concert with the overarching ambition to fortify the supply chain's robustness. Parallel to this, the government's regulatory role is crucial in preserving a delicate balance between encouraging domestic products and regulating the import of foreign products, thereby providing more flexibility to diversify the product sources and underpinning economic resilience. Indeed, the resilience of the supply chain, as examined through numerical analysis, is affected by parameters like the rate of foreign products (θ) and inventory security sensitivity (γ), which in turn influence the profits of both the government and the supplier.

The equilibrium wholesale price is found at the intersection of the store's purchase price and the supplier's selling price, with the sustainability sensitivity coefficient being a significant factor in this determination. This convergence underscores the indispensable importance of collaboration among supply chain stakeholders in achieving optimal profits. Through a synergistic partnership, suppliers, stores, and government entities can refine sustainability efforts.

VI. Conclusion

Sustainability and resilience have become essential pillars in the formulation of pricing policies, ensuring that economic strategies are adaptive and viable over the long term. These concepts, grounded in economic significance as demonstrated by the literature, require in-depth analysis of how pricing policies and governmental regulatory measures, such as the promotion of domestic products, can coexist to strengthen the sustainability and resilience of supply chains.

This study addresses the under-researched interplay between sustainability, resilience, and the promotion of domestic products within supply chains, offering new approaches for tackling the complex challenges in supply chain management. It highlights the unexpected competitive dynamics that can occur even for monopolistic suppliers when they supply and compete with their stores. Our supply chain management model scrutinizes the intricate interactions among three pivotal entities: a central supplier, multiple stores, and the government.

The supply chain framework is analyzed with a focus on the roles of stores, suppliers, and the government. Stores control pricing and sustainability strategies, suppliers manage distribution and inventory, and the government enforces regulations, including taxation and subsidies. The study emphasizes the resilience of the supply chain, considering factors like security stock, social impact, and diversification of supply sources. Stakeholders adopt profit-maximizing strategies, with stores having two pricing strategies linked to sustainability efforts. Suppliers focus on optimal wholesale prices aligned with sustainability and resilience metrics. Government strategies involve custom fees and subsidies to balance international trade and support domestic products. Sustainability efforts significantly influence pricing strategies, with lower elasticity resulting in smaller profit variations. Resilience is crucial for suppliers, involving reserved inventory quantities. Government regulation balances encouraging domestic products with regulating imports, enhancing economic resilience. The equilibrium wholesale price is determined by collaboration among stakeholders, emphasizing the importance of a synergistic partnership for optimal profits and sustainability efforts.

It is crucial to elucidate the limitations of our study, providing researchers with valuable context. The main limitation of the model developed in this research lies in its assumption that demand is deterministic, a simplification that does not reflect the dynamic and often unpredictable reality of the market. In practice, consumer demand is subject to fluctuations influenced by various factors such as changing preferences, competition, and economic conditions. This deterministic approach can lead to inaccurate forecasts and suboptimal decisions in a real business context. To enhance the practical relevance of this study, it would be crucial to explore more sophisticated models that incorporate demand variability, allowing companies to better adapt to market changes and optimize their strategies by considering inherent uncertainties.

Looking ahead, a prospective avenue for upcoming research studies involves extending the current model to incorporate a more complex network structure. This expansion would enable a more in-depth exploration of the cooperative dynamics among supply chain stakeholders. A particular focus should be placed on developing a stochastic model to better align with the real-world scenario where demand is variable, allowing for a more accurate representation of uncertainties. The objective is to examine whether the observed impacts in this study persist or if new patterns emerge within the intricacies of a larger supply chain network. Such an investigation could significantly enrich our understanding of supply chain sustainability, resilience, and collaboration by providing insights that are more reflective of the complexities and uncertainties inherent in real-world demand dynamics.

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Conflicts of Interest

Authors declare no conflict of interest.

