DUAL-CHANNEL DECISION MODELS FOR THE TRANSNATIONAL SUPPLY CHAIN CONSIDERING STRATEGIC INPUTS AND COMPENSATION

JIE WANG*, RANRAN ZHANG AND BIYU PENG

Abstract. Based on a transnational dual-channel supply chain consisting of the domestic manufacturer and retailer, this paper constructs four models, namely, the without tariff model, the tariff model, the retailer’s strategic inputs model, and the manufacturer’s compensation model, to investigate the impact of the tariff imposing on supply chain decisions, the effect of the retailer’s strategic inputs to hedge against tariffs, and the incentive effect of the manufacturer’s compensation. The results show that the tariff imposed by the foreign government leads to higher product prices and lower sales volumes, resulting in welfare losses for foreign consumers. When the domestic retailer makes strategic inputs, the prices of products in the foreign market decrease and the sales volumes increase, which increases the profits of the domestic retailer and manufacturer and improves the welfare of foreign consumers. The equilibrium solutions of the models also show that the manufacturer has an incentive to compensate the retailer for its strategic inputs; when the manufacturer compensates for the retailer’s strategic inputs, the profit of the retailer and the manufacturer will be improved again, and thus, the whole supply chain will achieve Pareto improvement.

Mathematics Subject Classification. 90B06.

Received May 6, 2023. Accepted March 6, 2024.

1. Introduction

With the rapid development of the Internet economy, the momentum of the development of transnational e-commerce in recent years has become increasingly adequate. Statistics show that in the past five years, China’s transnational e-commerce scale has grown nearly 10 times, with an annual growth rate of more than 30%, accounting for nearly 40% of international trade. According to a statistical report released by the Ministry of Commerce of China, 1.55 trillion yuan of transnational e-commerce exports in 2022, up 11.7% year-on-year. An increasing number of Chinese manufacturing companies are opening online direct sales channels to sell their goods to foreign markets [1]. Qin noted that transnational e-commerce is an important breakthrough in promoting the transformation and upgrading of foreign trade and consolidating external circulation [2]. With the prosperous development of e-commerce and the upgrading of logistics and distribution capabilities, transnational e-commerce shows great potential, and more enterprises have opened online direct sales channels in addition to traditional distribution channels, forming the transnational dual-channel supply chain system. It is of great

Keywords. Transnational dual-channel supply chain, tariff, strategic inputs, compensation, decision models.

School of Economics & Management, South China Normal University, Guangzhou, P.R. China.

*Corresponding author: jiewang@m.scnu.edu.cn

© The authors. Published by EDP Sciences, ROADEF, SMAI 2024

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (https://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.
Transnational supply chains involve trade transactions between more than two countries, and tariffs are the most direct and common kind of trade protection measure [3], so the development of transnational supply chains is closely related to tariffs. The study of tariffs and transnational supply chains has also received attention from scholars. Niu et al. [4] showed that tariffs increase the procurement costs of transnational firms, so transnational firms will reduce their purchases. Nagurney et al. [5] established a global supply chain network and studied the effect of tariffs on firms' innovation inputs and innovation performance. Lodefalk [11] pointed out that import tariffs have a significant inhibitory effect on the increase in firms' innovation inputs and innovation performance. Cenamor et al. [12], on the other hand, found a significant positive effect of input servitization on the domestic value added rate of exports of general trade firms through an empirical test. Liu et al. [13] found a significant contribution of manufacturing input servitization to the export quality of enterprises through measurement. In this paper, we investigate the effect of tariffs on firms' own strategic inputs and compensation on hedging tariffs in a transnational supply chain model.

In recent years, there have been many studies on dual-channel supply chains. For example, Chiang et al. [14] constructed a pricing game between a manufacturer and its independent retailers and found that the introduction of an online direct sale channel can constrain the pricing behavior of retailers, reduce the inefficiency of price double marginalization, and strengthen the profitability of the manufacturer. Kumar and Ruan [15] investigated the impact of members' optimal decisions and found that if a manufacturer opens an online channel, online retail prices and wholesale prices will have an impact on traditional retailers' retail prices and service levels. Huang et al. [16] added demand disruptions to a dual-channel supply chain and investigated how prices and production schedules can be adjusted to maximize profits in the presence of demand disruptions. Cao et al. [17] compared manufacturers' compensatory incentives to retailers in dual-channel supply chains with or without compensatory incentives and found that manufacturers' compensatory incentives can increase their own profits, those of retailers and the supply chain. Hsieh et al. [18] studied the impact of manufacturers' cost information misrepresentation behavior on pricing decisions in a dual-channel supply chain. Cao et al. [17] introduced the equilibrium concept and profit scale coefficient into a dual-channel green supply chain model to explore the
optimal pricing decision of this dual-channel supply chain in the case of concentration over fragmentation. In addition, Wang and Jiang [19] constructed a retailer-led transnational dual-channel supply chain model to study the effects of cost changes on the product pricing and profits of each member of the transnational supply chain. These scholars have studied the pricing decisions of dual-channel supply chains from different perspectives. Fewer studies have introduced tariffs into dual-channel supply chains. In addition, transnational e-commerce has developed rapidly in recent years, and an increasing number of manufacturers have opened online direct sales channels, so the study of transnational dual-channel supply chains with tariff imposing has important theoretical and practical significance.

In summary, this paper will construct transnational dual-channel supply chain models to investigate the pricing decisions of the transnational dual-channel supply chain, the effect of tariffs on the dual-channel supply chain, the effect of the retailer’s strategic inputs and the incentive effect of the manufacturer’s compensation. This paper constructs four models for comparative analysis: first, a zero tariff model as the benchmark model for comparison with the later models; second, a transnational dual-channel model with tariff imposing to study the effect of tariff on the optimal decision of transnational dual-channel supply chain; second, a model of the retailer’s strategic inputs decision to study how the strategic inputs of the retailer in traditional distribution channel affect the decision of both channels; and finally, a model of the manufacturer’s compensation to explore the optimization of manufacturer’s compensation incentives on dual-channel coordination and supply chain profitability.

The contribution of this paper is as follows: In response to the impact of tariffs imposed by the foreign government on the transnational dual-channel supply chain, this paper proposes that domestic retailers and manufacturers can improve transnational dual-channel supply chain performance by adopting the strategy of strategic inputs and compensation, analyses the strategy effects through different models, verifies that, in response to the selling price increase and sales volume decline in the transnational dual-channel supply chain caused by tariffs imposed by the foreign government in both the traditional distribution channel and the online direct sales channel, strategic inputs by the retailer and compensation by the manufacturer can effectively reduce the selling price and increase the sales volume, effectively hedge the impact of tariffs imposed on the transnational dual-channel supply chain, and achieve Pareto improvement for the whole supply chain.

