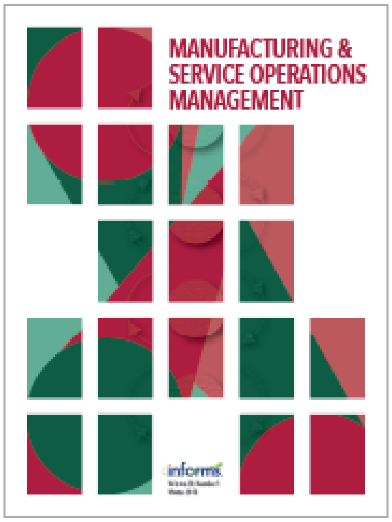

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Quick Response Under Strategic Manufacturer

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Abstract. ***Problem definition*:** Quick response is a classic operations strategy that allows a retailer to place a rapid replenishment order during the selling season using information learned from early sales. The benefits of quick response are widely studied in the literature under the condition that the manufacturer's wholesale prices are exogenously given. Motivated by the practice of emerging small and medium-sized enterprise (SME) fashion brands, this paper revisits the value of quick response for a retailer when a manufacturer can strategically set its wholesale prices. ***Methodology/results*:** We develop a game-theoretic model consisting of one manufacturer and one retailer. In contrast to the traditional quick response setting, the manufacturer can dynamically adjust wholesale prices for both regular and replenishment orders. First, we investigate whether and when quick response still benefits the retailer. We find that, under low or significantly high demand uncertainties, the firms share a common preferred ordering strategy, and quick response benefits the retailer as well as the supply chain. But, under moderately high demand uncertainty, the retailer's favored ordering strategy conflicts with the manufacturer's interest; as a result, the manufacturer would set wholesale prices to counter the retailer's ordering strategy, which makes quick response detrimental to the retailer. Second, we search for mechanisms that can resolve this conflict and restore the beneficial effect of quick response. We show that letting the manufacturer commit to wholesale prices up front is ineffective in fixing the problem. However, if the retailer can propose a take-it-or-leave-it wholesale price for the replenishment order (possibly with the replenishment quantity) once the regular wholesale price is set, then quick response leads to a win–win outcome for both firms. ***Managerial implications*:** The findings caution retailers with weak power (e.g., SMEs) when adopting quick response, especially when facing moderately high demand uncertainties. The retailer, although weak, should be aware of the retailer's natural ability to propose replenishment terms because, otherwise, the retailer can always forgo quick response; this opens up an opportunity to design more favorable arrangements.

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Keywords: quick response • supply chain • strategic inventory • demand learning • SME fashion retailer

1. Introduction

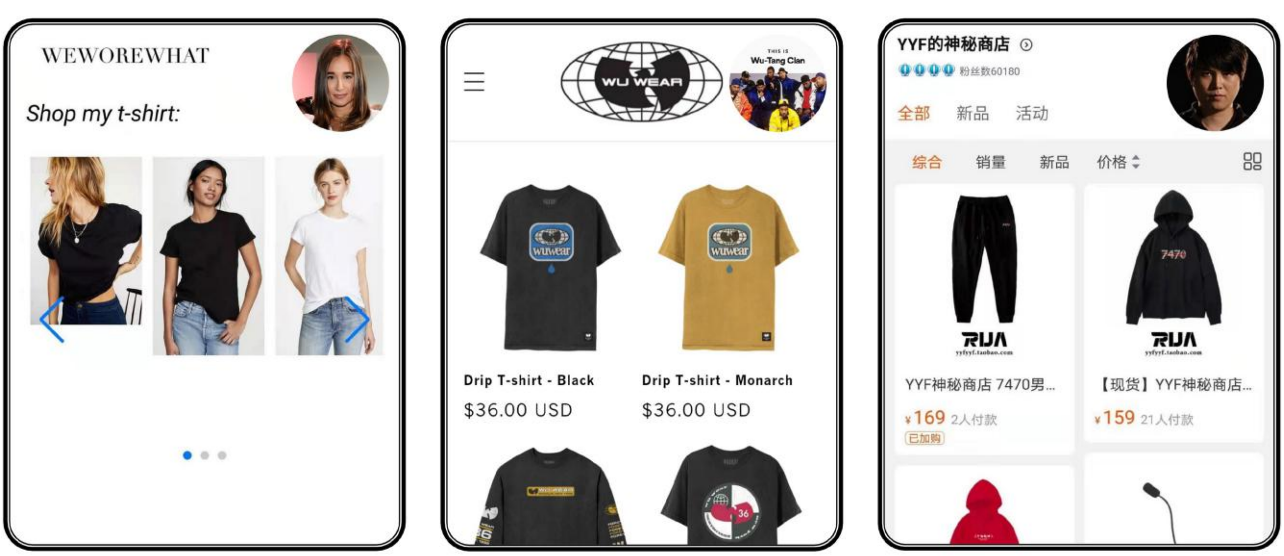
Quick response is widely recognized as a textbook operations strategy. It refers to the arrangement that a retailer can rapidly replenish inventory after observing early sales during a selling season. This strategy allows the retailer to postpone a portion of orders after learning more about demand and, thus, reduce supply–demand mismatch. In practice, many firms implement quick response, especially in industries with short product life cycles and highly uncertain market demand. For example, in a classic case study of Sport Obermeyer (Hammond and Raman 1994), the fashion skiwear designer first prepares inventory for the early selling period, then observes early sales as an indicator of late demand, and finally replenishes stock rapidly for the remaining period. Analogous strategies are utilized by other veteran brands, such as Zara (Ferdows et al. 2004), H&M (Lu 2014), and Topshop (O'Byrne 2017) as well as emerging fashion players, such as Shein (Chu and Wang 2021), Asos, and Zalando (Krauss and Decker 2016).

