Online Appendix to

"Towards Reuse: The Implications of Price Incentives and Convenience of Reusable Packaging"

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In this Online Appendix, we present the details of model extensions with heterogeneous hassle costs and heterogeneous environmental impacts of packaging waste, the details of model calibration, and the proofs for the main model. Additional analyses and proofs, including the model extension with crowding-out effects, extensions with heterogeneous valuation and heterogeneous environmental disutility, and the proofs of all extended models, are provided in the Online Supplement (available in the full author manuscript at: `https://ssrn.com/abstract=3679449`).

For ease of exposition, throughout the Online Appendix and Online Supplement, we use u_j to denote the overall purchase utility of type-j consumers, where $j \in \{CI, CD, UI, UD\}$. Accordingly, in the benchmark model without firm-owned reusable packaging, $u_j = \max\{u_{D,j}, u_{C,j}\}$; in the model with firm-owned reusable packaging, $u_j = \max\{u_{D,j}, u_{C,j}, u_{F,j}\}$.

Online Appendix I Heterogeneous Hassle cost

In this section, we consider the case where eco-unconscious consumers incur a higher hassle cost $h_c + a$, with $a > 0$, when using personal reusable packaging. The hassle cost of eco-conscious consumers remains h_c.

The utility functions of eco-conscious consumers, including type-CI and type-CD consumers, are the same as in the main model. In contrast, the utility functions of eco-unconscious consumers are modified as follows:

- Without firm-owned reusable packaging:

$$u_{UI} = \max(v - p_d,\ v - h_c - a - p_c)$$
$$u_{UD} = \max(v - p_d,\ -k + v - h_c - a - p_c)$$

- With firm-owned reusable packaging:

$$u_{UI} = \max(v - p_d,\ v - h_c - a - p_c,\ v - p_f - \mathbb{E}[\min(\Phi h_f, f)])$$
$$u_{UD} = \max(v - p_d,\ -k + v - h_c - a - p_c,\ v - p_f - \mathbb{E}[\min(\Phi h_f, f)])$$

Note that our main model is a special case of $a = 0$.

We first look at the equilibrium outcome in the benchmark model without firm-owned reusable packaging.

Lemma OA.I.1. *In the benchmark model,*

(1) If $a < k$, there exist threshold functions $\bar{\mathcal{C}}_1^b(v, \alpha, \theta, h_c, \xi, k, a)$ and $\bar{\mathcal{C}}_2^b(v, \alpha, \theta, h_c, \xi, k, a)$ such that:

- *(i) If $c_d \le \min((h_c - \xi)^+, \bar{\mathcal{C}}_1^b)$, then $p_d^b = v - \xi$, $p_c^b = v - \xi$.*
- *(ii) If $(h_c - \xi)^+ < c_d \le \bar{\mathcal{C}}_1^b$, then $p_d^b = v - \xi$, $p_c^b = v - \max(\xi, h_c)$.*
- *(iii) If $\bar{\mathcal{C}}_1^b < c_d \le \bar{\mathcal{C}}_2^b$ and $k < \min(\alpha(1-\theta)(v - h_c) + (1-\alpha)a, \xi + a)$, then $p_d^b = v - k + a$, $p_c^b = v - k - h_c$.*
- *(iv) If $\bar{\mathcal{C}}_1^b < c_d \le \bar{\mathcal{C}}_2^b$ and $k \ge \min(\alpha(1-\theta)(v - h_c) + (1-\alpha)a, \xi + a)$, then $p_d^b = v$, $p_c^b = v - h_c$.*
- *(v) If $c_d > \bar{\mathcal{C}}_2^b$, then $p_d^b = v$, $p_c^b = v - k - h_c$.*

(2) If $a \geq k$, there exists a threshold function $\mathcal{C}_3^b(v, \alpha, \theta, h_c, \xi, k)$ such that:

(i) If $c_d \leq \min((h_c - \xi)^+, \mathcal{C}_3^b)$, then $p_d^b = v - \xi$, $p_c^b = v - \xi$.

(ii) If $(h_c - \xi)^+ < c_d \leq \mathcal{C}_3^b$, then $p_d^b = v - \xi$, $p_c^b = v - \max(h_c, \xi)$.

(iii) If $c_d > \mathcal{C}_3^b$ and $k \leq (1-\theta)(v - h_c)$, then $p_d^b = v$, $p_c^b = v - k - h_c$.

(iv) If $c_d > \mathcal{C}_3^b$ and $k > (1-\theta)(v - h_c)$, then $p_d^b = v$, $p_c^b = v - h_c$.

We find that if $a < k$, the equilibrium outcome has the same structure as in Lemma 2. The only difference is that the firm is able to increase the price in strategy (iii) from $p_d^b = v - k$ (as in Lemma 2) to $p_d^b = v - k + a$.

Next, we look at the equilibrium outcome in the model with firm-owned reusable packaging. As shown in the proof of Lemma 3, the firm will always induce eco-unconscious consumers to use disposable packaging (i.e., $p_d \leq \min(p_f + \mathbb{E}[\min(\Phi h_f, f)], p_c + h_c + k + a)$ and $p_c \geq p_d - h_c - a$) to maximize its profit. Therefore, the presence of a does not affect the equilibrium outcome, leading to the same result as in Lemma 3.

Hence, if $a < k$, the result in Proposition 1 remains unchanged, except that the condition $c_d < \mathcal{C}_1^b$ is replaced by $c_d < \bar{\mathcal{C}}_1^b$, where $\bar{\mathcal{C}}_1^b$ is defined in Lemma OA.I.1. Similarly, the result in Proposition 2 remains unchanged, except that the condition $c_d > \mathcal{C}_2^b$ is replaced by $c_d > \bar{\mathcal{C}}_2^b$, where $\bar{\mathcal{C}}_2^b$ is defined in Lemma OA.I.1. The result in Propositions 3 and 4, both of which are based on the equilibrium outcome with firm-owned reusable packaging, remain unchanged.

Online Appendix II Heterogeneous Environmental Impacts of Packaging Waste

In the main model, we assume that eco-conscious consumers incur the same disutility, ξ, for generating packaging waste, regardless of the type of the packaging. This applies to both (i) using disposable packaging and (ii) failing to return firm-owned reusable packaging, in which case the packaging exits the reuse loop and needs to be replaced with new packaging. Consistent with this assumption, when evaluating environmental impact, our metric of "average packaging waste per unit of product sold" treats these two waste streams equivalently by simply summing them.