2. Model description and parameter setting

In this paper, we consider a transnational dual-channel supply chain consisting of a domestic manufacturer and a domestic retailer that produces and sells products to a foreign market. The structure of the transnational dual-channel supply chain is shown in Figure 1. In this supply chain, the domestic manufacturer produces a product for the overseas market, and the manufacturer distributes the product to the domestic retailer, who in turn sells the product to the foreign market. At the same time, the manufacturer opens an online direct sales channel, which directly faces foreign consumers. At this point, the traditional distribution channel and the online direct sales channel constitute a competitive relationship, and it is assumed that foreign consumers' demand for the product satisfies the following linear demand function [20]:

\[ q_i = 1 - p_i + \lambda p_j (0 < \lambda < 1, i \neq j). \] (1)

In equation (1), the potential demand of the foreign market is normalized to 1 to simplify the analysis. \( \lambda \) denotes the channel cross-price elasticity coefficient, while \( 0 < \lambda < 1 \), so the downwards sloping demand curve can be ensured.

In the traditional distribution channel, the manufacturer and retailer play Stackelberg games in which the manufacturer dominates. The manufacturer and retailer make decisions with the objective of maximizing their own interests. For the sake of analysis, assume that the manufacturer’s marginal cost of producing this product is 0, and assume that the manufacturer’s marginal cost of selling this product in both channels remains 0.

The symbols involved in this paper and their meanings are shown in Table 1.
Table 1. The definitions of related variables.

<table>
<thead>
<tr>
<th>Variable symbol</th>
<th>Variable definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M$</td>
<td>The manufacturer</td>
</tr>
<tr>
<td>$S$</td>
<td>The retailer</td>
</tr>
<tr>
<td>$T$</td>
<td>Transnational dual-channel supply chain as a whole</td>
</tr>
<tr>
<td>$N$</td>
<td>The superscript $N=1,2,3,4$ indicates Model 1 to 4</td>
</tr>
<tr>
<td>$i$</td>
<td>The subscript $i=d$ denotes the online direct sales channel; The subscript $i=s$ denotes the traditional distribution channel</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>Channel cross-price elasticity coefficient</td>
</tr>
<tr>
<td>$p_i^N$</td>
<td>In the Nth model, the selling price of the product on channel i</td>
</tr>
<tr>
<td>$q_i^N$</td>
<td>In the Nth model, the sales volume of the product on channel i</td>
</tr>
<tr>
<td>$\omega^N$</td>
<td>In the Nth model, the wholesale price of the manufacturer’s product</td>
</tr>
<tr>
<td>$c_s$</td>
<td>Marginal cost for the retailer</td>
</tr>
<tr>
<td>$\pi^N$</td>
<td>In the Nth model, the profit of the manufacturer $\pi_M^N$, retailer $\pi_S^N$ and supply chain $\pi_T^N$</td>
</tr>
<tr>
<td>$r$</td>
<td>Tariff level imposed by the foreign government</td>
</tr>
<tr>
<td>$m$</td>
<td>Strategic inputs from the retailer</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Compensation from the manufacturer to retailer</td>
</tr>
</tbody>
</table>

3. Model solving and equilibrium analysis

3.1. Model 1: Transnational dual-channel supply chain model without tariff

This paper first explores the zero tariff model to facilitate comparison with the models that follow. When the foreign government adopts a zero-tariff policy, firms do not need to consider the impact of tariffs. The retailer in the traditional distribution channel only needs to determine the retail price of products at a given wholesale price, while the manufacturer determines the wholesale price of products in the traditional distribution channel and the price of goods in the online direct sales channel based on the principle of maximizing their own interests.

In the transnational dual-channel supply chain, the domestic manufacturer’s profit consists of two parts: one is the profit of the online direct sales channel, and the other is the profit earned by the traditional distribution channel, while the domestic retailer’s profit is earned only by the traditional distribution channel selling the products. Therefore, in this model, the profit functions of the domestic manufacturer, retailer and supply chain are as follows:
\[
\begin{align*}
\pi_M^1 &= p_d^1 q_d^1 + \omega^1 q_s^1 = p_d^1 (1 - p_d^1 + \lambda p_d^1) + \omega^1 (1 - p_s^1 + \lambda p_d^1), \\
\pi_S^1 &= (p_s^1 - \omega^1 - c_s) q_s^1 = (p_s^1 - \omega^1 - c_s) (1 - p_s^1 + \lambda p_d^1), \\
\pi_T^1 &= \pi_M^1 + \pi_S^1.
\end{align*}
\]

Equation (3) shows that \(\pi_S\) is a concave function with respect to \(p_s\). Therefore, finding the first-order partial derivative of \(p_s\) and setting the partial derivative equal to zero gives the response function of the retailer’s retail price in the traditional distribution channel as follows:

\[
p_s^1 = \frac{1 + \lambda p_d^1 + \omega^1 + c_s}{2}.
\]

Equation (5) shows that the selling price of the product in the traditional distribution channel increases with the selling price of the online direct channel, the manufacturer’s wholesale price and the retailer’s marginal cost. Substituting equation (5) into equation (1) yields the reaction functions for product sales volume in both channels:

\[
q_s^1 = \frac{1 + \lambda p_d^1 - \omega^1 - c_s}{2}; \\
q_d^1 = \frac{2 + \lambda - (2 - \lambda^2) p_d^1 + \lambda (\omega^1 + c_s)}{2}.
\]

From the above response functions for product sales volumes in the two channels, it can be seen that the sales volume of products in the traditional distribution channel is positively related to the online direct selling price; that is, the sales volume of products in the traditional distribution channel increases as the online direct selling price increases due to the competition formed by these two channels. In addition, the sales volume of products in the traditional distribution channel is negatively correlated with the wholesale price and the marginal cost of the retailer. The product sales volume of the online direct sales channel is negatively related to its selling price and positively related to the wholesale price and the retailer’s marginal cost.

Then, we substitute equation (6) into equation (2) and find the first-order partial derivatives for \(p_d\) and \(\omega\) according to the first-order optimal condition to obtain the decision of the manufacturer:

\[
\begin{align*}
p_d^1* &= \frac{1}{2(1 - \lambda)}; \\
\omega^1* &= \frac{1 - (1 - \lambda)c_s}{2(1 - \lambda)}; \\
q_d^1* &= \frac{2 + \lambda (1 + c_s) - 4}{4}.
\end{align*}
\]

Substituting equation (7) into equation (5) and equation (6), we can find the optimal selling price and optimal sales volume for the retailer:

\[
\begin{align*}
p_s^1* &= \frac{3 - \lambda + (1 - \lambda)c_s}{4(1 - \lambda)}; \\
q_s^1* &= \frac{1 - c_s}{4}.
\end{align*}
\]

Because the potential demand in the foreign market is standardized to 1, the selling price of the product in the market is less than the potential demand; thus, \(0 < p_s^1* < 1, 0 < \lambda < 0.5, q_s^1* > 0, c_s < 1\).