The fashion industry is multifaceted. In addition to the aforementioned renowned brands, many individuals, including designers and artists, also own their private labels. According to a McKinsey industry report, "The State of Fashion 2020" (McKinsey & Company 2020), these small and medium-sized enterprises (SMEs) are growing rapidly and becoming formidable challengers to established brands. Moreover, the widespread use of social media is accelerating the emergence of these niche brands: social influencers create their own fashion brands to serve markets consisting primarily of their followers (Brown 2020); Figure 1 lists a few such examples. As with any other fashion company, these SMEs also face significant demand uncertainties. A natural question then arises: should these emerging fashion brands adopt quick response? The answer is mixed based on our interaction with practitioners in this industry (see Online Supplement A for more information). Whereas some fashion SMEs actively embrace quick response because they feel it is a smart and convenient way to utilize demand information collected on e-commerce platforms, others simply prepare single inventory batches for the entire selling season. There are also fashion SMEs that adopt quick response for a few product categories within selected time frames and/or when sourcing from selected manufacturers.

A key factor determining whether and how quick response is being adopted is a retailer's relationship with manufacturers. Giant brands, such as Zara, have enormous buying power that enables them to maintain strong control over their supply chains, leaving little space for their manufacturers to negotiate wholesale prices. Among upstart retailers, Shein uses a sophisticated information system to manage its small and loyal base of manufacturers (Chu and Wang 2021), whereas Asos and Zalando maintain more equal long-run partnerships with established manufacturers, such as PUMA (Krauss and Decker 2016). With billions of U.S. dollars in yearly revenues, these market winners are enthusiastic fans of quick response. In comparison, SME retailers with millions or below in sales have been, at best, lukewarm about adopting quick response. Their orders are too small to matter much to the manufacturers, and given the high cost of supply chain development, they have to stick to a few manufacturers. In our interviews with SME brand owners, one responded that the brand sources from only one manufacturer for each product category. The manufacturer is the sole decision maker in setting the wholesale price and may even charge different wholesale prices for different orders of the same product. Another interviewee noted that the brand did not adopt quick response when contracting with a medium-sized manufacturer, doing so only after switching to a much smaller manufacturer.

The classic quick response strategy has been discussed by practitioners and scholars for decades. Nevertheless, emerging fashion SMEs have shifted the context for quick response from retailer-dominated and equal-relationship supply chains to manufacturer-dominated supply chains. In this situation, a strategic manufacturer can set wholesale prices and even manipulate wholesale prices dynamically for different orders. It is unclear whether and to what extent such a manufacturer can leverage a retailer's quick response strategy and how the retailer will react. In the new context of a weak retailer facing a powerful and strategic manufacturer, this paper revisits the impact of quick response and seeks to understand (1) the retailer's, manufacturer's, and supply chain's profitability and (2) mechanisms that can improve quick response's performance.

Figure 1. (Color online) Social Influencers and Their Brands



Danielle Bernstein & We Wore What **Wu-Tang Clan & Wu Wear** **Cen Jiang & YYF's Secret Shop**

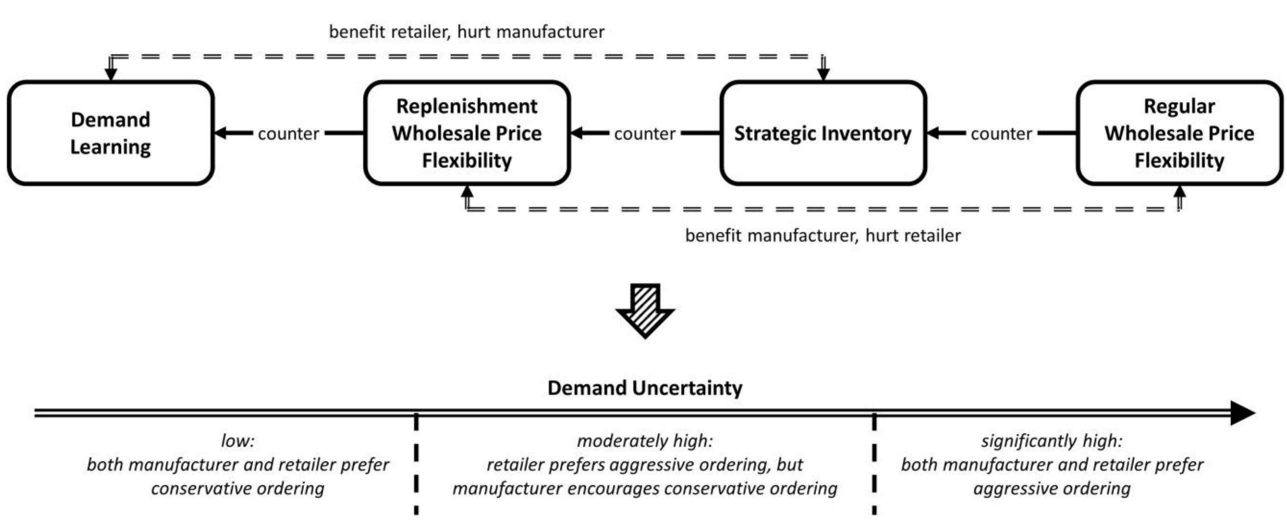
We build a model with a one-manufacturer, one-retailer supply chain facing a selling season of two periods. Demands in the two periods are positively correlated such that first period demand can signal second period demand. We consider the most fundamental setting, in which the manufacturer preserves full wholesale pricing flexibility: without quick response, the manufacturer charges only one wholesale price, and the retailer orders only once before the selling season starts; with quick response, the retailer has another order opportunity after observing first period demand, and the manufacturer can charge wholesale prices dynamically for the two orders. We compare the manufacturer's, retailer's, and supply chain's profits in these two scenarios.