References

[1] D. Saidi, J. E. Alami, et M. Hlyal, « Building Sustainable Resilient Supply Chains in Emerging Economies: Review of Motivations and Holistic Framework », IOP Conf. Ser.: Earth Environ. Sci., vol. 690, no 1, p. 012057, mars 2021, doi: 10.1088/1755-1315/690/1/012057.

[2] D. Saidi, J. El Alami, et M. Hlyal, « Sustainable Supply Chain Management: review of triggers, challenges and conceptual framework. », in IOP Conference Series: Materials Science and Engineering, IOP Publishing, 2020, p. 012054.

[3] D. Saidi, K. Jharni, J. Alami, et M. Hlyal, « WHAT MODELING APPROACHES USED FOR A SUSTAINABLE RESILIENT SUPPLY CHAIN », Journal of Theoretical and Applied Information Technology, vol. Vol.100, p. 35, déc. 2022, doi: 10.5281/zenodo.7542949.

[4] A. Ranjan et J. K. Jha, « Pricing and coordination strategies of a dual-channel supply chain considering green quality and sales effort », Journal of Cleaner Production, vol. 218, p. 409-424, 2019, doi: 10.1016/j.jclepro.2019.01.297.

[5] H. Rajabzadeh et R. Babazadeh, « A game-theoretic approach for power pricing in a resilient supply chain considering a dual channel biorefining structure and the hybrid power plant », Renewable Energy, vol. 198, p. 1082-1094, 2022, doi: 10.1016/j.renene.2022.08.118.

[6] A. De et S. P. Singh, « A resilient pricing and service quality level decision for fresh agri-product supply chain in post-COVID-19 era », International Journal of Logistics Management, vol. 34, no 4, p. 1101-1140, 2023, doi: 10.1108/IJLM-02-2021-0117.

[7] S. Amiri-Pebdani, M. Alinaghian, et S. Safarzadeh, « Time-Of-Use pricing in an energy sustainable supply chain with government interventions: A game theory approach », Energy, vol. 255, p. 124380, sept. 2022, doi: 10.1016/j.energy.2022.124380.

[8] A. Jafari-Nodoushan, M. H. D. Sadrabadi, M. Nili, A. Makui, et R. Ghousi, « Designing a sustainable disruption-oriented supply chain under joint pricing and resiliency considerations: a case study », Computers & Chemical Engineering, p. 108481, oct. 2023, doi: 10.1016/j.compchemeng.2023.108481.

[9] I. E. Nielsen, S. Majumder, S. S. Sana, et S. Saha, « Comparative analysis of government incentives and game structures on single and two-period green supply chain », Journal of Cleaner Production, vol. 235, p. 1371-1398, oct. 2019, doi: 10.1016/j.jclepro.2019.06.168.

[10] J.-Y. Chen, S. Dimitrov, et H. Pun, « The impact of government subsidy on supply Chains' sustainability innovation », Omega, vol. 86, p. 42-58, juill. 2019, doi: 10.1016/j.omega.2018.06.012.

[11] A. Toptal, H. Özlü, et D. Konur, « Joint decisions on inventory replenishment and emission reduction investment under different emission regulations », International Journal of Production Research, vol. 52, no 1, p. 243-269, janv. 2014, doi: 10.1080/00207543.2013.836615.

[12] B. Zhang et L. Xu, « Multi-item production planning with carbon cap and trade mechanism », International Journal of Production Economics, vol. 144, no 1, p. 118-127, juill. 2013, doi: 10.1016/j.ijpe.2013.01.024.

[13] X. Chen, X. Wang, V. Kumar, et N. Kumar, « Low carbon warehouse management under cap-and-trade policy », Journal of Cleaner Production, vol. 139, p. 894-904, déc. 2016, doi: 10.1016/j.jclepro.2016.08.089.

[14] D. Krass, T. Nedorezov, et A. Ovchinnikov, « Environmental Taxes and the Choice of Green Technology », Production and Operations Management, vol. 22, no 5, p. 1035-1055, 2013, doi: 10.1111/poms.12023.