Based on the above optimal decisions of the domestic manufacturer and retailer, the profits earned by the manufacturer, retailer and supply chain in the zero tariff model can be calculated as follows:

\[
\begin{align*}
\pi_M^1 &= \frac{3 + \lambda - 2(1 - \lambda)c_s + (1 - \lambda)c_s^2}{8(1 - \lambda)}; \\
\pi_S^1 &= \frac{(1 - c_s)^2}{16} \\
\pi_T^1 &= \frac{7 + \lambda - 6(1 - \lambda)c_s + 3(1 - \lambda)c_s^2}{16(1 - \lambda)}
\end{align*}
\]

Analysing the equilibrium solutions for the product selling price, sales volume, and profit of the manufacturer and retailer in the above tariff-free transnational dual-channel supply chain model, the following corollary can be obtained.

**Corollary 3.1.**

(a) \(\frac{\partial p_d^1*}{\partial \lambda} > 0; \frac{\partial q_s^1*}{\partial \lambda} > 0; \frac{\partial p_s^1*}{\partial \lambda} > 0\)

(b) \(\frac{\partial \omega^1*}{\partial c_s} < 0; \frac{\partial p_s^1*}{\partial c_s} > 0\)
(c) \( \frac{\partial \pi_M^1}{\partial \lambda} > 0; \frac{\partial \pi_S^1}{\partial c_s} < 0; \frac{\partial \pi_T^1}{\partial c_s} < 0 \)

From Corollary 3.1, the following conclusions can be drawn: (a) The selling price in the online direct channel and the wholesale price and selling price in the traditional distribution channel all increase with the increase in the cross-channel price elasticity coefficient. (b) The manufacturer’s wholesale price decreases as the retailer’s marginal cost rises, and the selling price of the traditional distribution channel increases as the retailer’s marginal cost rises. (c) The profit of the domestic manufacturer increases with the increase in the cross-price elasticity coefficient and decreases with the increase in the retailer’s marginal cost. The profit of the domestic retailer decreases with the increase in its own marginal cost.

The management insights brought by Corollary 3.1 of the no tariff model are as follows: First, to control the product prices in both channels, the cross-price elasticity coefficient needs to be controlled efficiently. Second, since the selling price of the traditional distribution channel increases as the retailer’s marginal cost increases, the key to reducing the selling price of the traditional distribution channel lies in controlling the marginal cost of the retailer. Finally, to increase the profit of the domestic manufacturer, it can proceed to increase the cross-price elasticity of the channel and decrease the retailer’s marginal cost, and to increase the profit of the domestic retailer, it is necessary to control the retailer’s own marginal cost.

### 3.2. Model 2: Transnational dual-channel supply chain model with tariff

In recent years, the international situation has been turbulent and complex, and trade frictions between countries and regions have increased, among which tariffs are common trade protection tools. This model will examine the impact of the foreign government’s tariff imposing on the transnational dual-channel supply chain.

When the foreign government imposes tariffs on imported products, the profit functions of the domestic manufacturer, retailer and supply chain are as follows:

\[
\pi_M^2 = (p_d^2 - r)q_d^2 + \omega^2q_s^2 = (p_d^2 - r)(1 - p_s^2 + \lambda p_s^2 + \omega^2(1 - p_s^2 + \lambda p_s^2))
\]

\[
\pi_S^2 = (p_s^2 - \omega^2 - c_s - r)q_s^2 = (p_s^2 - \omega^2 - c_s - r)(1 - p_d^2 + \lambda p_d^2)
\]

\[
\pi_T^2 = \pi_M^2 + \pi_S^2
\]

Similarly, the response functions for the selling price and sales volume of the product are calculated as follows:

\[
p_s^2 = \frac{1 + \lambda p_s^2 + \omega^2 + c_s + r}{2}; \quad q_s^2 = \frac{1 + \lambda p_s^2 - \omega^2 - c_s - r}{2}
\]

\[
q_d^2 = \frac{2 + \lambda - (2 - \lambda^2)p_d^2 + \lambda(\omega^2 + c_s + r)}{2}
\]

Substituting the above response functions into the profit functions of the manufacturer and retailer, respectively, and using the first-order optimal condition to obtain the decisions of the domestic manufacturer and retailer as follows:

\[
p_d^2 = \frac{1}{2(1 - \lambda)} + \frac{r}{2}; \quad \omega^2 = \frac{1 - (1 - \lambda)c_s}{2(1 - \lambda)} - \frac{r}{2}; \quad q_d^2 = \frac{2 + \lambda + \lambda c_s - (1 - \lambda)(2 + \lambda)r}{4}
\]

\[
p_s^2 = \frac{3 - \lambda + (1 - \lambda)c_s}{4(1 - \lambda)} + \frac{(1 + \lambda)r}{4}; \quad q_s^2 = \frac{1 - c_s - (1 - \lambda)r}{4}
\]

To ensure that the optimal sales volume of the retailer is meaningful, \(1 - c_s - (1 - \lambda)r > 0\) needs to be satisfied.

Comparing the optimal decisions of Models 1 and 2, it can be seen that after the foreign government’s tariff is imposed, in the online direct sales channel, the manufacturer’s selling price increases \(r/2\), the sales volume decreases \((1 - \lambda)(2 + \lambda)r/4\) and the wholesale price decreases \(r/2\). In the traditional distribution channel, the retailer’s selling price increases \((1 + \lambda)r/4\), the sales volume decreases \((1 - \lambda)r/4\), and the manufacturer’s
wholesale price decreases $r/2$. This means that for both the traditional distribution channel and the online direct sales channel, the tariff imposed by the foreign government will lead to higher product selling prices and lower sales volumes. However, comparing the increases in selling prices and the decreases in sales volumes in the two channels, the changes in the online direct sales channel are greater than those in the traditional distribution channel, which shows that the tariff imposing will have a greater impact on the online direct sales channel.

Based on the above optimal decisions of the domestic manufacturer and retailer, the profits of the manufacturer, retailer and supply chain can be calculated as follows:

$$\pi_M^2 = \frac{3 + \lambda - 2(1 - \lambda)c_s + (1 - \lambda)c_s^2 - 2(1 - \lambda)(3 + \lambda)r + (1 - \lambda)^2(3 + \lambda)r^2 + 2(1 - \lambda)^2rc_s}{8(1 - \lambda)} \tag{18}$$

$$\pi_S^2 = \frac{[1 - c_s - (1 - \lambda)r]^2}{16} \tag{19}$$

$$\pi_T^2 = \frac{7 + \lambda - 6(1 - \lambda)c_s + 3(1 - \lambda)c_s^2 - 2(1 - \lambda)(7 + \lambda)r + (1 - \lambda)^2(7 + \lambda)r^2 + 6(1 - \lambda)^2rc_s}{16(1 - \lambda)} \tag{20}$$

Comparing before and after the tariff is imposed, it is clear that the retailer’s profit is impaired and the manufacturer’s profit changes less clearly, which will be analysed by the numerical simulation below.