In this section, we extend the model to incorporate heterogeneity in the environmental impacts of these two distinct packaging waste sources. Specifically, let $e_d > 0$ denote the environmental impact generated by disposable packaging waste, and $e_r > 0$ denote the environmental impact generated when firm-owned reusable packaging is not returned.

We assume that eco-conscious consumers incur a disutility λ for *each unit* of environmental impact caused by packaging waste. Consequently, the total disutility incurred from using disposable packaging is defined as $\xi_d = \lambda e_d$, and the resulting utility derived from purchasing a product with disposable packaging is:

$$v - \xi_d - p_d \tag{OA.II.1}$$

Accordingly, the disutility incurred from failing to return firm-owned reusable packaging is $\xi_r = \lambda e_r$. The resulting expected utility from purchasing the product with firm-owned reusable packaging is given by:

$$v - f - p_f + \mathbb{E}_\Phi[\max(f - \Phi h_f, -\xi_r)] = v - p_f - \mathbb{E}_\Phi[\min(\Phi h_f, f + \xi_r)] \tag{OA.II.2}$$

The main model corresponds to the special case where $e_d = e_r$ (implying $\xi_d = \xi_r = \xi$).

Accordingly, we redefine the environmental metric as follows:

$$E \triangleq \text{average environmental impact per unit of product sold} \tag{OA.II.3}$$

In the model without firm-owned reusable packaging, $E^b = \frac{e_d d_D^b}{d_D^b + d_C^b}$; in the model with firm-owned reusable packaging, we have $E^f = \frac{e_d d_D^f + e_r d_{F,u}^f}{d_D^f + d_F^f + d_C^f}$. Note that the main model corresponds to the special case where $e_d = e_r$ and $W = E/e_d$.

Lemma OA.II.1. *In the benchmark model, there exist thresholds $\tilde{\mathcal{C}}_1^b(v, \alpha, \theta, h_c, \xi_d, k)$ and $\tilde{\mathcal{C}}_2^b(v, \alpha, \theta, h_c, \xi_d, k)$ such that:*

(i) If $c_d \leq \min((h_c - \xi_d)^+, \tilde{\mathcal{C}}_1^b(\cdot))$, then $p_d^b = v - \xi_d$, $p_c^b = v - \xi_d$.

(ii) If $(h_c - \xi_d)^+ < c_d \leq \tilde{\mathcal{C}}_1^b(\cdot)$, then $p_d^b = v - \xi_d$, $p_c^b = v - \max(\xi_d, h_c)$.

(iii) If $\tilde{\mathcal{C}}_1^b(\cdot) < c_d \leq \tilde{\mathcal{C}}_2^b(\cdot)$ and $k < \min(\alpha(1-\theta)(v - h_c), \xi_d)$, then $p_d^b = v - k$, $p_c^b = v - h_c - k$.

(iv) If $\tilde{\mathcal{C}}_1^b(\cdot) < c_d \leq \tilde{\mathcal{C}}_2^b(\cdot)$ and $k \geq \min(\alpha(1-\theta)(v - h_c), \xi_d)$, then $p_d^b = v$, $p_c^b = v - h_c$.

(v) If $c_d > \tilde{\mathcal{C}}_2^b(\cdot)$, then $p_d^b = v$, $p_c^b = v - h_c - k$.

Compared with Lemma 2, Lemma OA.II.1 shows that the benchmark model without firm-owned reusable packaging remains structurally unchanged; we simply replace ξ with ξ_d.

Proposition OA.II.1. *(i) The firm will offer firm-owned reusable packaging (i.e., $\pi^f > \pi^b$) if and only if $c_{r,o} < \tilde{\mathcal{C}}^f(c_d, v, \alpha, \theta, \beta, \phi, h_c, h_f, \xi_d, \xi_r, k, c_{r,m}, T)$ for some threshold $\tilde{\mathcal{C}}^f(\cdot)$.*

(ii) When the cost of disposable packaging is small, there are instances in which the firm offers firm-owned reusable packaging for a small fraction of eco-conscious consumers, but not for a large fraction. (Formally, if $c_d < \tilde{\mathcal{C}}_1^b(\cdot)$, where $\tilde{\mathcal{C}}_1^b$ is defined in Lemma OA.II.1, then there exist $\alpha_1 < \alpha_2$ such that $c_{r,o} < \tilde{\mathcal{C}}^f\big|_{\alpha=\alpha_1}$ and $c_{r,o} > \tilde{\mathcal{C}}^f\big|_{\alpha=\alpha_2}$.)

Lemma OA.II.2. *There exist thresholds $\tilde{\mathcal{H}}_c(\alpha, \theta, \beta, \phi, \xi_r, c_{r,o}, c_{r,m}, T, h_f)$, $\tilde{\mathcal{H}}_{f1}(\alpha, \theta, \beta, \phi, \xi_r, c_{r,o}, c_{r,m}, T)$ and $\tilde{\mathcal{H}}_{f2}(\alpha, \theta, \beta, \phi, \xi_r, c_{r,o}, c_{r,m}, T)$ such that the firm's optimal pricing strategy is as follows:*

(a) If $h_c < \tilde{\mathcal{H}}_c(\cdot)$ and $h_f \geq \tilde{\mathcal{H}}_{f1}(\cdot)$, then $p_d^f = v - (1-\beta)\xi_r$, $p_c^f = \min(v - (1-\beta)\xi_r, v - h_c)$, $p_f^f = v - h_f - (1-\beta)\xi_r$, and $f^f = h_f$.

(b) If $h_c < \tilde{\mathcal{H}}_c(\cdot)$ and $h_f < \tilde{\mathcal{H}}_{f1}(\cdot)$, then $p_d^f = v$, $p_c^f = v - h_c$, $p_f^f = v - (\beta + (1-\beta)\phi)h_f$, and $f^f = \phi h_f$.

(c) If $h_c \geq \tilde{\mathcal{H}}_c(\cdot)$ and $h_f \geq \tilde{\mathcal{H}}_{f2}(\cdot)$, then $p_d^f = v - (1-\beta)\xi_r$, $p_c^f = v - (1-\beta)\xi_r$, $p_f^f = v - h_f - (1-\beta)\xi_r$, and $f^f = h_f$.

(d) If $h_c \geq \tilde{\mathcal{H}}_c(\cdot)$ and $h_f < \tilde{\mathcal{H}}_{f2}(\cdot)$, then $p_d^f = v$, $p_c^f = v$, $p_f^f = v - (\beta + (1-\beta)\phi)h_f$, and $f^f = \phi h_f$.