We find that the magnitude of demand uncertainty plays a key role in the effectiveness of quick response. When demand uncertainty is low or significantly high (see Fisher (1997) for an approximate classification of demand uncertainties), there is strategic resonance between the manufacturer and the retailer such that quick response improves both parties' profits. When demand uncertainty is moderately high, however, there is a mismatch between the two parties' strategic incentives, and therefore, quick response harms the retailer as well as the supply chain. We offer the following explanation for this result (see also Figure 2 for a summary). Under low demand uncertainty, the retailer should order conservatively to ensure market clearance, whereas under high demand uncertainty, the retailer should order aggressively to capture the benefit of a strong market at the risk of inventory leftover. Without quick response, the manufacturer sets a wholesale price to support such an ordering plan. With quick response, however, the two parties' preferences conflict with each other when demand uncertainty falls into the moderately high range. Such a conflict is driven jointly by four effects: the retailer's benefit from demand learning, the manufacturer's replenishment wholesale price flexibility to leverage demand learning, the retailer's utilization of strategic inventory to endeavor a favorable replenishment wholesale price, and the manufacturer's regular wholesale price flexibility to suppress strategic inventory. The interplay of these effects turns the manufacturer's wholesaling scheme into a weapon against the retailer: when the retailer is better off with an aggressive ordering plan, the manufacturer may force the retailer to order conservatively.

We then search for mechanisms that can resolve this conflict and, thus, make quick response a win–win strategy. Price commitment, although effective in mitigating the negative effects of strategic behaviors in many situations, does not work in our setting. We consider a setting in which the manufacturer commits to a replenishment wholesale price before the selling season. In this scenario, the manufacturer's power becomes too strong such that retailer surplus gets further squeezed. In addition, we consider a setting in which the manufacturer commits to a uniform wholesale price for both regular and rapid replenishment orders. This arrangement may help the retailer mitigate the drawbacks of quick response, but it could be detrimental to the manufacturer. Therefore, it is not a viable solution from the manufacturer's perspective.

The third mechanism we consider is retailer-proposed rapid replenishment. That is, once the manufacturer has set the regular wholesale price, the retailer proposes the terms for the replenishment order, leaving the manufacturer to accept it or leave it. If the manufacturer rejects the replenishment terms, then the two firms return to the scenario without quick response. This mechanism is straightforward to implement and executable for SME retailers who, although weak, can always commit not to order a second time. We find that the retailer-proposed rapid replenishment approach always leads to a win–win outcome in comparison with the no

Figure 2. When and Why Quick Response Can Be Detrimental



quick response setting; that is, the retailer benefits from quick response, and meanwhile, the manufacturer is (weakly) better off as well. Such an outcome is particularly effectual if the retailer proposes not only a replenishment wholesale price, but also a fixed or zero replenishment quantity; that is, during the selling season, the retailer either replenishes a predetermined quantity or does not replenish.

Our results provide guidelines for SME retailers on how to implement the textbook quick response strategy. An SME retailer should not grant manufacturers unlimited leeway to adjust wholesale prices at any amount or at any time because this may make quick response backfire. Yet letting manufacturers commit to wholesale prices does not fully solve the problem because such a commitment is either ineffective or unacceptable to manufacturers. We recommend that an SME retailer should propose (rapid) replenishment terms and seek approval from the manufacturer, who still maintains the power to determine the regular order wholesale price in the first place. This is executable for an SME retailer because the retailer always has the option of giving up quick response. Such a sophisticated quick response implementation requires more active efforts and deeper collaboration with manufacturers, and this is a growth path for SME retailers.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 presents our model. Sections 4 and 5 analyze the impact of quick response, whereas Sections 6 and 7 explore mechanisms that may improve quick response. We conclude the paper in Section 8.

