Green Service Commitments, Strategic Waiting, and Carbon Transparency in Digital Platform Supply Chains

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Abstract

This article revisits a platform supply chain problem in which a manufacturer chooses a wholesale price and product-level green effort, while an online retailer sets intertemporal prices and promised service speeds under strategic consumer waiting. Building on a two-period game-theoretic structure, the study explains how carbon transparency, fulfillment promises, and forward-looking demand interact in digital retail settings. The analysis compares a fixed-service regime with a dynamic-service regime and shows that service flexibility can work as an intertemporal screening device rather than a simple logistics adjustment. Dynamic service is most valuable when the market contains a meaningful but not overwhelming share of strategic consumers, because early fulfillment acceleration can partially substitute for markdowns. Green effort also changes the timing of demand by increasing the attractiveness of early purchase, especially when service sensitivity is moderate. To reduce channel misalignment, the paper evaluates a service-investment sharing contract in which the manufacturer subsidizes part of the retailer's service cost. The contract improves coordination in parameter regions where flexible service raises total channel profit but weakens the retailer's private incentive to invest. The paper contributes a unified perspective on green operations, digital platform design, and intertemporal consumer behavior.

Keywords: strategic consumers; platform supply chain; carbon transparency; green service; dynamic pricing; supply chain coordination

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1. Introduction

Digital commerce has transformed competition from a pure pricing problem into a broader commitment problem. In contemporary platform retailing, sellers do not merely quote a price; they also signal when an order will arrive, how reliable the fulfillment process is, and whether the product is environmentally responsible. These signals are interpreted together rather than independently. A buyer comparing two offers often weighs the convenience of rapid delivery against the possibility of waiting for a markdown and against the perceived environmental quality of the product. As a result, pricing, logistics, and sustainability have become tightly coupled in demand formation [Gao & Souza, 2022; Gopalakrishnan et al., 2021; Aghaei et al., 2025; Cannas et al., 2024; Olan et al., 2022].

A parallel change has occurred on the consumer side. A large body of operations research shows that many buyers are forward-looking: they infer the seller's likely future actions and strategically time their purchases. This literature traditionally focuses on markdown pricing, capacity rationing, and commitment problems, but digital retailing introduces another lever that is especially visible in platform markets: the service promise. Instead of relying only on price reductions to clear demand, a retailer may quote faster delivery in the first period to induce immediate purchase and then relax service later for less time-sensitive consumers [Su, 2007; Aviv & Pazgal, 2008; Liu & van Ryzin, 2008; Su & Zhang, 2008].

Environmental considerations make this intertemporal problem richer. Consumers increasingly react to product-level carbon claims, low-carbon packaging, and sustainability-oriented fulfillment policies. For many categories, green operations no longer act only as a reputational add-on; they shape willingness to pay and can change when consumers choose to buy. Recent studies on sustainable supply chains, green operations, and carbon-sensitive demand suggest that environmental investment affects both market expansion and channel incentives [Gao & Souza, 2022; Gopalakrishnan et al., 2021; Saberi et al., 2019; Olan et al., 2022].

At the same time, digital infrastructure is broadening the toolkit available to firms. Work on blockchain in information systems, Web 3.0, FinTech, decentralized finance, quantum finance, and large language model-enabled supply chain finance shows how transparency, programmability, and intelligent coordination are reshaping digital markets. While those streams are often discussed in financial or information-systems terms, they also matter for platform supply chains because they strengthen traceability, carbon disclosure, transaction security, and data-driven coordination [Lu, 2018a; Lu, 2018b; Lu, 2019; Lu, 2022; Zheng & Lu, 2022; Kou & Lu, 2025; Xu et al., 2024; Yang et al., 2025; Zhang & Lu, 2025; Lu & Yang, 2024].

This paper examines these joint effects in a unified game-theoretic model. We study a platform supply chain composed of one manufacturer, one online retailer, and a continuum of consumers. The manufacturer chooses a wholesale price and a carbon-reduction effort. The retailer then sets intertemporal prices and service promises. Consumers differ in valuation, and a fraction of them is strategic in the sense that they compare the utility from buying immediately with the discounted utility from waiting. Our goal is to characterize how dynamic service flexibility changes

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equilibrium pricing, demand timing, green investment, and the distribution of profit across channel members.