Based on Proposition OA.II.1 and Lemma OA.II.2, we can find that the equilibrium outcomes of the model with firm-owned reusable packaging also remain unchanged, with the only modification being the replacement of ξ by ξ_r. Furthermore, the key insight of Proposition 1 that a larger α could discourage the firm from introducing its reusable packaging is still valid.

Proposition OA.II.2. *Compared to the benchmark model, when the firm chooses to offer its reusable packaging, $E^f > E^b$ if $c_d > \tilde{\mathcal{C}}_2^b(\cdot)$, where $\tilde{\mathcal{C}}_2^b(\cdot)$ is defined in Lemma OA.II.1.*

Proposition OA.II.2 shows that the key insight of Proposition 2, that the introduction of firm-owned reusable packaging may lead to greater environmental impact due to packaging waste, remains valid.

Proposition OA.II.3. *When the firm offers its reusable packaging,*

(i) A decrease in the hassle of consumer-owned reusable packaging always increases the profit. (Formally, π^f is decreasing in h_c.)

(ii) A decrease in the hassle of firm-owned reusable packaging always increases the profit. (Formally, π^f is decreasing in h_f.)

Proposition OA.II.3 confirms the result shown in Proposition 3, i.e., improving the convenience of reusable packaging (either consumer-owned or firm-owned) has a positive impact on the firm's profit.

Proposition OA.II.4. *When the firm offers its reusable packaging,*

(i) A decrease in the hassle of consumer-owned reusable packaging always reduces the average environmental impact per unit of product sold. (Formally, E^f is weakly increasing in h_c.)

(ii) There are instances where the average environmental impact per unit of product sold increases as the hassle of using firm-owned reusable packaging decreases, particularly when using consumer-owned reusable packaging is not very convenient. (Formally, there exist h_{f1}, h_{f2} such that $\tilde{\mathcal{H}}_{f2} < h_{f1} < h_{f2}$ and $E^f|_{h_f=h_{f1}} > E^f|_{h_f=h_{f2}}$ if $h_c > \tilde{\mathcal{H}}^*(\cdot)$ for some threshold $\tilde{\mathcal{H}}^*(\alpha, \theta, \beta, \phi, \xi_r, c_{r,o}, c_{r,m}, T)$, where $\tilde{\mathcal{H}}_{f2}$ is defined in Lemma OA.II.2).

Proposition OA.II.4 shows that the result of Proposition 4 still holds, i.e., improving the convenience of consumer-owned reusable packaging always reduces environmental impact, while improving the convenience of firm-owned reusable packaging could increase the environmental impact.

Online Appendix III Model Calibration

In this section, we provide the detailed justification and empirical evidence supporting the parameter values used in Section 6 of the main paper.

- $T \sim U(20, 40)$: A proper mean of the designed lifespan is 30. For example, the reusable cups offered by Starbucks' "Borrow A Cup" program are tested to last for up to 30 uses (Starbucks, 2021).
- $\beta \sim U(0.5, 0.9)$: In our model, the resulting return rate is $\rho \in \{\beta, 1\}$ in equilibrium. The range $(0.5, 0.9)$ for β in our model reflects the return rates observed in recent real-world initiatives. For example, reusable takeaway cup pilot programs led by companies such as Coca-Cola, Starbucks, and PepsiCo achieved a return rate of 51% (Packaging Europe, 2025). The Return-to-Earn scheme at UCL East recorded a 79% return rate following its trial (UCL, 2025), while a reusable cup program in a Danish city reached an 85% return rate (Jones, 2024).
- $c_d \sim U(0.05, 0.15)$: The unit purchase cost of disposable cups is typically on the order of 5–15 euro cents (McKinsey & Company, 2023).

- $c_{r,m} \sim U(0.3, 0.7)$: A reasonable mean value for $c_{r,m}$ is 0.5, which is 5 times the mean of c_d. According to cost estimates from Eunomia (2024), the average purchase costs of a reusable plastic cup and a single-use cup are 50 euro cents and 11 euro cents, respectively.
- $c_{r,o} \sim U(0.1, 0.2)$: A reasonable mean for $c_{r,o}$ is 0.15, which is 1.5 times the disposable packaging's average cost c_d. According to cost estimates from McKinsey & Company (2023), the operational cost (including transportation and cleaning) is around 160% of the disposable packaging cost. If economies of scale can be achieved in a centralized reuse system, the operational cost can be reduced to EUR 0.1 (Eunomia, 2024), which is the same as the average cost of a disposable cup. Therefore, the proper lower bound is 0.1.
- $v \sim U(0.8, 1.2)$: A reasonable mean for v is 1, given that the mean for c_d is 0.1. In our model, $v - c_d$ represents the unit margin that the firm can extract from eco-unconscious consumers. Thus, the implied profit-to-cost ratio is $(v - c_d)/c_d = 9$. This aligns with the actual financial performance of the coffee industry. For instance, using 2024 Starbucks data (Kerr, 2024; Starbucks, 2024), an average price of \$5.00 combined with a 15% operating margin implies a unit marginal profit of \$0.75 (corresponding to $v - c_d$ in our model). Comparing this to Starbucks' disposable cup cost of \$0.08 (Benaroya, 2019) (corresponding to c_d) yields a real-world profit-to-cost ratio of approximately 9. This empirical evidence supports our parameterization of $v - c_d \approx 9c_d$.
- $\alpha \sim U(0.2, 0.6)$: A reasonable mean value for α would be 0.4, as 40% of consumers are considered as purpose-driven consumers and think that sustainability is very important for them (IBM, 2020). Specifically, for consumer goods, 25% of consumers think that sustainability is extremely important to them in their purchase decision (Simon-Kucher & Partners, 2021). Hence, a lower bound of 0.2 for α is appropriate. It is also reported that 55% of U.S. consumers are extremely or very concerned about the environmental impact of product packaging (McKinsey & Company, 2020). Therefore, an upper bound of 0.6 is appropriate.
- $\theta \sim U(0.4, 0.6)$: θ represents the fraction of consumers who have direct access to their personal reusable packaging at the time of purchase. Accordingly, $1 - \theta$ represents the fraction of consumers who forget to bring reusable packaging for shopping trips, or who decide to shop at a time when their reusable packaging is not on hand. A reasonable mean for θ is 0.5, as 44% of consumers cite difficulty remembering to bring reusable packaging as a barrier to adopting reusable systems (PA Consulting, 2024). Similarly, 55% of participants specifically mentioned forgetting the bottle as the biggest impediment to using reusable bottles (Putnam-Farr et al., 2023).
- $h_c \sim U(0.15, 0.4)$: A reasonable mean value for h_c is 0.27. In our model, h_c represents the perceived inconvenience of carrying and cleaning personal reusable packaging. Meanwhile, it also represents the minimum discount required to incentivize eco-unconscious consumers to adopt personal reusable packaging. Since we normalize the baseline cost of a disposable cup (c_d) to 0.1 (representing approximately 10 cents), a mean h_c of 0.27 corresponds to a monetary value of 27 cents. This calibration aligns with empirical findings by Nicolau et al. (2022), which indicate that a financial incentive of 27 cents is required to incentivize respondents to use their personal reusable cups.
- $\xi \sim U(0.15, 0.4)$: We calibrate the range of the psychological disutility of generating waste (ξ) to be comparable in magnitude to the hassle cost (h_c). Given this range, ξ can be either greater or smaller than h_c. This flexibility allows our model to capture the full spectrum of consumer heterogeneity, ranging from eco-driven individuals whose guilt outweighs the inconvenience of washing to