2. Literature Review

This paper builds upon the extensive literature on quick response. Fisher and Raman (1996) study the value of quick response in the context of Sports Obermeyer. Iyer and Bergen (1997) consider quick response in a supply chain and show that it always benefits the retailer and may harm the supplier. Cachon and Swinney (2009, 2011) focus on the value of quick response when consumers can strategically delay their purchases. Krishnan et al. (2010) show that, when retailer effort is considered, quick response may backfire for the manufacturer. Caro and Martínez-de Albéniz (2010) and Lin and Parlaktürk (2012) examine the value of quick response under retailer competition. Among these papers, a manufacturer can strategically set the wholesale price only in Lin and Parlaktürk (2012), but they focus on whether a manufacturer should offer the quick response option to competing retailers and, thus, yield different managerial insights. In our paper, we examine a one-manufacturer, one-retailer setting and show that the manufacturer's strategic pricing itself can make quick response detrimental to the retailer.

With quick response as a tool of demand learning, our paper is also related to the studies on demand information acquisition in a supply chain. Chu and Messinger (1997) focus on how channel profit can be improved and shared with either or both channel members acquiring information. Iyer et al. (2007) show that, with inventory concerns, the manufacturer may not want to acquire information because of the retailer's strategic pricing. Guo (2009) isolates two opposite effects of the retailer's information acquisition: the efficiency effect and the strategic effect. Guo and Iyer (2010) study the interaction between the manufacturer's information acquisition and information-sharing strategies. Li et al. (2014) consider a retailer's decision about whether to disclose the retailer's information acquisition status to the manufacturer. Guan and Chen (2017) study the interaction between a manufacturer's information acquisition and quality disclosure strategies. In these papers, information is usually assumed to be acquired before the selling season, which is supported by advanced data-collection technologies or external consulting. The setting considered in our paper is operationally different because, with quick response, information is acquired by observing early demand, which takes place in the middle of the selling season and is coupled with a second ordering opportunity. Hence, our model leads to different insights from these papers.

Because strategic inventory (or forward buying) is an effect associated with quick response in our model, this paper also contributes to the literature on strategic inventory. Lal et al. (1996) find that strategic inventory can reduce the intensity of competition among manufacturers. Cui et al. (2008) demonstrate the role of strategic inventory in discriminating between a dominant retailer and small retailers. Anand et al. (2008) study the role of strategic inventory under different channel contracts. Arya et al. (2015) show that strategic inventory can influence the decision on centralized versus decentralized procurement for multiple retail markets. Hartwig et al. (2015) use an experiment to show that strategic inventory is even more valuable when accounting for behavioral factors. Guan et al. (2019) study the joint impact of strategic inventory and vertical competition. Roy et al. (2019) consider a situation in which the manufacturer lacks observability on the retailer's use of strategic inventory. In this stream of literature, two more papers that consider strategic inventory and demand uncertainty/learning jointly may be the most relevant works to ours: Desai et al. (2010) study the role of strategic inventory in different channel structures and include the demand uncertainty/learning factor as an extension; their focus is on explaining why the retailer carries inventory. Qu and Raff (2021) demonstrate that a decentralized supply chain may be less susceptible to the bullwhip effect (the demand uncertainty/learning factor) than a centralized supply chain because of the manufacturer's price effect (the strategic inventory factor). Different from these papers, in our setting, strategic inventory is triggered by the quick response arrangement, which also involves demand uncertainty/learning considerations. We focus on understanding how quick response influences retailer profit and the underlying dynamics and, therefore, contextually differ from Desai et al. (2010) and Qu and Raff (2021).

3. Model

We consider a supply chain consisting of a manufacturer and a retailer. The retailer launches a new product to sell in the market, which contains highly innovative elements and, thus, faces uncertain market reactions. For example, the retailer is a fashion company. The product's selling season is divided into two periods, periods 1 and 2. The two periods have demand functions $d_i = A_i - p_i$ $(i = 1, 2)$, where d_i denotes the demand, p_i denotes the retail price, and the market size A_i is a random variable following a Bernoulli distribution:

$$A_i = \begin{cases} H = 1 + \sigma & \text{with probability } 0.5, \\ L = 1 - \sigma & \text{with probability } 0.5. \end{cases} \tag{1}$$

In Equation (1), $\sigma \in [0, 1]$ is the standard deviation of A_i. Because the mean of the market size is 1, σ is essentially the coefficient of variation (CV) of A_i and, thus, can be used to measure market demand uncertainty.

We choose the Bernoulli distribution to model demand uncertainty for two reasons. First, it is relatively simple and can facilitate transparent analysis. Second and more importantly, such a bimodal distribution reflects the usual demand pattern observed in the fashion industry, one of the main application contexts for quick response. According to Nenni et al. (2013), the demand for a fashion product is rarely stable or linear and, thus, should not be predicted by regular distributions, such as the normal distribution. This is because demand for a fashion product can be easily influenced by random shocks, such as big hit movies and celebrity shows. If there is a positive shock, the fashion product becomes popular and enjoys a high market state; otherwise, the fashion product is unpopular and has a low market state. Thus, bimodal distributions, such as the Bernoulli distribution, are more appropriate for our problem setting.