[15] B. Yalabik et R. J. Fairchild, « Customer, regulatory, and competitive pressure as drivers of environmental innovation », International Journal of Production Economics, vol. 131, no 2, p. 519-527, juin 2011, doi: 10.1016/j.ijpe.2011.01.020.

[16] Z. Yanju, H. Fengying, et Z. Zhenglong, « Study on joint contract coordination to promote green product demand under the retailer-dominance », Journal of Industrial Engineering and Engineering Management, vol. 34, no 2, p. 194-204, 2020, doi: 10.13587/j.cnki.jieem.2020.02.021.

[17] K. Yan, G. Hua, T. Cheng, T. Choi, J. Dong, et X. Li, « Optimal Pricing and Quality Decisions Under Cooperative Promotion of Cross-Market Service Platforms », IEEE Transactions on Engineering Management, p. 1-25, 2023, doi: 10.1109/TEM.2023.3301886.

[18] H. Yang et W. Chen, « Retailer-driven carbon emission abatement with consumer environmental awareness and carbon tax: Revenue-sharing versus Cost-sharing », Omega, vol. 78, p. 179-191, juill. 2018, doi: 10.1016/j.omega.2017.06.012.

[19] Q. Li et B. Shen, « Sustainable Design Operations in the Supply Chain: Non-Profit Manufacturer vs. For-Profit Manufacturer », Sustainability, vol. 8, no 7, Art. no 7, juill. 2016, doi: 10.3390/su8070639.

[20] Z. H. Adnan, K. Chakraborty, S. Bag, et J. S. Wu, « Pricing and green investment strategies for electric vehicle supply chain in a competitive market under different channel leadership », Annals of Operations Research, 2023, doi: 10.1007/s10479-023-05523-y.

[21] A. M. Ledari, A. A. Khamseh, et B. Naderi, « Pricing Models for a Two-echelon Supply Chain with Substitute and Complementary Products Considering Disruption Risk », International Journal of Supply and Operations Management, vol. 10, no 2, p. 187-208, 2023, doi: 10.22034/ijsom.2022.108726.1903.

[22] A. A. Taleizadeh, A. Ghavamifar, et A. Khosrojerdi, « Resilient network design of two supply chains under price competition: game theoretic and decomposition algorithm approach », Oper Res Int J, vol. 22, no 1, p. 825-857, mars 2022, doi: 10.1007/s12351-020-00565-7.

[23] G. Lyu, M. Zhao, Q. Ji, et X. Lin, « Improving resilience via capacity allocation and strategic pricing: Co-opetition in a shipping supply chain », Ocean and Coastal Management, vol. 244, 2023, doi: 10.1016/j.ocecoaman.2023.106779.

[24] S. P. Parvasi, A. A. Taleizadeh, et L. E. Cárdenas-Barrón, « Retail price competition of domestic and international companies: A bi-level game theoretical optimization approach », RAIRO - Operations Research, vol. 57, no 1, p. 291-323, 2023, doi: 10.1051/ro/2023007.

[25] S. P. Parvasi et A. A. Taleizadeh, « Competition pricing between domestic and foreign manufacturers: a bi-level model using a novel hybrid method », Sadhana - Academy Proceedings in Engineering Sciences, vol. 46, no 2, 2021, doi: 10.1007/s12046-021-01627-y.

[26] A. Mostofi, V. Jain, Y. Mei, et L. Benyoucef, « A new pricing mechanism for pharmaceutical supply chains: a game theory analytical approach for healthcare service », International Journal of Logistics Research and Applications, 2022, doi: 10.1080/13675567.2022.2122421.

[27] H. Rajabzadeh, A. Arshadi Khamseh, et M. Ameli, « A Game-Theoretic Approach for Pricing Considering Sourcing, Andrecycling Decisions in a Closed-Loop Supply Chain Under Disruption », Communications in Computer and Information Science, vol. 1458 CCIS, p. 137-157, 2021, doi: 10.1007/978-3-030-89743-7_9.