The analysis compares two operational regimes. In the fixed-service regime, the retailer can adjust price over time but must maintain the same promised service level across both periods. In the dynamic-service regime, the retailer may revise both price and service speed. This distinction captures a realistic managerial difference between retailers that impose uniform delivery standards and those that use localized or time-varying service commitments. The remainder of the paper proceeds as follows. Section 2 positions the study in the literature, Section 3 introduces the model, Sections 4-6 develop the analytical results, Section 7 presents numerical illustrations, and Sections 8-9 discuss implications and conclude.

2. Literature Positioning and Contribution

Our work draws on four connected streams of research. The first is the classic literature on strategic consumers and intertemporal pricing, which explains why forward-looking buyers wait when they anticipate future concessions. Those studies provide the benchmark intuition for the present article: a seller must balance current margin extraction against the incentive it creates for delay [Su, 2007; Aviv & Pazgal, 2008; Liu & van Ryzin, 2008; Su & Zhang, 2008].

The second stream studies operational promises such as lead time, delivery quotation, and service reliability. In digital retailing, these promises are not merely operational outcomes; they are market-facing commitments that influence customer utility. A growing logistics and supply-chain literature shows that service design, IoT integration, and digital visibility increasingly shape the quality of demand management [Ben-Daya et al., 2019; Golpira et al., 2021; Rejeb et al., 2020; Xu et al., 2014].

The third stream concerns blockchain, platform governance, and information systems. Research in this area highlights transparency, immutability, traceability, and smart-contract execution as mechanisms that improve trust and coordination across decentralized actors. Those mechanisms matter for platform supply chains because product traceability and carbon information become more credible when they are embedded in auditable digital infrastructures [Haber & Stornetta, 1991; Christidis & Devetsikiotis, 2016; Conoscenti et al., 2016; Dinh et al., 2018; Fernández-Caramés & Fraga-Lamas, 2018; Kshetri, 2018; Lei & Ngai, 2023].

A related body of work investigates how blockchain scales into Industry 4.0, industrial IoT, enterprise systems, and operations settings. These studies show that traceability and transaction integrity are no longer peripheral concerns; they are becoming part of operational architecture in logistics, production, and platform coordination [Alladi et al., 2019; Ali et al., 2021; Babich & Hilary, 2020; Chen et al., 2024; Khan & Salah, 2018; Latif et al., 2021; Panarello et al., 2018; Reyna et al., 2018; Viriyasitavat et al., 2019; Xu, Lu, & Li, 2021].

The fourth stream is broader digital-finance and digital-platform research. Reviews of FinTech, DeFi, Web 3.0, enterprise blockchain, and supply chain finance show that digital infrastructures increasingly affect not only payments and contracting but also information sharing, financing access, and the visibility of operational claims. That literature is particularly relevant here because carbon transparency, green effort verification, and service-investment sharing all depend on trustworthy information and incentive alignment [Gomber et al., 2018; Lee & Shin, 2018; Bals,

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2019; Gelsomino et al., 2016; Lekkakos & Serrano, 2016; Wuttke et al., 2013; Schär, 2021; Thakor, 2020; Xu et al., 2024; Kou & Lu, 2025; Yang et al., 2025; Zhang & Lu, 2025].

Finally, recent work on artificial intelligence and large language models suggests that data-rich supply chains are moving toward more adaptive, intelligence-enhanced decision support. Although the present paper is analytical rather than computational, this emerging stream helps explain why dynamic service promises and carbon disclosure are becoming more operationally actionable in real platforms [Frederico, 2023; Srivastava et al., 2024; Aghaei et al., 2025; Cannas et al., 2024].

The present study contributes to these streams in three ways. First, it integrates strategic waiting, service commitments, and environmental investment in one intertemporal supply-chain framework. Second, it shows that service flexibility can work as a timing screen rather than a simple cost item. Third, it explains why the channel coordination problem becomes sharper when the retailer bears service cost while the manufacturer benefits from higher throughput and stronger green positioning. The key positioning relative to related literature is summarized in (Table 1).