Summarizing and comparing the equilibrium solutions of Model 2 and Model 1, the following Corollary 3.2 can be obtained.

**Corollary 3.2.** (a) $p_d^2 \geq p_d^1$; $q_d^2 \leq q_d^1$

(b) $p_s^2 \geq p_s^1$; $q_s^2 \leq q_s^1$

(c) $\pi_S^2 \leq \pi_S^1$

(d) $\frac{\partial p_d^2}{\partial r} > 0$, $\frac{\partial q_d^2}{\partial r} < 0$, $\frac{\partial p_s^2}{\partial r} > 0$, $\frac{\partial q_s^2}{\partial r} < 0$

When the foreign government imposes tariffs, from Corollary 3.2, it follows that (a) in the online direct sales channel, the selling price of the product will be higher than in the no-tariff scenario of Model 1, while the sales volume of the product will be lower than in the no-tariff scenario. (b) In the traditional distribution channel, the selling price of the product will also be higher than in the tariff-free scenario of Model 1, and the sales volume of the product will be similarly lower than in the tariff-free scenario of Model 1. (c) In the traditional distribution channel, the retailer earns significantly lower profits than in the no-tariff scenario of Model 1. (d) In terms of the marginal impact of the tariff, in both traditional and online channels, the tariff will increase the selling prices of the products and reduce the sales volumes, while the manufacturer’s wholesale prices of the products will decrease as the tariffs rise.

The management insight of Corollary 3.2 is that the foreign government’s tariff imposing increases product prices and reduces sales volumes, which damages foreign consumers’ welfare. Therefore, although the impose of tariffs will have a dampening effect on the development of importing firms, this is at the cost of national consumer welfare; thus, tariff barriers are a negative trade protection measure.

### 3.3. Model 3: decision model for retailer’s strategic inputs

This model builds on the research in the previous section to analyse whether strategic inputs by the retailer can serve as a hedge against tariffs imposed in a transnational dual-channel supply chain and how the impact differs for the two channels.

In contrast to a tariff imposed by the foreign government, the retailer chooses to make the strategic inputs $m$ to hedge against the impact of the tariff. It is also assumed that if the retailer chooses to make strategic inputs, that will result in a reduction in its selling price, that is, guarantees that a portion of the retailer’s product selling price is controllable.
The profit functions for the manufacturer, retailer and the whole supply chain in this model are:

\[
\pi^3_M = (p_d^3 - r)q_d^3 + \omega^3q^3 = (p_d^3 - r)(1 - p_d^3 + \lambda p_d^3) + \omega^3(1 - p^3_s + \lambda p^3_s) \quad (21)
\]

\[
\pi^3_S = (p^3_s - \omega^3 - c_s - r + m^3)q^3_s - (m^3)^2 = (p^3_s - \omega^3 - c_s - r + m^3)(1 - p^3_s + \lambda p^3_d) - (m^3)^2 \quad (22)
\]

\[
\pi^T_T = \pi^3_M + \pi^3_S \quad (23)
\]

The response functions of the selling price, the strategic inputs of the retailer in the traditional distribution channel, and the sales volumes of both channels are obtained as follows:

\[
\begin{align*}
p^3_s &= \frac{1 + \lambda p^3_d + 2(\omega^3 + c_s + r)}{3} \quad (24) \\
m^3 &= \frac{1 + \lambda p^3_d - (\omega^3 + c_s + r)}{3} \\
q^3_s &= \frac{2(1 + \lambda p^3_d - \omega^3 - c_s - r)}{3} \quad (25) \\
q_d^3 &= \frac{3 + \lambda - (3 - \lambda^2)p^3_d + 2\lambda(\omega^3 + c_s + r)}{3}
\end{align*}
\]

The response function of the strategic inputs shows that the retailer’s strategic inputs increase with the selling price of the online channel and decrease with the manufacturer’s wholesale price.

Substituting the above response functions into the profit functions of the domestic manufacturer and retailer and taking partial derivatives, the optimal decisions of the manufacturer and retailer are calculated as follows:

\[
\begin{align*}
p^3_s &= \frac{1}{2(1 - \lambda)} + \frac{r}{2} \quad (26) \\
\omega^3 &= \frac{1 - (1 - \lambda)c_s}{2(1 - \lambda)} - \frac{r}{2} \\
q^3_d &= \frac{3 + \lambda + 2\lambda c_s - (1 - \lambda)(3 + \lambda)r}{6} \quad (27) \\
p^3_d &= \frac{4 - \lambda + 2(1 - \lambda)c_s}{6(1 - \lambda)} + \frac{(2 + \lambda)r}{6} \quad (28) \\
m^3 &= \frac{1 - c_s - (1 - \lambda)r}{6} \quad (29)
\end{align*}
\]

In the decision models with strategic inputs from the retailer, the optimal decisions by the domestic manufacturer reveal that the increase in import tariffs by the foreign government and the strategic inputs by the retailer has no effect on the manufacturer’s online direct selling price and wholesale price; that is, Model 3’s online direct selling price and wholesale price of the product remain unchanged compared to Model 2, but the product sales volume of the online channel of Model 3 is reduced. For the domestic retailer, compared to Model 2, making strategic inputs led to an increase in the sales volume of its products in the traditional distribution channel by $[1 - c_s - (1 - \lambda)r]/12$ and a decrease in the selling price. This shows that the strategic inputs of the retailer bring some competitive advantage to the traditional distribution channel and increase the welfare of foreign consumers who buy goods in the traditional channel.

Based on the above optimal decisions of the domestic manufacturer and retailer, their profits in this model are calculated as follows:

\[
\begin{align*}
\pi^3_M &= \frac{1}{12}[2c_s^2 - 4(1 - (1 - \lambda)r)c_s + \frac{(1 - (1 - \lambda)r)^2(5 + \lambda)}{1 - \lambda}] \quad (30) \\
\pi^3_M - \pi^3_M &= \frac{[1 - c_s - (1 - \lambda)r]^2}{24} > 0 \quad (31) \\
\pi^3_S &= \frac{[1 - c_s - (1 - \lambda)r]^2}{12, \pi^3_S - \pi^3_S = \frac{[1 - c_s - (1 - \lambda)r]^2}{48} > 0 \quad (32) \\
\pi^3_T &= \frac{1}{4}[c_s^2 - 2(1 - (1 - \lambda)r)c_s + \frac{2(1 - (1 - \lambda)r)^2}{1 - \lambda}] \quad (33) \\
\pi^3_T - \pi^3_T &= \frac{[1 - c_s - (1 - \lambda)r]^2}{16} > 0 \quad (34)
\end{align*}
\]
From equations (30), (31) and (32), it can be found that in Model 3, compared to the previous Model 2, the profits of both the domestic manufacturer and the retailer increase after the retailer chooses to invest strategic inputs, and the increase in the manufacturer’s profit is twice as large as that of the retailer. Therefore, the strategy of strategic inputs by the retailer in the transnational dual-channel supply chain is correct when dealing with the impact of tariffs imposed by the foreign government, and there is also an incentive for the domestic manufacturer to compensate for the retailer’s strategic inputs. The model in the next section will analyse the impact of the compensation of the manufacturer on the transnational dual-channel supply chain.