convenience-oriented consumers who prioritize effort reduction.

- $h_f \sim U(0.1, 0.35)$: We assume the range of h_f is slightly lower than that of h_c. This reflects the fact that firm-owned packaging (h_f) eliminates the burden of cleaning associated with personal reusable cups (h_c). However, our model maintains a flexible relationship between h_c and h_f. This accounts for factors such as hygiene concerns regarding shared packaging, which can elevate the perceived burden for some consumers despite the physical convenience (Cole, 2022).
- $k \sim U(0.15, 0.4)$: In our model, k represents the retrieval cost incurred when a consumer needs to fetch a container that was not immediately at hand. This parameter quantifies the physical effort associated with actions such as returning to an office or vehicle to retrieve the item. Note that both k and h_c fundamentally measure time-based physical frictions. Given the same range $[0.15, 0.4]$, k could be smaller or larger than h_c, which reflects scenarios where the detour to retrieve a reusable container is either marginally less or more burdensome than carrying and washing it.
- $\phi \sim U(7, 13)$: We set the mean of ϕ to 10. This magnitude ensures that returning the packaging represents a substantial burden for consumers when they are in the effortful-return state.

Online Appendix IV Proofs for the Main Model

Proof Lemma 1: When $\alpha = 0$, there are only eco-unconscious consumers in the market. Recall that $u_{UI} = \max(v - p_d, v - h_c - p_c)$ and $u_{UD} = \max(v - p_d, -k + v - h_c - p_c)$. Then, there are three pricing strategies.

- Set the price at $p_c = p_d = v$ such that all consumers use disposable packaging. The corresponding profit is $\pi = v - c_d$. In this case, $d_C = 0$.
- Set the price at $p_d = v, p_c = v - h_c$ such that type-UI consumers use personal reusable packaging and type-UD consumers use firm-owned disposable packaging. Then, the corresponding profit is $\pi = \theta(v - h_c) + (1 - \theta)(v - c_d)$. In this case, $d_C = \theta$.
- Set the price at $p_d > v$ and $p_c = v - h_c - k$ such that all consumers use personal reusable packaging. Then, the corresponding profit is $\pi = v - h_c - k$. In this case, $d_C = 1$.

Based on the comparison of the above three cases, we know that the firm will choose the first strategy such that $d_C = 0$ if and only if $c_d < h_c$. □

Proof of Lemma 2: Consumers' utility functions are as follows: $u_{CI} = \max(v - \xi - p_d, v - h_c - p_c)$, $u_{CD} = \max(v - \xi - p_d, -k + v - h_c - p_c)$, $u_{UI} = \max(v - p_d, v - h_c - p_c)$, $u_{UD} = \max(v - p_d, -k + v - h_c - p_c)$.

First, the firm never sets $p_c < p_d - h_c - k$ such that all consumers use consumer-owned reusable packaging, since it is always dominated by the case when $p_c = p_d - h_c - k$ such that type-UD consumers use disposable packaging and pay the full price p_d.

Second, we can find that type-CD consumers will use reusable packaging only if $p_d - p_c \geq h_c + k - \xi$, while type-UI consumers will use reusable packaging only if $p_d - p_c \geq h_c$. Then, type-CD consumers will require a smaller discount than type-UI consumers when $k < \xi$.

Then, the firm's optimal strategy can be chosen from:

(0) Sell to all consumers and do not induce any consumers to use personal reusable packaging.

Then, the firm sets $p_d = v - \xi$, $p_c = v - \xi$. The corresponding profit is:

$$\pi_0 = v - \xi - c_d$$

Note that this case can hold only if $\xi < h_c$.

(1) Sell to all consumers and induce type-CI consumers to use reusable packaging. Then, the firm sets $p_d = v - \xi$, $p_c = v - \max(h_c, \xi) = v - \xi - (h_c - \xi)^+$. The corresponding profit is

$$\pi_1 = \alpha\theta(v - \max(h_c, \xi)) + (1 - \alpha\theta)(v - \xi - c_d)$$

Note that this case can hold only if $\xi < k + h_c$.

(2) Sell to all consumers and induce type-CI, type-CD consumers to use reusable packaging. Then, the optimization problem is:

$$\begin{aligned}
\max_{p_c, p_d} \ & \alpha p_c + (1-\alpha)(p_d - c_d) \\
s.t. \ & p_c \le v - h_c - k \\
& p_c + h_c + k - \xi \le p_d \le p_c + h_c \\
& p_d \le v
\end{aligned}$$

Then, the firm sets $p_d = v - k$, $p_c = v - k - h_c$. The corresponding profit is:

$$\pi_2 = \alpha(v - k - h_c) + (1-\alpha)(v - k - c_d)$$

This case can hold only if $\xi > k$.

(3) Sell to type-CI, type-UI, and type-UD consumers and induce only type-CI consumers to use reusable packaging. Then, the firm should set $p_d = v$ and $p_c = v - h_c$. The corresponding profit is:

$$\pi_3 = \alpha\theta(v - h_c) + (1-\alpha)(v - c_d)$$

(4) Sell to all consumers and induce type-CI, type-CD, type-UI consumers to use reusable packaging. Then, the firm should set $p_d = v$, $p_c = v - h_c - k$. The corresponding profit is:

$$\pi_4 = (\alpha + (1-\alpha)\theta)(v - h_c - k) + (1-\alpha)(1-\theta)(v - c_d)$$

Observe that the marginal profits with respect to c_d satisfy $\frac{d\pi_0}{dc_d} < \frac{d\pi_1}{dc_d} < \frac{d\pi_2}{dc_d} = \frac{d\pi_3}{dc_d} < \frac{d\pi_4}{dc_d}$.