We assume that A_1 and A_2 are positively and perfectly correlated; that is, the model reflects situations in which the realized state of A_1 can be an accurate indicator of A_2. Allowing for imperfect correlation significantly complicates the analysis but does not change the qualitative insights. Before the selling season, the manufacturer and the retailer both have an unbiased belief about the distributions of A_1 and A_2. At the beginning of period 1, they observe the state of A_1 and, thus, also know the future demand A_2. Then, at the beginning of period 2, A_2 is realized.

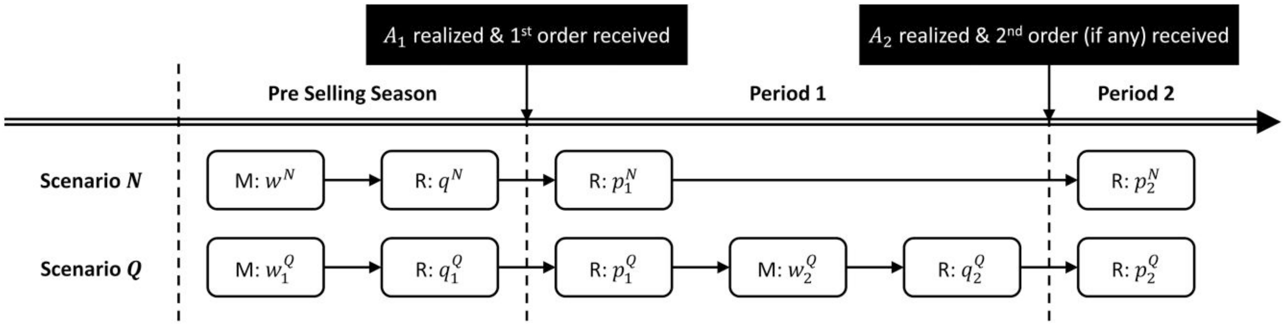
Two different scenarios are studied and compared to derive insights: scenario N (without quick response) and scenario Q (with quick response). The sequences of events for these scenarios are given as follows and also depicted in Figure 3.

Scenario N (no quick response): Before the selling season, the manufacturer determines the wholesale price w^N, and the retailer orders quantity q^N. Then, A_1 is realized, the order is received, and the retailer subsequently determines p_1^N. After A_2 is realized, the retailer determines p_2^N.

Scenario Q (with quick response): Before the selling season, the manufacturer determines the regular wholesale price w_1^Q for the initial order, and the retailer orders q_1^Q. Then, A_1 is realized, the initial order is received, and the retailer determines p_1^Q. After that, the manufacturer determines the (rapid) replenishment wholesale price w_2^Q for the second order, and the retailer orders q_2^Q, sequentially. Finally, A_2 is realized, the second order is received, and the retailer subsequently determines p_2^Q.

Some discussions are in order about these two scenarios. First, scenario N is essentially a single-period benchmark given that the two periods are identical without any quantity decision in between. The interaction between the manufacturer and the retailer is more involved in scenario Q because the firms make decisions alternately. Comparing scenario Q with scenario N illuminates the strategic impact of quick response with a strategic manufacturer.

Figure 3. Sequence of Events



Second, we allow the retailer to use responsive pricing, that is, to change the price based on updated demand information. This helps isolate the quantity decision from the price decision, the former of which is the focus of our study. In most retail environments, price is a more flexible decision than quantity. Responsive pricing is quite common both in practice and in the academic literature; see, for example, Van Mieghem and Dada (1999), Chod and Rudi (2005), Jerath et al. (2017), and Aviv et al. (2019) for more discussions. Our decision sequence implies that the manufacturer can observe the retailer's first period inventory and charge the replenishment wholesale price accordingly. We also investigate alternative decision sequences in Online Supplement C and demonstrate the robustness of the results. For instance, the qualitative insights still hold when the manufacturer decides w_2^Q and the retailer decides p_1^Q simultaneously, meaning that the manufacturer has no visibility of the retailer's first-period inventory.

Third, the firms' decisions depend on the realized states of A_1 and A_2. For easy reference, we use the subscript H (e.g., p_{1H}^N) for decisions under the high market state ($A_1 = A_2 = H = 1 + \sigma$) and L (e.g., p_{1L}^N) for decisions under the low market state ($A_1 = A_2 = L = 1 - \sigma$). In addition, we use $r_{1H}^X, r_{1L}^X, r_{2H}^X$, and r_{2L}^X $(X \in \{N, Q\})$ to denote the leftover inventory in each period. The expected profits of the manufacturer, the retailer, and the whole supply chain are denoted by $\pi_M^X, \pi_R^X, \pi_S^X$ $(X \in \{N, Q\})$, respectively.

Finally, for clarity and to highlight the key drivers of the results, we assume zero production cost for the manufacturer and zero inventory holding cost for the retailer. Because of the short lead time required, there may also be an additional rapid procurement cost for the retailer to order during the selling season. In Online Supplement C, we consider situations with a positive holding cost and a positive rapid procurement cost, respectively, and show that our main findings remain valid. We also assume that any unfulfilled demand in the first period is lost and does not carry over to the second period, which is common in retail practice; the case of allowing backorder is also included in Online Supplement C.