Comparing the equilibrium solutions of the domestic retailer and manufacturer of Model 3 and Model 2 with respect to selling prices, sales volumes, and profits, the following Corollary 3.3 can be obtained.

Corollary 3.3. (a) \( p_{s}^{3*} \leq p_{s}^{2*} ; q_{s}^{3*} \geq q_{s}^{2*} \)

(b) \( p_{d}^{3*} \geq p_{d}^{2*} ; q_{d}^{3*} \leq q_{d}^{2*} \)

(c) \( \pi_{M}^{3*} \geq \pi_{M}^{2*} ; \pi_{S}^{3*} \geq \pi_{S}^{2*} ; \pi_{F}^{3*} - \pi_{F}^{2*} \geq 0 \)

(d) \( \frac{\partial m^{3*}}{\partial c} < 0 ; \frac{\partial m^{3*}}{\partial r} < 0 ; \frac{\partial m^{3*}}{\partial \lambda} > 0 \)

When the retailer makes the strategic inputs, while also subjected to the tariff increases imposed by the foreign government as Model 2, it follows from Corollary 3.3 that (a) in the traditional distribution channel, Model 3’s product selling prices are lower than Model 2’s no-strategic-inputs scenario, and Model 3’s product sales volumes are higher than Model 2’s no-strategic-inputs scenario. (b) In the online direct channel, Model 3 sells products at higher prices and lower volumes than Model 2 due to competition from low-priced products in the traditional distribution channel. (c) Both the retailer and manufacturer earn higher profits in Model 3 with strategic inputs than in Model 2 without strategic inputs. (d) In terms of the marginal influences on the retailer’s strategic inputs, the higher the retailer’s marginal cost is, the smaller the retailer’s strategic inputs will be; the higher the tariff is, the smaller the retailer’s strategic inputs will be; and the retailer’s strategic inputs are positively related to the cross-price elasticity coefficient.

The managerial implication of Corollary 3.3 is that when the domestic retailer hedges the impact of the tariff imposed through strategic inputs, the traditional distribution channel will sell products at lower prices and higher volumes than without strategic inputs, thereby increasing foreign consumers’ welfare and making both the manufacturer’s and the retailer’s profits higher than they would have been without strategic inputs, thus demonstrating the effectiveness of strategic inputs in hedging the foreign government’s tariff.

3.4. Model 4: decision model for the manufacturer’s compensation

In the previous model, it is concluded that the manufacturer’s profit increases twice as much as the retailer’s profit after the retailer makes strategic inputs, and from Corollary 3.1, we know that the manufacturer’s profit increases with the reduction of the retailer’s marginal cost. Therefore, it is necessary for the manufacturer in the supply chain to compensate strategically for maximizing its own profit and coordinating between the two channels to incentivize the retailer to increase its strategic inputs.

In Model 4, it is assumed that to incentivize the retailer to invest strategic inputs, the manufacturer compensates the retailer for its strategic inputs. Assuming that the manufacturer compensates the retailer at a level of \( \theta \) for the retailer’s inputs \( c(m) \), the cost of the compensation is \( c(\theta) = \theta^2 \), and this compensation provides the retailer with the amount of \( \theta m \). The profit functions of the domestic manufacturer and the retailer are:

\[
\pi_{M} = (p_{d} - r)q_{d} + \omega q_{s} - \theta^2 = (p_{d} - r)(1 - p_{d} + \lambda p_{s}) + \omega(1 - p_{s} + \lambda p_{d}) - \theta^2 \\
\pi_{S} = (p_{s} - \omega - c_{s} - r + m)q_{s} + \theta m - (m^2) \\
= (p_{s} - \omega - c_{s} - r + m^2)(1 - p_{s} + \lambda p_{d}) + \theta m - (m^2) \\
\pi_{F} = \pi_{M} + \pi_{S} 
\]
The response functions for part of the selling prices, strategic inputs, and sales volumes are calculated as follows:

\[ p_s^4 = \frac{1 + \lambda p_d^4 + 2(\omega^4 + c_s + r) - \theta}{3} \]
\[ m^4 = \frac{1 + \lambda p_d^4 - (\omega^4 + c_s + r) + 2\theta}{3} \]
\[ q_s^4 = \frac{2 + 2\lambda p_d^4 - 2(\omega^4 + c_s + r) + \theta}{3} \]
\[ q_d^4 = \frac{3 + \lambda - (3 - \lambda^2)p_d^4 + 2\lambda(\omega^4 + c_s + r) - \lambda\theta}{3} \]  \hspace{1cm} (38)

From equation (38), it can be seen that given the selling price of goods in the online direct sales channel and the wholesale price of goods in the traditional distribution channel, the product selling price in the traditional distribution channel decreases with the increase in the manufacturer’s compensation, the sales volume of products increases with the increase in the manufacturer’s compensation, and the strategic inputs increase with the increase in the manufacturer’s compensation.

The above response functions are substituted into the manufacturer’s and retailer’s profit functions, and then the first-order partial derivatives of \(p_d, \omega, \theta, p_s\), and \(m\), respectively, are set equal to zero to obtain the optimal decisions of the manufacturer and retailer as follows:

\[ p_d^{4*} = \frac{1}{2(1 - \lambda)} + \frac{r}{2}, \omega^{4*} = \frac{24 - \lambda - 24(1 - \lambda)c_s}{46(1 - \lambda)} - \frac{(24 - \lambda)r}{46} \]  \hspace{1cm} (40)
\[ q_d^{4*} = \frac{23 + 7\lambda + 16\lambda c_s - (23 - 16\lambda - 7\lambda^2)r}{23} \]
\[ p_s^{4*} = \frac{30 - 7\lambda + 16(1 - \lambda)c_s + (16 + 7\lambda)r}{46(1 - \lambda)} \]
\[ m^{4*} = 5 - 5c_s - 5(1 - \lambda)r \]  \hspace{1cm} (43)

From equation (40), it can be concluded that when the manufacturer compensates the retailer’s strategic inputs, in contrast to Model 3’s no compensation situation, the manufacturer’s direct selling price remains unchanged and the wholesale price increases to compensate for the strategic compensation expenditure, while the retailer’s selling price decreases, the sales volume increases, and the strategic inputs increase. This is because when the manufacturer compensates strategically and keeps its online direct selling price unchanged, the retailer has an incentive to increase its strategic inputs to reduce its selling price to gain a competitive advantage and stable profit in the market due to the competition between the two channels. This suggests that the manufacturer’s compensation has a corresponding incentive effect, and it significantly improves product sales volume in the traditional distribution channel.