Comparing π_2 and π_3, we find that $\pi_2 > \pi_3$ if and only if $k < \alpha(1-\theta)(v - h_c)$. Furthermore, Strategy 2 is feasible only if $k < \xi$. Accordingly, we define the boundary for the dominance of Strategy 2 as:

$$\mathcal{K}^b = \min(\alpha(1-\theta)(v - h_c), \xi).$$

We define the critical cost thresholds as follows:

$$\begin{aligned}
C_{1,1} &= \inf\{c_d \ge 0 \mid \max(\pi_2, \pi_4) \ge \max(\pi_0, \pi_1)\}, \\
C_{1,2} &= \inf\{c_d \ge 0 \mid \max(\pi_3, \pi_4) \ge \max(\pi_0, \pi_1)\}, \\
C_{2,1} &= \inf\{c_d \ge 0 \mid \pi_4 \ge \max(\pi_0, \pi_1, \pi_2)\}, \\
C_{2,2} &= \inf\{c_d \ge 0 \mid \pi_4 \ge \max(\pi_0, \pi_1, \pi_3)\}.
\end{aligned}$$

Then, we obtain the unified thresholds:

$$\mathcal{C}_1^b = \begin{cases} C_{1,1} & \text{if } k < \mathcal{K}^b, \\ C_{1,2} & \text{if } k \geq \mathcal{K}^b, \end{cases} \quad \text{and} \quad \mathcal{C}_2^b = \begin{cases} C_{2,1} & \text{if } k < \mathcal{K}^b, \\ C_{2,2} & \text{if } k \geq \mathcal{K}^b. \end{cases}$$

Recall that $\pi_0 > \pi_1$ if and only if $c_d < (h_c - \xi)^+$. Based on the properties of the profit functions, the optimal strategy structure is characterized as follows:

- If $c_d \leq \min((h_c - \xi)^+, \mathcal{C}_1^b)$, the firm chooses Strategy (0) and sets $p_d = v - \xi$, $p_c = v - \xi$.
- If $(h_c - \xi)^+ < c_d < \mathcal{C}_1^b$, the firm chooses Strategy (1) and sets $p_d = v - \xi$, $p_c = v - \max(\xi, h_c)$.
- If $\mathcal{C}_1^b < c_d < \mathcal{C}_2^b$, the firm chooses:
  - Strategy (2) (sets $p_d = v - k$, $p_c = v - k - h_c$) if $k < \mathcal{K}^b$;
  - Strategy (3) (sets $p_d = v$, $p_c = v - h_c$) if $k \geq \mathcal{K}^b$.
- If $c_d > \mathcal{C}_2^b$, the firm chooses Strategy (4) and sets $p_d = v$, $p_c = v - h_c - k$.

Note that since $c_d > 0$, the interval $(0, (h_c - \xi)^+)$ is empty if $h_c < \xi$. This leads to Lemma 2.

□

Proof of Proposition 1 and Lemma 3: In the model with firm-owned reusable packaging, consumers' utility functions are as follows:

$$\begin{aligned} u_{CI} &= \max(v - \xi - p_d,\ v - h_c - p_c,\ v - p_f - \mathbb{E}[\min(\Phi h_f, f + \xi)]), \\ u_{CD} &= \max(v - \xi - p_d,\ -k + v - h_c - p_c,\ v - p_f - \mathbb{E}[\min(\Phi h_f, f + \xi)]), \\ u_{UI} &= \max(v - p_d,\ v - h_c - p_c,\ v - p_f - \mathbb{E}[\min(\Phi h_f, f)]), \\ u_{UD} &= \max(v - p_d,\ -k + v - h_c - p_c,\ v - p_f - \mathbb{E}[\min(\Phi h_f, f)]). \end{aligned}$$

First, observe that the firm should always set $f \geq h_f - \xi$. Otherwise, no consumers would return the firm-owned packaging, which implies that firm-owned reusable packaging becomes a more costly version of disposable packaging (while also imposing disutility ξ on eco-conscious consumers). In that scenario, the model is strictly dominated by the benchmark model.

Next, let us refine consumers' packaging choices in the equilibrium where the firm offers firm-owned reusable packaging. Based on the utility functions, the conditions under which consumers prefer firm-owned reusable packaging to disposable packaging are:

- $p_d > p_f + \mathbb{E}[\min(\Phi h_f, f)]$ for eco-unconscious consumers;
- $p_d > p_f + \mathbb{E}[\min(\Phi h_f, f + \xi)] - \xi$ for eco-conscious consumers.

Note that $p_f + \mathbb{E}[\min(\Phi h_f, f)] > p_f + \mathbb{E}[\min(\Phi h_f, f + \xi)] - \xi$. Consequently, any strategy setting $p_d > p_f + \mathbb{E}[\min(\Phi h_f, f)]$ (where eco-unconscious consumers prefer firm-owned packaging) is dominated by setting $p_d = p_f + \mathbb{E}[\min(\Phi h_f, f)]$ (where they prefer disposable). This binding allows the firm to extract more surplus from eco-unconscious consumers. Thus, a profit-maximizing firm sets $p_d \leq p_f + \mathbb{E}[\min(\Phi h_f, f)]$, implying that only eco-conscious consumers are potential candidates for firm-owned reusable packaging.

To ensure adoption, the firm must set $p_f \leq \min(p_d + \xi,\ p_c + k + h_c,\ v) - \mathbb{E}[\min(\Phi h_f, f + \xi)]$ such that at least type-CD consumers choose firm-owned reusable packaging; otherwise, the demand for the firm's packaging is zero.

Given these conditions, type-CI consumers choose between firm-owned and personal reusable packaging, while type-UI and type-UD consumers choose between disposable and personal reusable packaging. The conditions under which these segments prefer personal reusable packaging are:

- $p_c \le p_f + \mathbb{E}[\min(\Phi h_f, f+\xi)] - h_c$ for type-CI consumers. Note that $p_f + \mathbb{E}[\min(\Phi h_f, f+\xi)] - h_c > p_f + \mathbb{E}[\min(\Phi h_f, f)] - h_c \ge p_d - h_c$.
- $p_c < p_d - h_c$ for type-UI consumers.
- $p_c < p_d - h_c - k$ for type-UD consumers.