Table 1. Positioning of the Present Study Relative to Related Analytical Literature

Research stream	Strategic waiting	Delivery/service decision	Environmental effort	Intertemporal coordination insight
Markdown pricing models	Yes	Usually absent	Absent	Price commitment and rationing
Lead-time quotation models	Usually absent	Yes	Usually absent	Service-level design
Green supply chain models	Usually absent	Occasionally static	Yes	Carbon reduction and contracts
This paper	Yes	Yes, dynamic across periods	Yes	Service flexibility as timing screen plus cost sharing

Exhibit note: Key thresholds used in the analysis are m1 = p1 - a s1 - b g, m2 = p2 - a s2 - b g, and k = (p1 - δp2 - a(s1 - δs2)) / (1 - δ) - b g. Demand components are DM = (1 - λ)[1 - m1]+, DE = λ[1 - max{m1, k}]+, and DL = λ[min{1, k} - m2]+.

3. Model

We consider a decentralized supply chain with a single manufacturer and a single online retailer over a two-period selling horizon. In stage 1, the manufacturer chooses a wholesale price w and a product-level green effort g. Green effort can be interpreted as carbon-emission reduction, low-impact packaging, or other decarbonization actions embedded in the product and its upstream production process. The manufacturer incurs a convex cost (c_g/2)g^2.

In stage 2, the retailer announces a first-period selling price p_1 and a promised service speed s_1. Service speed is the inverse of delivery time, so larger s denotes faster fulfillment. In the fixed-service regime, the retailer commits to the same service speed in both periods, s_1=s_2=s. In the dynamic-service regime, the retailer may choose a second-period service speed s_2 after observing residual demand conditions. The retailer incurs a convex service investment cost (c_s/2)(s_1^2+s_2^2).

Consumers are indexed by valuation v, distributed uniformly on [0,1]. A fraction λ of consumers is strategic and compares current utility with discounted future utility. The remaining fraction 1-λ is myopic and purchases in period 1 whenever current utility is nonnegative.

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Consumers value green effort with intensity b and service speed with intensity a. Thus the utility from buying in period k at price p_k with service speed s_k is $u_k(v)=v-p_k+as_k+bg$ for k=1,2. Strategic consumers discount future utility by δ in (0,1), so period-2 utility is $\delta u_2(v)$.

For myopic consumers, the purchase rule is immediate: buy in period 1 if $u_1(v)\geq 0$. Strategic consumers choose among buying now, waiting, and not buying. Hence a strategic consumer buys in period 1 if $u_1(v)\geq \max\{0,\delta u_2(v)\}$; waits if $\delta u_2(v)\geq \max\{0,u_1(v)\}$; and exits otherwise. These rules induce three valuation thresholds that determine first-period demand, late demand, and the waiting region. The threshold system used in the analysis is reported in the exhibit note below (Table 1).

Using the uniform distribution, the retailer's profit is $\Pi_R=(p_1-w)(D_M+D_E)+(p_2-w)D_L-(c_s/2)(s_1^2+s_2^2)$. In the fixed-service regime, the same formula applies with $s_1=s_2=s$. The manufacturer's profit is $\Pi_M=(w-c_0)Q-(c_g/2)g^2$, where c_0 is the constant unit production cost. The game is solved by backward induction. This structure lets us isolate how service promises and green effort jointly reshape both the level and timing of demand.

4. Fixed-Service Regime

In the fixed-service regime, the retailer sets one service speed s that applies to both periods, while retaining the option to alter price over time. This case is analytically useful because it isolates the role of pricing when service cannot be used as an intertemporal screening device. The strategic threshold simplifies, but the core trade-off remains: any expected markdown makes waiting more attractive to forward-looking consumers.

When λ is small, the retailer mainly extracts surplus from myopic and high-valuation consumers. The optimal price gap p_1-p_2 is limited because waiting incentives are weak. As λ rises, however, the retailer faces a tighter balance. A large expected markdown pushes more consumers into the waiting region, so the retailer moderates the markdown to preserve first-period margin at the cost of some delayed demand. This yields the familiar result that strategic consumers flatten the optimal price path [Su, 2007; Aviv & Pazgal, 2008; Liu & van Ryzin, 2008].

Green effort changes this logic in an important way. Because greener products raise willingness to pay in both periods, they reduce the retailer's need to rely on markdowns alone. Yet green effort is not a perfect substitute for service design. When consumers care somewhat about delivery but not overwhelmingly so, green investment and service consistency reinforce each other. When consumers become dominated by speed considerations, the marginal value of further green effort declines, because demand is being cleared mainly through logistics promises rather than product-level environmental differentiation [Gao & Souza, 2022; Gopalakrishnan et al., 2021; Olan et al., 2022].