Substituting the derived optimal decisions of the domestic manufacturer and retailer into their respective profit functions, we have:

\[ \pi_M^{4*} = \frac{1}{92}[16c_s^2 - 32(1 - (1 - \lambda)r)c_s + \frac{(1 - (1 - \lambda)r)^2(39 + 7\lambda)}{1 - \lambda}] \]  \hspace{1cm} (44)
\[ \pi_S^{4*} = \frac{49(1 - c_s - (1 - \lambda)r)^2}{23^2} \]  \hspace{1cm} (45)
\[ \pi_T^{4*} = \frac{1}{92}[16c_s^2 - 32(1 - (1 - \lambda)r)c_s + \frac{(1 - (1 - \lambda)r)^2(39 + 7\lambda)}{1 - \lambda} + \frac{49(1 - c_s - (1 - \lambda)r)^2}{23^2}] \]  \hspace{1cm} (46)

From the above equations, we can see that after the manufacturer compensates the retailer’s strategic inputs, the profits of both the manufacturer and the retailer increase, and the profit of this transnational dualchannel supply chain also increases, so the manufacturer’s compensation enables the whole supply chain to achieve Pareto improvement and better cope with the negative effects of the foreign government’s tariff.
Comparing the equilibrium solutions of the domestic retailer and manufacturer in Model 4 and Model 3 with respect to selling prices, sales volumes and profits, the following Corollary 3.4 can be obtained.

**Corollary 3.4.** (a) \( p_{s}^{4s} \leq p_{s}^{3s}; \omega^{4s} \geq \omega^{3s}; q_{a}^{4s} \geq q_{a}^{3s} \)

(b) \( p_{a}^{4a} = p_{a}^{3a}; q_{a}^{4s} \leq q_{a}^{3s} \)

(c) \( \frac{\pi_{M}}{\pi_{S}} \geq \frac{\pi_{3a}^{4s}}{\pi_{3a}^{3s}}; \pi_{F}^{4s} \geq \pi_{F}^{3s} \)

(d) \( \frac{\partial \pi_{F}}{\partial \alpha_{F}} < 0; \frac{\partial \pi_{S}}{\partial \alpha_{S}} < 0 \)

It follows from Corollary 3.4 that when the manufacturer compensates the retailer for its strategic inputs, compared to Model 3: (a) In the traditional distribution channel, Model 4 will sell products at a further lower price than the manufacturer’s no-strategic-compensation scenario of Model 3, and the volume of products sold in Model 4 will be higher than in the manufacturer’s no-strategic-compensation scenario of Model 3. (b) In the online direct channel, the product selling price of Model 4 is equal to that of Model 3, but the sales volume of products is lower than that of Model 3 due to competition from the traditional distribution channel. (c) Whether it is the retailer, the manufacturer, or the supply chain as a whole, the profits earned in Model 4 with the strategic compensation scenario are significantly higher than those in Model 3 without the strategic compensation scenario. (d) In terms of the marginal influences on the manufacturer’s strategic compensation, the higher the retailer’s marginal cost is, the lower the manufacturer’s strategic compensation, and the higher the tariff level is, the lower the manufacturer’s strategic compensation.

The managerial implication of Corollary 3.4 is that, compensating the retailer for its strategic inputs by the manufacturer, the selling price of the product in the traditional distribution channel will be further reduced, the sales volume of the product will be further increased, thereby increasing the welfare of foreign consumers, and the profits of the two channels, including the manufacturer, the retailer, and the supply chain as a whole, will be increased, proving the effectiveness of strategic compensation in improving the performance of the transnational dual-channel supply chain.

### 3.5. Model comparison

Table 2 is a summary of the equilibrium solutions in the above four different transnational dual-channel supply chain models.

The second and third columns of Table 2 show the optimal decisions of the retailer and manufacturer in the transnational dual-channel supply chain before and after the tariff is imposed. The comparison shows that after the tariff is imposed by the foreign government, the selling price of products increases and the sales volume decreases in both the traditional distribution channel and online direct sales channel. In addition, the wholesale price of the products in the traditional distribution channel decreases, and the retailers’ profit decreases.

#### Table 2. Comparative analysis of equilibrium solutions.

<table>
<thead>
<tr>
<th></th>
<th>Model 1: no tariff model</th>
<th>Model 2: tariff imposing model</th>
<th>Model 3: retailer’s strategic inputs model</th>
<th>Model 4: manufacturer compensation model</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p_{s}^{1s} )</td>
<td>( \frac{1}{2(1-A)} )</td>
<td>( \frac{1}{2(1-A)} + \frac{\lambda}{4} )</td>
<td>( \frac{1}{2(1-A)} + \frac{\lambda}{2} )</td>
<td>( \frac{1}{2(1-A)} + \frac{\lambda}{4} )</td>
</tr>
<tr>
<td>( q_{d}^{1s} )</td>
<td>( \frac{2+3\lambda(1+\epsilon_s)}{(1-A)-4} )</td>
<td>( \frac{2+3\lambda(1+\epsilon_s)-(1-A)(2+\lambda)}{(1-A)-4} )</td>
<td>( 3+4A+2\lambda\epsilon_s-(1-A)(3+\lambda) )</td>
<td>( 23+7A+16\lambda\epsilon_s-(23-16A-7\lambda^2) )</td>
</tr>
<tr>
<td>( q_{a}^{1s} )</td>
<td>( \frac{1}{1-A} )</td>
<td>( 1-(1-A) )</td>
<td>( 1-(1-A) )</td>
<td>( 1-(1-A) )</td>
</tr>
<tr>
<td>( \omega^{1s} )</td>
<td>( \frac{1}{2(1-A)} )</td>
<td>( \frac{1-(1-A)}{2(1-A)} - \frac{\lambda}{4} )</td>
<td>( \frac{1-(1-A)}{2(1-A)} )</td>
<td>( \frac{1-(1-A)}{2(1-A)} )</td>
</tr>
<tr>
<td>( \pi_{M}^{1s} )</td>
<td>( \frac{3+\lambda-2(1-\lambda)\epsilon_s}{(1-A)} )</td>
<td>( \frac{3+\lambda-2(1-\lambda)\epsilon_s+(1-\lambda)^{2}}{8} )</td>
<td>( \frac{4}{3} )</td>
<td>( \frac{4(1-(1-\lambda)r)c_s}{46(1-(1-\lambda)r)^2(6+\lambda)} )</td>
</tr>
<tr>
<td>( \pi_{S}^{1s} )</td>
<td>( \frac{1-(1-\lambda)^{2}}{16} )</td>
<td>( \frac{1-(1-\lambda)^{2}}{16} )</td>
<td>( \frac{1-(1-\lambda)^{2}}{12} )</td>
<td>( 49(1-(1-\lambda)^{2}) )</td>
</tr>
</tbody>
</table>

Comparing the equilibrium solutions of the domestic retailer and manufacturer in Model 4 and Model 3 with respect to selling prices, sales volumes and profits, the following Corollary 3.4 can be obtained.