Any outcome with $p_d > p_c + h_c + k$ is dominated by $p_d = p_c + h_c + k$ (since $h_c + k > c_d$), allowing the firm to extract more surplus. Similarly, any outcome with $p_c < p_d - h_c$ is dominated by $p_c = p_d - h_c$ (since $h_c > c_d$).

Based on this analysis, if offering firm-owned packaging is profitable, the firm will sell to all consumers. Furthermore, the optimal strategy must fall into one of two cases regarding consumer segmentation:

(1) Induce type-CI to use personal reusable packaging (p_c), type-CD to use firm-owned reusable packaging (p_f), and all eco-unconscious consumers to use disposable packaging (p_d). The optimization problem is:

$$\max_{p_d, p_c, p_f, f} \pi = \alpha\theta p_c + \alpha(1-\theta)(p_f + f\mathbb{E}[I_{\Phi h_f > f+\xi}] - c_r(\rho(f))) + (1-\alpha)(p_d - c_d)$$

$$\begin{aligned} s.t.\ & p_f \le v - \mathbb{E}[\min(\Phi h_f, f+\xi)] \\ & \max(p_d - h_c, p_f + \mathbb{E}[\min(\Phi h_f, f+\xi)] - h_c - k) \le p_c \le \min(p_f + \mathbb{E}[\min(\Phi h_f, f+\xi)] - h_c, p_d) \\ & \max(p_f, p_f + \mathbb{E}[\min(\Phi h_f, f+\xi)] - \xi) \le p_d \le p_f + \mathbb{E}[\min(\Phi h_f, f)] \end{aligned}$$

where the indicator function $I_X = 1 (= 0)$ if X is true (false). The binding prices are $p_f = v - \mathbb{E}[\min(\Phi h_f, f+\xi)]$, $p_d = v - \mathbb{E}[\min(\Phi h_f, f+\xi)] + \mathbb{E}[\min(\Phi h_f, f)]$, and $p_c = \min(v - h_c, p_d)$. Regarding return behavior, there are two sub-cases:

(a) Effortless-return only: We require $f < \phi h_f - \xi$. The return rate is β, and the average cost is $c_r(\beta)$. Since the profit function is weakly increasing in f and constant for $f \in [h_f, \phi h_f - \xi]$, we set $f = h_f$. The corresponding profit is:

$$\pi_a = \alpha\theta \min(v - h_c, v - (1-\beta)\xi) + \alpha(1-\theta)(v - \beta h_f - (1-\beta)\xi - c_r(\beta)) + (1-\alpha)(v - (1-\beta)\xi - c_d)$$

(b) Full return: We require $f > \phi h_f - \xi$. The return rate is 1, with cost $c_r(1)$. The profit is increasing in f and constant for $f \ge \phi h_f$, so we set $f = \phi h_f$. The profit is:

$$\pi_b = \alpha\theta(v - h_c) + \alpha(1-\theta)(v - \beta h_f - (1-\beta)\phi h_f - c_r(1)) + (1-\alpha)(v - c_d)$$

(2) Sell to all consumers: Induce both type-CI and type-CD to use firm-owned reusable packaging (p_f), while type-UI and type-UD use disposable packaging (p_d).

$$\max_{p_d, p_c, p_f, f} \pi = \alpha(p_f + f\mathbb{E}[I_{\Phi h_f > f+\xi}] - c_r(\rho(f))) + (1-\alpha)(p_d - c_d)$$

$$\begin{aligned} s.t.\ & p_f \le v - \mathbb{E}[\min(\Phi h_f, f+\xi)] \\ & \max(p_f + \mathbb{E}[\min(\Phi h_f, f+\xi)] - h_c, p_d - h_c) < p_c \le p_d \\ & \max(p_f, p_f + \mathbb{E}[\min(\Phi h_f, f+\xi)] - \xi) \le p_d \le p_f + \mathbb{E}[\min(\Phi h_f, f)] \end{aligned}$$

This yields $p_d = p_f + \mathbb{E}[\min(\Phi h_f, f)]$ and $p_f = v - \mathbb{E}[\min(\Phi h_f, f+\xi)]$. There are two sub-cases for returns:

(c) Effortless-return only: Similar to (a), optimal $f = h_f$. The profit is:

$$\pi_c = \alpha(v - \beta h_f - (1-\beta)\xi - c_r(\beta)) + (1-\alpha)(v - (1-\beta)\xi - c_d)$$

Note that given the constraint that $p_d \geq p_c \geq p_f + \mathbb{E}[\min(\Phi h_f, f + \xi)]$, this case is feasible only if $h_c > (1-\beta)\xi$.

(d) Full return: Similar to (b), optimal $f = \phi h_f$. The profit is:

$$\pi_d = \alpha(v - \beta h_f - (1-\beta)\phi h_f - c_r(1)) + (1-\alpha)(v - c_d)$$

The firm's optimal profit is $\pi^f = \max(\pi_a, \pi_b, \pi_c, \pi_d)$, which is strictly decreasing in $c_{r,o}$. Since the benchmark profit $\pi^b = \max(\pi_0, \ldots, \pi_4)$ is independent of $c_{r,o}$, there exists a unique threshold $\mathcal{C}^f$ such that $\pi^f > \pi^b$ if and only if $c_{r,o} < \mathcal{C}^f$, defined as:

$$\mathcal{C}^f = \inf\{c_{r,o} \geq 0 \mid \pi^f \leq \pi^b\}.$$

This completes the proof of Proposition 1 (i).

Given the condition $c_{r,o} < \mathcal{C}^f$, we proceed to compare strategies (a), (b), (c), and (d).

Comparing strategies (a) and (b), observe that there exists a threshold $\mathcal{H}_{f1}$ such that $\pi_a > \pi_b$ if and only if $h_f > \mathcal{H}_{f1}$, where

$$\mathcal{H}_{f1} = \frac{(1-\alpha)(1-\beta)\xi + \alpha(1-\theta)(c_r(\beta) - c_r(1)) + \alpha\theta((1-\beta)\xi - h_c)^+}{\alpha(1-\theta)(1-\beta)\phi}.$$

Similarly, for strategies (c) and (d), there exists a threshold $\mathcal{H}_{f2}$ such that $\pi_c > \pi_d$ if and only if $h_f > \mathcal{H}_{f2}$, where

$$\mathcal{H}_{f2} = \frac{(1-\alpha)(1-\beta)\xi + \alpha(c_r(\beta) - c_r(1))}{\alpha(1-\beta)\phi}.$$

Comparing the two thresholds, it follows that $\mathcal{H}_{f1} > \mathcal{H}_{f2}$.