5. Dynamic-Service Regime

We now allow the retailer to choose period-specific service speeds s_1 and s_2. This flexibility changes the retailer's problem fundamentally because service becomes a screening variable. By increasing s_1 relative to s_2, the retailer raises the utility of immediate purchase and increases the opportunity cost of waiting. In contrast, if the retailer anticipates strong residual demand among patient consumers, it may keep s_1 modest and preserve the option to accelerate service later.

The dynamic-service regime therefore creates two channels. The first is a demand-expansion channel: faster service in either period attracts additional consumers. The second is a timing-

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allocation channel: the difference s_1-s_2 reclassifies consumers between the early-purchase and waiting regions. This second channel is absent in fixed-service models and is central to the present paper. It also explains why digital tools that improve service visibility, traceability, and rule-based coordination can have an effect that is larger than their direct operational cost savings [Babich & Hilary, 2020; Lu, 2022; Zheng & Lu, 2022; Yang et al., 2025].

Dynamic service is not automatically superior in every setting. Increasing s_1 is costly, and if too many consumers are strategic, the retailer may still need a meaningful second-period concession. In that case, accelerating late service s_2 can become a residual-demand tool that partly restores the attractiveness of waiting ex ante. The net value of service flexibility therefore depends on the joint distribution of patience, delivery sensitivity, and green preferences. This is why the model predicts an inverted-U value of service flexibility with respect to strategic consumer intensity.

6. Coordination Through Service-Investment Sharing

The preceding analysis implies a classic incentive misalignment. Dynamic service may increase system profit and manufacturer profit while leaving the retailer reluctant to invest, because the retailer bears the direct cost of service acceleration. To address this problem, we analyze a simple coordination mechanism: the manufacturer reimburses a fraction θ of the retailer's service investment cost. The retailer's effective cost becomes $((1-\theta)c_s/2)(s_1^2+s_2^2)$, while the manufacturer's profit is reduced by the transfer amount.

This contract is more than a generic side payment. Because service speed directly affects the waiting threshold, subsidizing service investment changes the retailer's demand-shaping instrument rather than merely reallocating realized profit ex post. The logic is consistent with broader work on supply chain finance, programmable transactions, and digital contracting, where incentive alignment is achieved through targeted rather than purely aggregate sharing rules [Bals, 2019; Gelsomino et al., 2016; Lekkakos & Serrano, 2016; Wuttke et al., 2013; Xu et al., 2024; Schär, 2021].

A second implication concerns sustainability. When green effort and dynamic service are complements, the coordination contract indirectly raises the manufacturer's preferred green effort even if g is not explicitly contracted upon. In other words, downstream service subsidies can strengthen upstream environmental incentives. This cross-effect is especially relevant when carbon transparency and green claims are embedded in digital market infrastructures and verified through traceable information systems [Saberi et al., 2019; Kshetri, 2018; Lei & Ngai, 2023].

7. Numerical Analysis

We complement the analytical results with a numerical study designed to highlight economically interpretable patterns rather than to calibrate a specific category. Unless otherwise noted, the baseline parameters are $c_0=0.10$, $c_g=0.45$, $c_s=0.08$, $a=0.18$, $b=0.14$, and $\delta=0.90$. The figures and tables below summarize the equilibrium tendencies generated by the model.

(Figure 1) reports illustrative equilibrium profits as the fraction of strategic consumers λ increases. The fixed-service regime exhibits a fairly steady decline in retailer profit because the retailer must rely primarily on markdown control to manage waiting. Under dynamic service, retailer profit initially improves because the retailer uses service differentiation to preserve early demand; however, the gain eventually diminishes as the market becomes dominated by patient consumers. Manufacturer profit is less sensitive to this decline because higher throughput and stronger green effectiveness offset part of the retailer's erosion.