[28] K. Wang, Y. Zhao, Y. Cheng, et T.-M. Choi, « Cooperation or Competition? Channel Choice for a Remanufacturing Fashion Supply Chain with Government Subsidy », Sustainability, vol. 6, no 10, Art. no 10, oct. 2014, doi: 10.3390/su6107292.

[29] N. Droste et al., « Steering innovations towards a green economy: Understanding government intervention », Journal of Cleaner Production, vol. 135, p. 426-434, nov. 2016, doi: 10.1016/j.jclepro.2016.06.123.

[30] S. S. Sana, « Price competition between green and non green products under corporate social responsible firm », Journal of Retailing and Consumer Services, vol. 55, p. 102118, juill. 2020, doi: 10.1016/j.jretconser.2020.102118.

[31] D. Yang et T. Xiao, « Pricing and green level decisions of a green supply chain with governmental interventions under fuzzy uncertainties », Journal of Cleaner Production, vol. 149, p. 1174-1187, avr. 2017, doi: 10.1016/j.jclepro.2017.02.138.

[32] P. He, Y. He, et H. Xu, « Channel structure and pricing in a dual-channel closed-loop supply chain with government subsidy », International Journal of Production Economics, vol. 213, p. 108-123, juill. 2019, doi: 10.1016/j.ijpe.2019.03.013.

[33] S. Amiri-Pebdani, M. Alinaghian, et H. Khosroshahi, « Pricing in competitive energy supply chains considering government interventions to support CCS under cap-and-trade regulations: A game-theoretic approach », Energy Policy, vol. 179, 2023, doi: 10.1016/j.enpol.2023.113630.

[34] M. Rasti-Barzoki et I. Moon, « A game theoretic approach for analyzing electric and gasoline-based vehicles' competition in a supply chain under government sustainable strategies: A case study of South Korea », Renewable and Sustainable Energy Reviews, vol. 146, p. 111139, août 2021, doi: 10.1016/j.rser.2021.111139.

[35] D.-H. Lee et J.-C. Yoon, « Decisions on Pricing, Sustainability Effort, and Carbon Cap under Wholesale Price and Cost-Sharing Contracts », Sustainability (Switzerland), vol. 14, no 8, 2022, doi: 10.3390/su14084863.

[36] R. W. Anderson, « Some theory of inverse demand for applied demand analysis », European Economic Review, vol. 14, no 3, p. 281-290, janv. 1980, doi: 10.1016/S0014-2921(80)80001-8.

[37] B. Niu, J. Li, J. Zhang, H. K. Cheng, et Y. (Ricky) Tan, « Strategic Analysis of Dual Sourcing and Dual Channel with an Unreliable Alternative Supplier », Production and Operations Management, vol. 28, no 3, p. 570-587, 2019, doi: 10.1111/poms.12938.

[38] S. Y. Tang et P. Kouvelis, « Supplier Diversification Strategies in the Presence of Yield Uncertainty and Buyer Competition », M&SOM, vol. 13, no 4, p. 439-451, oct. 2011, doi: 10.1287/msom.1110.0337.

[39] S. R. Madani et M. Rasti-Barzoki, « Sustainable supply chain management with pricing, greening and governmental tariffs determining strategies: A game-theoretic approach », Computers and Industrial Engineering, vol. 105, p. 287-298, 2017, doi: 10.1016/j.cie.2017.01.017.

[40] A. Ranjan et J. K. Jha, « Pricing and coordination strategies of a dual-channel supply chain considering green quality and sales effort », Journal of Cleaner Production, vol. 218, p. 409-424, mai 2019, doi: 10.1016/j.jclepro.2019.01.297.

[41] C. Wang, W. Wang, et R. Huang, « Supply chain enterprise operations and government carbon tax decisions considering carbon emissions », Journal of Cleaner Production, vol. 152, p. 271-280, mai 2017, doi: 10.1016/j.jclepro.2017.03.051.