4. Equilibrium Analysis

In this section, we analyze the equilibrium outcomes under scenario N (i.e., no quick response) and scenario Q (i.e., quick response with dynamic wholesale pricing).

4.1. The Benchmark No-Quick-Response Scenario

Under scenario N (i.e., no quick response), the manufacturer's profit is given by

$$\pi_M^N = w^N q^N, \tag{2}$$

and the retailer's profit can be written as

$$\pi_R^N = -w^N q^N + \frac{1}{2} \sum_{a \in \{L, H\}} \left[p_{1a}^N \min\{a - p_{1a}^N, q^N\} + p_{2a}^N \min\{a - p_{2a}^N, r_{1a}^N\} \right], \tag{3}$$

where $r_{1a}^N = \max\{q^N - (a - p_{1a}^N), 0\}$.

We solve the equilibrium using backward induction. Let $\sigma^N = \sqrt{2} - 1 \approx 0.414$; we then have the following lemma.

Lemma 1. *Under scenario N, the equilibrium can be summarized by Table 1.*

From Table 1, we observe that the retail prices charged in the two periods are always the same. This is because the retailer can perfectly learn the market state of the two periods at the beginning of period 1 and, thus, applies identical decisions to both periods. The equilibrium may present two distinct situations. When demand uncertainty is low ($\sigma \le \sigma^N$), the retailer acts conservatively: the retailer orders a low quantity $(q^N = 1/2)$ and guarantees inventory clearance (i.e., $r_{2H}^N = r_{2L}^N = 0$) under both market states. This is because, under a small market variance, the retailer is able to match supply with demand solely by pricing flexibility. When demand uncertainty is high ($\sigma > \sigma^N$), the retailer acts aggressively: the retailer orders a high quantity $(q^N = (1+\sigma)/2)$ such that inventory clearance is possible only when the market state is high $(r_{2H}^N = 0$ and $r_{2L}^N = (3\sigma - 1)/2)$. In the case of a large market variance, pricing flexibility in itself is insufficient for the retailer to match supply with demand; instead, the retailer has to prepare safety stock that may not be cleared in the low-demand state.

The manufacturer's wholesaling scheme supports the retailer's ordering incentives. This is reflected by the discontinuity of the wholesale price decision in Table 1: the wholesale price jumps from $1/2$ down to $\sqrt{2}/4$ as σ increases to pass σ^N. The former scheme encourages the retailer to act conservatively, and we define it as conservative wholesaling; symmetrically, the latter scheme encourages the retailer to act aggressively, and we define it as aggressive wholesaling. We remark that, from the retailer's perspective, being exposed to a higher supply–demand mismatch risk turns out to be beneficial because it endows the retailer

Table 1. Equilibrium Under Scenario N

	w^N	q^N	p_{1H}^N	r_{1H}^N	p_{2H}^N	r_{2H}^N	p_{1L}^N	r_{1L}^N	p_{2L}^N	r_{2L}^N	π_M^N	π_R^N	π_S^N
$\sigma \le \sigma^N$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3+4\sigma}{4}$	$\frac{1}{4}$	$\frac{3+4\sigma}{4}$	0	$\frac{3-4\sigma}{4}$	$\frac{1}{4}$	$\frac{3-4\sigma}{4}$	0	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{3}{8}$
$\sigma > \sigma^N$	$\frac{1+\sigma}{4}$	$\frac{1+\sigma}{2}$	$\frac{3(1+\sigma)}{4}$	$\frac{1+\sigma}{4}$	$\frac{3(1+\sigma)}{4}$	0	$\frac{1-\sigma}{2}$	σ	$\frac{1-\sigma}{2}$	$\frac{3\sigma-1}{2}$	$\frac{(1+\sigma)^2}{8}$	$\frac{5-6\sigma+5\sigma^2}{16}$	$\frac{7-2\sigma+7\sigma^2}{16}$

with a privilege to ask for a lower wholesale price. In the subsequent analysis, we show that the switchover between the two wholesaling schemes (and the corresponding ordering schemes) plays a crucial role in our results.

4.2. The Quick Response Scenario

Under scenario Q (i.e., with quick response), the manufacturer's profit can be written as

$$\pi_M^Q = w_1^Q q_1^Q + \frac{1}{2}\sum_{a\in\{L,H\}} w_{2a}^Q q_{2a}^Q, \tag{4}$$

and the retailer's profit is given by

$$\pi_R^Q = -w_1^Q q_1^Q + \frac{1}{2}\sum_{a\in\{L,H\}} \Big[p_{1a}^Q \min\Big\{a - p_{1a}^Q, q_1^Q\Big\} - w_{2a}^Q q_{2a}^Q + p_{2a}^Q \min\Big\{a - p_{2a}^Q, q_{2a}^Q + r_{1a}^Q\Big\}\Big], \tag{5}$$

where $r_{1a}^Q = \max\{q^Q - (a - p_{1a}^Q), 0\}$.