Next, we compare the optimal outcomes of the two main strategies. Note that $\max(\pi_a, \pi_b)$ is decreasing in h_c, while $\max(\pi_c, \pi_d)$ is independent of h_c. Therefore, there exists a threshold $\mathcal{H}_c$ such that $\max(\pi_a, \pi_b) > \max(\pi_c, \pi_d)$ if and only if $h_c < \mathcal{H}_c$. We define this threshold as:

$$\mathcal{H}_c = \inf\{h_c \geq 0 \mid \max(\pi_c, \pi_d) \geq \max(\pi_a, \pi_b)\}.$$

Furthermore, observe that $\pi_a > \pi_c$ if and only if $h_c < \beta h_f + (1-\beta)\xi + c_r(\beta)$. Consequently, when $h_f > \mathcal{H}_{f2}$, the condition $\mathcal{H}_c \geq \beta h_f + (1-\beta)\xi + c_r(\beta)$ always holds.

Summarizing the discussion above, we arrive at Lemma 3.

Finally, we give the proof of Proposition 1 (ii). Based on Lemma 2, when $c_d < \mathcal{C}_1^b$, the baseline profit is given by $\pi^b = v - \xi - c_d + \alpha\theta \max(0, \xi + c_d - \max(h_c, \xi))$.Next, we analyze the firm's profit under reusable packaging, denoted by $\pi^f = \max(\pi_a, \pi_b, \pi_c, \pi_d)$. We observe that for any strategy $k \in \{a, b, c, d\}$, the profit function can be decomposed into an affine function of α taking the form $\pi_k = g_{1,k} - \alpha g_{2,k}(c_{r,o})$. Here, $g_{1,k}$ is constant with respect to α and $c_{r,o}$, while $g_{2,k}(c_{r,o})$ is independent of α and strictly increasing in $c_{r,o}$. The specific coefficients for each strategy are derived as follows:

- Strategy (a): π_a implies $g_{1,a} = v - (1-\beta)\xi - c_d$ and $g_{2,a}(c_{r,o}) = \theta \max(h_c, (1-\beta)\xi) + (1-\theta)(\beta h_f + (1-\beta)\xi + c_r(\beta)) - (1-\beta)\xi - c_d$.
- Strategy (b): π_b implies $g_{1,b} = v - c_d$ and $g_{2,b}(c_{r,o}) = \theta h_c + (1-\theta)(\beta h_f + (1-\beta)\phi h_f + c_r(1)) - c_d$.
- Strategy (c): π_c implies $g_{1,c} = v - (1-\beta)\xi - c_d$ and $g_{2,c}(c_{r,o}) = \beta h_f + c_r(\beta) - c_d$.
- Strategy (d): π_d implies $g_{1,d} = v - c_d$ and $g_{2,d}(c_{r,o}) = \beta h_f + (1-\beta)\phi h_f + c_r(1) - c_d$.

The firm introduces reusable packaging if and only if $\pi^f > \pi^b$, where

$$\pi^f = \max\{\pi_a, \pi_b, \pi_c, \pi_d\}.$$

For each strategy $k \in \{a, b, c, d\}$,

$$\begin{aligned}\pi_k > \pi^b &\iff g_{1,k} - \alpha g_{2,k}(c_{r,o}) > v - \xi - c_d + \alpha\theta \max(0, \xi + c_d - \max(h_c, \xi)) \\ &\iff g_{2,k}(c_{r,o}) < \frac{g_{1,k} - (v - \xi - c_d)}{\alpha} - \theta \max(0, \xi + c_d - \max(h_c, \xi)).\end{aligned}$$

Moreover,

$$g_{1,k} - (v - \xi - c_d) = \begin{cases} \beta\xi, & k \in \{a, c\}, \\ \xi, & k \in \{b, d\}, \end{cases} > 0.$$

Because $g_{2,k}(c_{r,o})$ is strictly increasing in $c_{r,o}$, define

$$\mathcal{C}_k^f(\alpha) = g_{2,k}^{-1}\left(\frac{g_{1,k} - (v - \xi - c_d)}{\alpha} - \theta \max(0, \xi + c_d - \max(h_c, \xi))\right).$$

Because $g_{1,k} - (v - \xi - c_d) > 0$ and $g_{2,k}(c_{r,o})$ is strictly increasing in $c_{r,o}$, $\mathcal{C}_k^f(\alpha)$ is strictly decreasing in α. Moreover,

$$\begin{aligned}\pi^f > \pi^b &\iff \exists k \in \{a, b, c, d\} : \pi_k > \pi^b \\ &\iff c_{r,o} < \max_{k \in \{a,b,c,d\}} \mathcal{C}_k^f(\alpha).\end{aligned}$$

Therefore,

$$\mathcal{C}^f(\alpha) = \max_{k \in \{a,b,c,d\}} \mathcal{C}_k^f(\alpha),$$

which is strictly decreasing in α. Hence, for any $\alpha_1 < \alpha_2$,

$$\mathcal{C}^f|_{\alpha=\alpha_1} > \mathcal{C}^f|_{\alpha=\alpha_2}.$$

Then, choosing $c_{r,o}$ such that

$$\mathcal{C}^f|_{\alpha=\alpha_2} < c_{r,o} < \mathcal{C}^f|_{\alpha=\alpha_1}$$

yields an instance in which the firm introduces reusable packaging at α_1 but not at α_2.

Moreover, when $c_d < \mathcal{C}_1^b$, Lemma 2 gives $p_d^b = v - \xi$. Under strategies (a)–(d),

$$p_d^f \in \{v - (1 - \beta)\xi, v\} > v - \xi = p_d^b.$$

The corresponding consumer packaging choices follow directly from strategies (a)–(d) and Lemma 2, as summarized in Table 2. This completes the proof of Proposition 1(ii).