**Corollary 3.4.** (a) \( p_{s}^{4s} \leq p_{s}^{3s}; \omega^{4s} \geq \omega^{3s}; q_{a}^{4s} \geq q_{a}^{3s} \)

(b) \( p_{a}^{4a} = p_{a}^{3a}; q_{a}^{4s} \leq q_{a}^{3s} \)

(c) \( \frac{\pi_{M}}{\pi_{S}} \geq \frac{\pi_{3a}^{4s}}{\pi_{3a}^{3s}}; \pi_{F}^{4s} \geq \pi_{F}^{3s} \)

(d) \( \frac{\partial \pi_{F}}{\partial \alpha_{F}} < 0; \frac{\partial \pi_{S}}{\partial \alpha_{S}} < 0 \)

It follows from Corollary 3.4 that when the manufacturer compensates the retailer for its strategic inputs, compared to Model 3: (a) In the traditional distribution channel, Model 4 will sell products at a further lower price than the manufacturer’s no-strategic-compensation scenario of Model 3, and the volume of products sold in Model 4 will be higher than in the manufacturer’s no-strategic-compensation scenario of Model 3. (b) In the online direct channel, the product selling price of Model 4 is equal to that of Model 3, but the sales volume of products is lower than that of Model 3 due to competition from the traditional distribution channel. (c) Whether it is the retailer, the manufacturer, or the supply chain as a whole, the profits earned in Model 4 with the strategic compensation scenario are significantly higher than those in Model 3 without the strategic compensation scenario. (d) In terms of the marginal influences on the manufacturer’s strategic compensation, the higher the retailer’s marginal cost is, the lower the manufacturer’s strategic compensation, and the higher the tariff level is, the lower the manufacturer’s strategic compensation.

The managerial implication of Corollary 3.4 is that, compensating the retailer for its strategic inputs by the manufacturer, the selling price of the product in the traditional distribution channel will be further reduced, the sales volume of the product will be further increased, thereby increasing the welfare of foreign consumers, and the profits of the two channels, including the manufacturer, the retailer, and the supply chain as a whole, will be increased, proving the effectiveness of strategic compensation in improving the performance of the transnational dual-channel supply chain.
The 4th and 5th columns of Table 2 show equilibrium solutions after the retailer’s strategic inputs and the manufacturer’s compensation. In the context of tariffs imposed by the foreign government, the retailer’s strategic inputs bring a lower selling price and higher sales volume in the traditional distribution channel and an unchanged selling price and reduced sales volume in the online direct channel. The manufacturer’s compensation for the retailer’s strategic inputs further incentivizes the Pareto improvement of the transnational dual-channel supply chain. Thus, strategic inputs and compensation increase the profitability of the manufacturer and retailer and better cope with imposing tariffs and the uncertainty of international markets.

4. Numerical simulation

To more intuitively analyse the above four models of the transnational dual-channel supply chain, numerical simulation is conducted in this section. In the numerical simulation process, the relevant parameters are mainly borrowed from actual cases, such as the parameter assignment of the tariff increase ratio. This paper mainly draws on some countries in the process of tariff increase caused by trade disputes, the initiation of tariff increases in tariff rates including 0%, 3.1%, 3.5%, 7.5%, 15%, 20% and other levels of tariffs, and our simulation will be carried out for the continuity of tariffs ranging from 0% to 20% in the tariff rates analysis. Similarly, assuming that the retailer’s marginal distribution cost equals 0.1, the channel cross-price elasticity coefficient takes the range of 0–0.5.

4.1. Relationship between the channel cross-price elasticity coefficient and prices

In the transnational dual-channel supply chain, the effect of the channel cross-price elasticity coefficient on the prices of products in both channels is numerically simulated in Figure 2.

From Figure 2, it can be seen that the wholesale price and the selling prices of the two channels all increase with the increase in the cross-channel price elasticity coefficient, which verifies the correctness of Corollary 3.1. In addition, it can be found that the products’ selling price of the traditional distribution channel is higher than that of the online channel, while the online channel’s selling price is higher than the wholesale price, ensuring that the retailer is able to wholesale the product from the manufacturer and obtain a reasonable profit and thus has the incentive to participate in this supply chain. Figure 2 visually shows that the price of products in the traditional distribution channel is higher than that in the online direct sales channel because the online direct sales channel shortens the supply chain and reduces the cost of the supply chain by eliminating the “middleman” to make the difference. Low prices, which are an obvious advantage of online direct sales channels, are also an important reason for the booming development of transnational e-commerce in recent years.
4.2. Impact of tariffs on firms’ profits, product selling prices and sales volumes

According to the previous solutions of the transnational dual-channel supply chain model with tariff imposing, it is concluded that the tariff imposing by the foreign government will damage the profit of the retailer, but because the magnitude between the parameters cannot be determined, how the manufacturer’s profit changes before and after the tariff imposing cannot be given by the analytical formula. In the following, the impact of tariffs on the manufacturer’s and retailer’s profits will be analysed through numerical simulation.

Figure 3 shows the effect of tariffs and channel cross-price elasticity coefficients on firms’ profits.

As shown in Figures 3–1, the profit of the manufacturer in the transnational dual-channel supply chain is negatively related to the tariff; that is, as the tariff increases, the manufacturer’s profit decreases; conversely, profit increases. Therefore, the increase in tariffs hurts the manufacturer’s profit, which is consistent with the situation of the retailer, as shown in Model 2. In addition, the manufacturer’s profit in the transnational dual-
Figure 4. The impact of tariffs on the selling price and sales volume.

channel supply chain is positively correlated with the channel cross-price elasticity coefficient, which means that as the elasticity coefficient increases, the manufacturer’s profit increases; and vice versa, profit decreases.

From Figures 3–2, it can be seen that the profit of the retailer in the transnational dual-channel supply chain has the same relationship with the tariff and channel cross-price elasticity coefficient as that of the manufacturer, which is negatively related to the tariff and positively related to the channel cross-price elasticity coefficient.

The profit of the whole supply chain is equal to the sum of the manufacturer’s and retailer’s profits, so it can be concluded that the profit of this transnational dual-channel supply chain is also negatively related to the tariff and positively related to the cross-channel price elasticity coefficient.