Note that the two players' decisions are made alternately: before the selling season, the manufacturer sets the regular wholesale price w_1^Q; then, the retailer decides q_1^Q; after market demand is realized, the retailer chooses p_{1a}^Q, which determines the leftover inventory r_{1a}^Q; then, the manufacturer sets w_{2a}^Q; and finally, the retailer decides q_{2a}^Q and p_{2a}^Q. Using backward induction, we first characterize the equilibrium of the subgame that includes all the decisions involving the second order.

Lemma 2. *Under scenario Q, given the value of market state a ($a \in \{L,H\}$) and first period leftover inventory r_{1a}^Q, we have*

$$\left(w_{2a}^Q, q_{2a}^Q, p_{2a}^Q, r_{2a}^Q \mid a, r_{1a}^Q\right) = \begin{cases} \left(\dfrac{a-2r_{1a}^Q}{2}, \dfrac{a-2r_{1a}^Q}{4}, \dfrac{3a-2r_{1a}^Q}{4}, 0\right) & \text{if } r_{1a}^Q \le \dfrac{a}{2}, \\ \left(N/A, 0, \dfrac{a}{2}, r_{1a}^Q - \dfrac{a}{2}\right) & \text{if } r_{1a}^Q > \dfrac{a}{2}. \end{cases} \tag{6}$$

Lemma 2 shows that all the decisions made for the second order only depend on the realized demand and the leftover inventory from the first period. If the leftover inventory is low $\left(r_{1a}^Q \le a/2\right)$, then a second order is placed by the retailer to optimize second-period profit through clearance pricing. In this case, more inventory on hand makes it less necessary for the retailer to order additional units for second-period sales. In other words, more inventory carried over from the first period makes the retailer less sensitive to the replenishment wholesale price. With this consideration, the manufacturer has to charge a wholesale price that decreases in the leftover inventory from the first period. By contrast, if the leftover inventory is high $\left(r_{1a}^Q \ge a/2\right)$, then the retailer does not have sufficient pricing flexibility to clear the first period leftover inventory in the second-period. In this case, the retailer orders nothing from the manufacturer in the second-period regardless of the wholesale price.

This discussion implies that, when making the first pricing decision, the retailer may consider compromising first-period sales in exchange for a lower wholesale price in the second-period. The retailer may also order more before the selling season for the same purpose. The manufacturer, as the first mover of the game, should set the regular wholesale price to suppress such a strategic behavior of the retailer. Define $\sigma^Q = 21(21 - 13\sqrt{2})/103 \approx 0.533$, which is a useful threshold for characterizing the following equilibrium outcome.

Lemma 3. *Under scenario Q, the equilibrium can be summarized by Table 2.*

We can observe from Table 2 that, even if $\sigma = 0$ (i.e., the market is deterministic), the retailer still places the replenishment order instead of ordering all the quantity needed for the two periods with the regular order. The retailer also saves some leftover inventory from the first period. This fact reveals a strategic role of quick response for the retailer: the second ordering opportunity allows the retailer to renegotiate the wholesale price with the manufacturer, and the retailer can use strategic inventory to increase the retailer's power in this renegotiation. Demand uncertainty complicates the manufacturer's regular wholesale price decision when anticipating the retailer's strategic inventory because it cannot distinguish between the retailer's "true" order quantity (the quantity for sale in period 1) and the strategic

Table 2. Equilibrium Under Scenario Q

	w_1^Q	q_1^Q	p_{1H}^Q	r_{1H}^Q	w_{2H}^Q	q_{2H}^Q	p_{2H}^Q	r_{2H}^Q	
$\sigma \le \sigma^Q$	$\frac{9}{17}$	$\frac{13}{34}$	$\frac{182+221\sigma}{238}$	$\frac{35-17\sigma}{238}$	$\frac{42+68\sigma}{119}$	$\frac{21+34\sigma}{119}$	$\frac{322+374\sigma}{476}$	0	
$\sigma > \sigma^Q$	$\frac{9(1+\sigma)}{34}$	$\frac{13(1+\sigma)}{34}$	$\frac{13(1+\sigma)}{17}$	$\frac{5(1+\sigma)}{34}$	$\frac{6(1+\sigma)}{17}$	$\frac{3(1+\sigma)}{17}$	$\frac{11(1+\sigma)}{34}$	0	
	p_{1L}^Q	r_{1L}^Q	w_{2L}^Q	q_{2L}^Q	p_{2L}^Q	r_{2L}^Q	π_M^Q	π_R^Q	π_S^Q
$\sigma \le \sigma^Q$	$\frac{182+221\sigma}{238}$	$\frac{35+17\sigma}{238}$	$\frac{42-68\sigma}{119}$	$\frac{21-34\sigma}{119}$	$\frac{161-578\sigma}{238}$	0	$\frac{441+272\sigma^2}{1,666}$	$\frac{1,085+578\sigma^2}{8,092}$	$\frac{22,589+13,294\sigma^2}{56,644}$
$\sigma > \sigma^Q$	$\frac{1-\sigma}{2}$	$\frac{15\sigma-2}{17}$	N/A	0	$\frac{1-\sigma}{2}$	$\frac{47\sigma-21}{34}$	$\frac{9(1+\sigma)^2}{68}$	$\frac{733-846\sigma+733\sigma^2}{2,312}$	$\frac{1,039-234\sigma+1,039\sigma^2}{2,312}$

inventory. In this regard, the manufacturer cannot fully avoid strategic inventory.