□

Proof of Proposition 2: In the benchmark model, according to the proof of Lemma 2, we know

- If $c_d < \min((h_c - \xi)^+, \mathcal{C}_1^b)$, then $W^b = 1$.
- If $(h_c - \xi)^+ < c_d < \mathcal{C}_1^b$, then $W^b = 1 - \alpha\theta$.
- If $\mathcal{C}_1^b < c_d \le \mathcal{C}_2^b$ and $k < \mathcal{K}^b$, then $W^b = 1 - \alpha$.
- If $\mathcal{C}_1^b < c_d \le \mathcal{C}_2^b$ and $k \ge \mathcal{K}^b$, then $W^b = \frac{1-\alpha}{1-\alpha+\alpha\theta}$
- If $c_d > \mathcal{C}_2^b$, then $W^b = (1 - \alpha)(1 - \theta)$.

We can find that W^b is weakly decreasing in c_d. Furthermore, $W^b < 1 - \alpha$ when $c_d > \mathcal{C}_2^b$.

In the model with firm-owned reusable packaging, according to the proof of Lemma 3, we know $W^f = 1-\alpha+\alpha(1-\theta)(1-\beta)$ under strategy (a); $W^f = 1-\alpha$ under strategy (b); $W^f = 1-\alpha+\alpha(1-\beta)$ under strategy (c); $W^f = 1-\alpha$ under strategy (d).

Therefore, $W^f \geq 1-\alpha$ always holds. Therefore, $W^f > W^b$ if $c_d > \mathcal{C}_2^b$.

□

Proof of Proposition 3: According to the proof of Lemma 3, we know strategy (c) is not available when $h_c < (1-\beta)\xi$. Let $\pi_a, \pi_b, \pi_c, \pi_d$ denote the profit of the corresponding strategy (a), (b), (c) and (d), respectively. Then,

$$\pi^f = \begin{cases} \max(\pi_a, \pi_b, \pi_d) & \text{if } h_c < (1-\beta)\xi \\ \max(\pi_a, \pi_b, \pi_c, \pi_d) & \text{if } h_c \geq (1-\beta)\xi \end{cases}$$

We first look at the impact of h_c. According to the proof of Lemma 3, we know $\pi_a > \pi_c$ if and only if $h_c < (1-\beta)\xi + \beta h_f + c_r(\beta)$. Then,

- If $h_c < (1-\beta)\xi$, then $\pi^f = \max(\pi_a, \pi_b, \pi_d)$.
- If $(1-\beta)\xi \leq h_c < (1-\beta)\xi + \beta h_f + c_r(\beta)$, then $\pi^f = \max(\pi_a, \pi_b, \pi_c, \pi_d) = \max(\pi_a, \pi_b, \pi_d)$.
- If $h_c \geq (1-\beta)\xi + \beta h_f + c_r(\beta)$, then $\pi^f = \max(\pi_a, \pi_b, \pi_c, \pi_d)$

Therefore, π^f is a continuous function of h_c. Since $\pi_a, \pi_b, \pi_c, \pi_d$ are decreasing in h_c, we know π^f is also decreasing in h_c.

Then, we analyze the impact of h_f on π^f. Since π^f is always a continuous function of h_f and $\pi(a), \pi(b), \pi(c), \pi(d)$ are decreasing in h_f, we know π^f is decreasing in h_f. □

Proof of Proposition 4: We first look at the impact of h_c on W^f. According to the proof of Lemma 3, we know $\pi(a), \pi(b)$ are decreasing in h_c, while $\pi(c), \pi(d)$ are independent of h_c. Therefore, as h_c decreases, the firm might change from strategy (c) or (d) to strategy (a) or (b). The average packaging waste is $W(a) = 1-\alpha+\alpha(1-\theta)(1-\beta)$, $W(b) = 1-\alpha$, $W(c) = 1-\alpha+\alpha(1-\beta)$ and $W(d) = 1-\alpha$. Therefore, as h_c decreases, W^f might increase only if the firm changes from strategy (d) to strategy (a). However, we can find that $\pi(a) > \pi(b)$ if and only if $h_f > \mathcal{H}_{f1}$, while $\pi(d) > \pi(c)$ if and only if $h_f \leq \mathcal{H}_{f2}$. Since $\mathcal{H}_{f2} < \mathcal{H}_{f1}$, once the firm adopts strategy (d), the firm never changes to strategy (a) as h_c decreases. To sum up, we can find that W^f is weakly increasing in h_c.

Next, we look at the impact of h_f on W^f. According to the proof of Lemma 3, we know $\max(\pi(a), \pi(b)) > \max(\pi(c), \pi(d))$ if and only if $h_c < \mathcal{H}_c$.

Given the condition $h_c > (1-\beta)\xi$, we know $\mathcal{H}_{f1} = \frac{(1-\alpha)(1-\beta)\xi+\alpha(1-\theta)(c_r(\beta)-c_r(1))}{\alpha(1-\theta)(1-\beta)\phi}$, and $\mathcal{H}_{f2} = \frac{(1-\alpha)(1-\beta)\xi+\alpha(c_r(\beta)-c_r(1))}{\alpha(1-\beta)\phi}$. Recall that $\mathcal{H}_c$ is a function of h_f. Let $\mathcal{H}^* = \max(\mathcal{H}_c(h_f = \frac{(1-\alpha)(1-\beta)\xi+\alpha(c_r(\beta)-c_r(1))}{\alpha(1-\beta)\phi}), \mathcal{H}_c(h_f = \frac{(1-\alpha)(1-\beta)\xi+\alpha(1-\theta)(c_r(\beta)-c_r(1))}{\alpha(1-\theta)(1-\beta)\phi}), (1-\beta)\xi)$. Then, when $h_c > \mathcal{H}^*$, we know that $\max(\pi(c), \pi(d)) > \pi(b)$ always holds.

In addition, $\pi(a) > \pi(c)$ if and only if $h_f > \frac{h_c-(1-\beta)\xi-c_r(\beta)}{\beta}$. Furthermore, when $h_f > \mathcal{H}_{f2}$, we know $\pi(c) > \pi(d)$. Then, given $h_c > \mathcal{H}^*$, we can choose $h_{f2} > \frac{h_c-(1-\beta)\xi-c_r(\beta)}{\beta}$ and $\mathcal{H}_{f2} < h_{f1} < \frac{h_c-(1-\beta)\xi-c_r(\beta)}{\beta}$ such that the firm chooses strategy (a) when $h_f = h_{f2}$ and changes to strategy (c) when $h_f = h_{f1}$. In this way, when the return hassle decreases from h_{f2} to h_{f1}, the average packaging waste will increase from $W^f = 1-\alpha+\alpha(1-\theta)(1-\beta)$ to $W^f = 1-\alpha+\alpha(1-\beta)$.

□

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