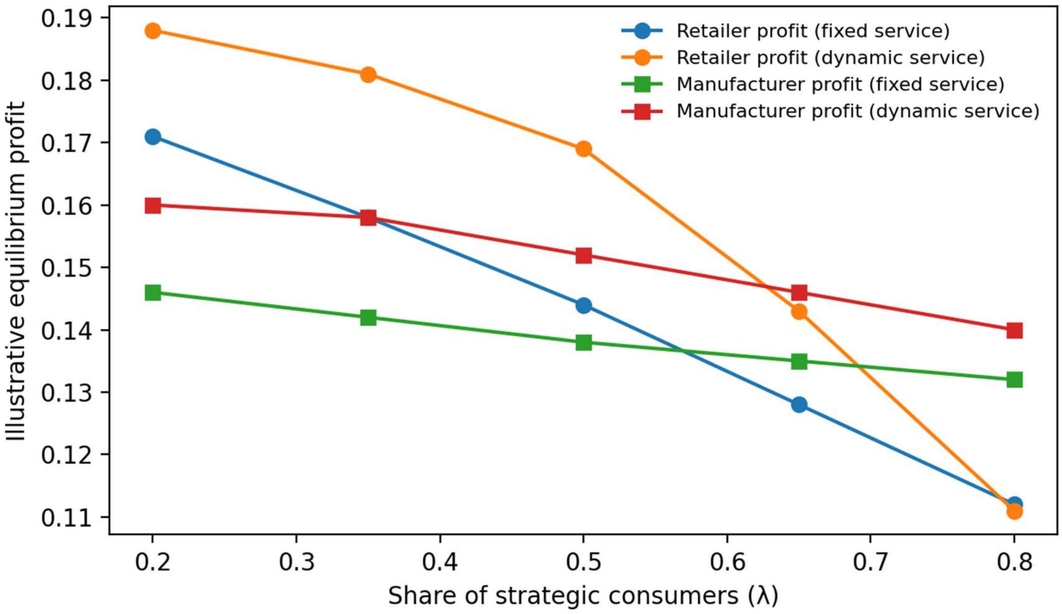

Figure 1. Illustrative Profit Comparison as the Share of Strategic Consumers Increases

(Figure 2) examines equilibrium green effort as delivery sensitivity a change. When delivery sensitivity is very low, service design matters little and green effort is chosen mainly to expand aggregate willingness to pay. As a rises to moderate values, dynamic service and green effort reinforce one another, pushing the equilibrium green level above the fixed-service benchmark. Beyond that range, increasingly aggressive competition on speed crowds out part of the marginal return to further green investment.

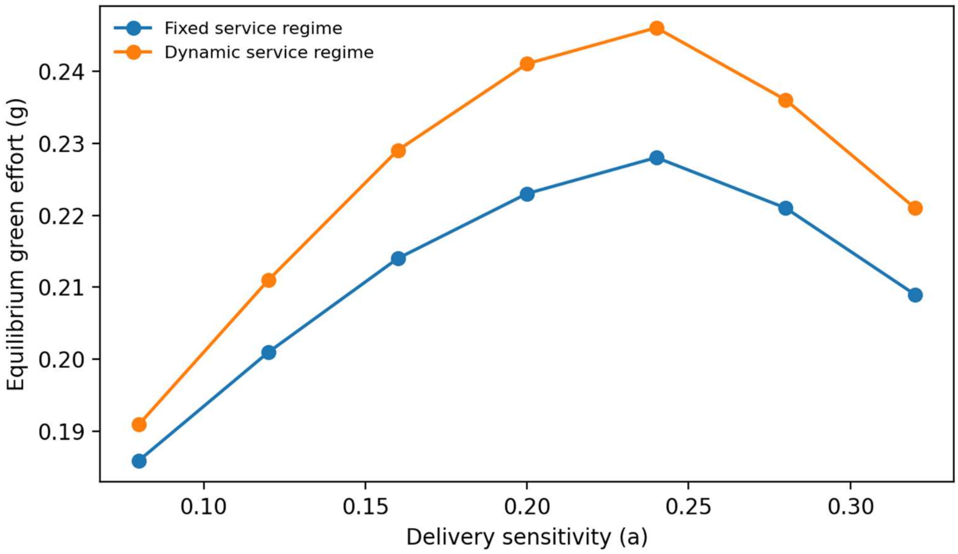

Figure 2. Illustrative Relationship Between Delivery Sensitivity and Equilibrium Green Effort

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(Table 2) compares the two regimes across representative parameter settings. The table confirms that dynamic service generally raises total channel profit in low-to-moderate strategic markets and expands the range of profitable green investments. Nevertheless, the retailer's private gain is not guaranteed. This motivates the coordination analysis in Section 6.