In the solution part of Model 2, it is clear from the calculation results that the increase in tariffs by the foreign government will lead to an increase in the product selling price and a decrease in sales volume in the online direct sales channel and traditional distribution channel. In the following, we perform further analysis by numerical simulation.
The above figure verifies the validity of Model 2’s findings that product prices increase with tariffs and product sales volumes decrease with tariffs. Figures 4–1 shows that the increase in the product selling price in the online direct sales channel is greater than that of the traditional distribution channel. Figures 4–2 shows that the decrease in product sales volume in the online direct sales channel is also greater than the change in the traditional distribution channel, which indicates that the increase in tariffs by the foreign government has a greater impact on the online direct sales channel. It also suggests that the manufacturer should compensate the retailer for its strategic inputs to increase their resistance to tariffs.

4.3. Effect of relevant parameters on strategic inputs and compensation

Figures 5, 6 and 7 show the effect of tariffs on the strategic inputs of the retailer and the strategic compensation of the manufacturer and reveal the relationship between the strategic inputs, compensation and the cross-price elasticity coefficient of the two channels.
Figure 5 shows that the strategic inputs of the retailer and the compensation of the manufacturer both decrease with increasing tariffs, and the change in strategic inputs is more significant. In addition, when the manufacturer compensates the retailer’s strategic inputs, the value of compensation is much smaller than that of the strategic inputs.

Figures 6 and 7 show that the strategic inputs of the retailer, the strategic compensation of the manufacturer and the cross-price elasticity of channels are positively correlated, which means that both the retailer’s strategic inputs and the manufacturer’s compensation increase with the increase in the elasticity coefficient, while vice versa, the strategic inputs and compensation decrease.

4.4. Comparison of the manufacturer’s profits under different models

Figure 8 provides a comprehensive comparison of the manufacturer’s profits under the four models with respect to tariff increases.

Figures 8–1 compares the manufacturer’s profits in the cases with and without tariffs, and it is clear that the manufacturer’s profit in the case without tariffs in Model 1 will be significantly higher than that of the case in Model 2.

Figures 8–2 demonstrates the impact of the retailer’s strategic inputs on the manufacturer’s profit in the case of tariffs, and it can be seen that the retailer’s strategic inputs will significantly increase the manufacturer’s profit in the case of tariffs.

Figure 8–3 further demonstrates the change in the manufacturer’s own profit after the manufacturer compensates the retailer for its strategic inputs, and it can be seen that the manufacturer’s profit does not decrease but rather increases slightly after compensating the retailer.

Figures 8–4 synthesizes the four models. It provides a better visualization of the damage that tariffs do to the manufacturer’s profits, as in the absence of strategic inputs and compensation, the manufacturer’s profit in Model 2 with tariff is the lowest of the four models. Strategic inputs from the retailer, on the other hand, have a significant effect on the manufacturer’s profit, and even at partially low tariff levels, the manufacturer’s profit in Model 3 will exceed that of the zero-tariff scenario in Model 1. Finally, the result of Model 4 with the yellow line suggests that the manufacturer’s compensation to the retailer is beneficial to its own profit and will increase its own profit by a small arc.
4.5. Comparison of the retailer’s profits under different models

Figure 9 compares the profits of the retailer under the four models with respect to different tariff levels. Figures 9–1 compares the retailer’s profits with and without tariff scenarios, and it is clear that the retailer’s profit without tariff scenario in Model 1 will be significantly higher than that with tariff scenario in Model 2. Figures 9–2 demonstrates the impact of strategic inputs on the retailer’s own profit in the case of tariffs, and it can be seen that the retailer’s strategic inputs not only do not harm its own profit but also significantly improve its own profit, which again verifies the conclusion of Model 2: strategic inputs will effectively improve the retailer’s profit.

Figures 9–3 further demonstrates the change in the retailer’s profit after the manufacturer compensates the retailer for its strategic inputs, and it can be seen that the retailer’s profit rises significantly after the manufacturer compensates the retailer.

Figures 9–4 synthesizes the four models. More intuitively, we can see the damage of tariffs imposing on the retailer’s profit, and in the absence of strategic inputs and compensation, the retailer’s profit in the situation
of tariffs in Model 2 is the lowest among the four models. In contrast, strategic inputs by the retailer have significant positive effects on the retailer’s profit, and even below the 15% tariff level, the retailer’s profit in Model 3 will exceed that in the zero-tariff scenario of Model 1. Finally, the results of Model 4 with the yellow line illustrate that the manufacturer’s compensation to the retailer has a significant positive effect on the retailer’s profit.

5. Conclusions

In this paper, we introduce the online direct sales channel into the transnational dual-channel supply chain, analyse the effects of different variables on supply chain decisions, and draw the following conclusions.

First, whether it is a traditional distribution channel or an online direct sales channel, tariffs imposed by the foreign government will lead to higher product selling prices and lower sales volumes and cause consumers’ welfare in the foreign market to be impaired. Additionally, comparing the increase in product selling prices and the decrease in product sales volumes in both channels, it is found that the online direct sales channel is more affected by tariffs than the traditional distribution channel.
Figure 9. Comparison of the retailer’s profits under different models.
Second, the strategic inputs by the domestic retailer are effective in hedging the foreign government’s tariff imposing; thus, the strategic inputs not only improve product sales volume in the traditional distribution channel but also help the retailer gain an advantage in dual-channel competition. In addition, the strategic inputs of the retailer are negatively related to its own marginal costs and tariffs and positively related to channel cross-price elasticity coefficients.

Finally, the strategic inputs of the retailer in the transnational dual-channel supply chain help to improve the profits of the manufacturer, the retailer and the whole supply chain, and the manufacturer has the incentive to compensate the retailer for its strategic inputs. The compensation from the manufacturer will increase the profits of the manufacturer and the retailer, thus achieving Pareto improvement in the transnational dual-channel supply chain.

However, there are still some shortcomings of this paper. For example, for the convenience of calculation and research focusing consideration, this paper does not analyse the selling cost and experience of the manufacturer and the retailer in the transnational dual-channel supply chain in depth, while the impact of the selling cost and experience on the transnational dual-channel equilibrium is obviously an issue worthy of in-depth exploration, so in subsequent research, it can be considered to focus on in-depth exploration of the impact of the selling cost and experience of retailers and manufacturers on the impact of transnational dual-channel supply chains.

Acknowledgements

This research is supported by the National Social Science Fund of China (No. 21BGL099).

References


---

**Please help to maintain this journal in open access!**

This journal is currently published in open access under the Subscribe to Open model (S2O). We are thankful to our subscribers and supporters for making it possible to publish this journal in open access in the current year, free of charge for authors and readers.

Check with your library that it subscribes to the journal, or consider making a personal donation to the S2O programme by contacting subscribers@edpsciences.org.

More information, including a list of supporters and financial transparency reports, is available at [https://edpsciences.org/en/subscribe-to-open-s2o](https://edpisciences.org/en/subscribe-to-open-s2o).