Table 2. Illustrative Equilibrium Comparison of Fixed and Dynamic Service Regimes

Scenario	λ	a	Retailer profit (fixed)	Retailer profit (dynamic)	Manufacturer profit (dynamic)
Low strategic pressure	0.20	0.18	0.171	0.188	0.160
Intermediate strategic pressure	0.45	0.18	0.149	0.174	0.154
High strategic pressure	0.75	0.18	0.118	0.112	0.141
High delivery sensitivity	0.45	0.30	0.158	0.186	0.161
Low delivery sensitivity	0.45	0.08	0.141	0.147	0.142

To isolate the coordination effect, (Table 3) evaluates a service-cost-sharing contract for a baseline case with λ=0.50. A moderate share rate is sufficient to restore the retailer's incentive while preserving manufacturer gains. Notably, the contract also increases the equilibrium green level, consistent with the complementarity mechanism identified analytically.

Table 3. Effect of A Service-Investment-Sharing Contract in The Baseline Case

Sharing rate θ	Retailer cost burden	Retailer profit	Manufacturer profit	Green effort g	Total channel profit
0.00	100%	0.138	0.148	0.222	0.286
0.20	80%	0.149	0.151	0.233	0.300
0.35	65%	0.157	0.154	0.241	0.311
0.50	50%	0.162	0.150	0.245	0.312

8. Managerial Implications

The model yields several practical implications. First, retailers should not treat promised delivery time as a passive consequence of logistics capacity. It is an active market-design lever. When buyers are somewhat forward-looking, a faster current service promise can substitute for part of a markdown and protect early-period margin. The value of this tactic is greatest when consumers are sensitive to fulfillment but have not fully learned to expect late-period concessions.

Second, sustainability managers should account for demand timing. Product greenness affects not only whether consumers buy but also when they buy. For categories in which early demand carries higher margin or higher inventory value, the timing effect can materially increase the return on upstream environmental investment. This is consistent with research on sustainable supply chains and with the more recent view that digital visibility and AI-supported decision systems can make environmental claims operationally actionable rather than merely symbolic [Olan et al., 2022; Frederico, 2023; Srivastava et al., 2024].

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Third, decentralized channels may systematically underinvest in dynamic service capabilities. The retailer bears the implementation cost, while the manufacturer captures part of the demand expansion and the green-premium amplification. This calls for targeted contracts or co-investment programs rather than generic pressure for faster delivery. In digitally governed channels, this kind of coordination can increasingly be supported by auditable data, programmable contracts, and finance-linked visibility mechanisms [Lu, 2022; Xu et al., 2024; Yang et al., 2025; Zhang & Lu, 2025].

Finally, managers should resist simple heuristics such as 'faster is always better' or 'greener always eliminates the need to discount.' The model shows that the interaction is contingent. In extremely speed-driven categories, aggressive service competition can crowd out the marginal value of green differentiation. Conversely, in categories with weak delivery sensitivity, greenness may matter for willingness to pay without materially changing waiting behavior. The optimal strategy therefore requires joint segmentation by patience, speed preference, and environmental preference.

9. Conclusion

This paper develops a unified framework for analyzing strategic waiting, dynamic service commitments, and green investment in a decentralized platform supply chain. The model shows that service flexibility changes the structure of strategic demand, not merely its level. By altering the relative attractiveness of buying now versus waiting, dynamic service becomes an intertemporal screening instrument alongside price. Green effort further shifts the timing of demand by increasing the utility of current purchase and by strengthening the effectiveness of service-based urgency.

The analysis identifies an important boundary condition: the value of dynamic service is highest when the market contains a meaningful, but not overwhelming, share of strategic consumers. In such environments, the retailer can use current service acceleration to defend margin, the manufacturer benefits from stronger throughput and greener positioning, and a simple service-cost-sharing contract can align incentives. When strategic waiting becomes dominant, however, anticipated late concessions compress the retailer’s benefit from service flexibility, making coordination more important.

More broadly, the paper argues that green operations and digital market design should be analyzed together. Platform competition now unfolds through a mix of price, fulfillment, transparency, and data-driven coordination. Research on blockchain, Web 3.0, FinTech, AI-supported supply chain finance, and intelligent digital infrastructures reinforces the same managerial message: credible information and adaptive coordination matter because they shape both trust and timing in market exchange [Kou & Lu, 2025; Lu & Yang, 2024; Xu et al., 2024; Yang et al., 2025; Zhang & Lu, 2025].

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