The manufacturer's wholesaling strategy varies as demand uncertainty σ increases. When demand uncertainty is low ($\sigma \le \sigma^Q$), the retailer targets to clear inventory under both market states; the retailer, thus, orders conservatively. The retailer's regular order should not be too large, and there is always space left for the replenishment order to adjust the retailer's on-hand inventory. This means that, if the retailer overorders the regular quantity, it is more for a strategic inventory purpose than a safety stock purpose because the retailer always orders a second time for adjustment. To weaken the retailer's strategic inventory incentive, the manufacturer sets the regular wholesale price high and the replenishment wholesale price low, which is conservative wholesaling. When demand uncertainty is high ($\sigma > \sigma^Q$), the high and low market states are distinct, and the retailer is unable to apply identical inventory policies for the two states. The retailer orders a second time and clears inventory if the market state is high but cancels the replenishment order and withholds some ending inventory if the market state is low. This means that the retailer uses an aggressive regular order to capture the benefits of the high market state. Accordingly, the manufacturer sets a low regular wholesale price to encourage the retailer's aggression in the first order (aggressive wholesaling) and a high replenishment wholesale price to leverage the retailer's inventory adjustment for the high-state market. We note again that there is a jump in retailer profit around σ^D, which implies that, when demand uncertainty is sufficiently high, the retailer gains an advantage to obtain more favorable contract terms from the manufacturer.

5. Impact of Quick Response

In this section, we examine the impact of quick response by comparing scenarios N and Q equilibrium outcomes derived in the last section.

5.1. Intermediate Scenarios and the Four Effects

Before diving into a direct comparison between scenarios N and Q, we introduce three intermediate scenarios to facilitate our analysis. These intermediate scenarios add complexities to the base scenario N step by step and can help delineate the strategic interactions between the firms under quick response.

Scenario $\dot{N}$: Adding Demand Learning. A second order during period 1 is allowed for the retailer after learning the demand. However, the manufacturer keeps the wholesale price under scenario N for all the orders. The retailer's unsold inventory from period 1 cannot carry over to period 2.

Scenario $\ddot{N}$: Allowing Replenishment Wholesale Price Flexibility. The manufacturer keeps the same initial wholesale price as in scenario N but can freely charge the wholesale price for the second order. The retailer's unsold inventory from period 1 cannot carry over to period 2.

Scenario $\dddot{N}$: Allowing Strategic Inventory. The retailer can now carry leftover inventory from period 1 to period 2. The manufacturer still keeps the same initial wholesale price as in scenario N but can freely charge the wholesale price for the second order.

In these intermediate scenarios, the manufacturer and the retailer are strategic to varying extents until they become fully strategic in scenario Q. As one moves from scenario N to scenarios $\dot{N}$, $\ddot{N}$, $\dddot{N}$, and finally Q, the two firms' interaction becomes increasingly involved. Although scenarios $\dot{N}$, $\ddot{N}$, and $\dddot{N}$ are hypothetical and may not happen in reality, they help single out the driving forces behind our main results. The next lemma presents the equilibria for the hypothetical scenarios.

Lemma 4. *Under scenarios $\dot{N}$, $\ddot{N}$, and $\dddot{N}$, the equilibria can be summarized by Tables 3–5.*

Based on Lemma 4, we obtain the following proposition.

Proposition 1. *The following statements hold in equilibrium:*

i. $\pi_R^{\dot{N}} - \pi_R^N \ge 0$ *and increases in* σ.
ii. $\pi_R^{\ddot{N}} - \pi_R^{\dot{N}} \le 0$ *and decreases in* σ.
iii. $\pi_R^{\dddot{N}} - \pi_R^{\ddot{N}} \ge 0$ *and is maximized at* σ^N.
iv. $\pi_R^Q - \pi_R^{\dddot{N}} \le 0$ *and is minimized at* σ^N.

Proposition 1 progressively compares the retailer's profits across scenario N, the three intermediate scenarios, and scenario Q. Along the $N \to \dot{N} \to \ddot{N} \to \dddot{N} \to Q$

Table 3. Equilibrium Under Scenario $\dot{N}$

	$w_1^{\dot{N}}$	$q_1^{\dot{N}}$	$p_{1H}^{\dot{N}}$	$r_{1H}^{\dot{N}}$	$w_{2H}^{\dot{N}}$	$q_{2H}^{\dot{N}}$	$p_{2H}^{\dot{N}}$	$r_{2H}^{\dot{N}}$	
$\sigma \le \sigma^N$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3+4\sigma}{4}$	0	$\frac{1}{2}$	$\frac{1+2\sigma}{4}$	$\frac{3+2\sigma}{4}$	0	
$\sigma^N < \sigma \le \frac{3}{5}$	$\frac{1+\sigma}{4}$	$\frac{1+\sigma}{4}$	$\frac{3(1+\sigma)}{4}$	0	$\frac{1+\sigma}{4}$	$\frac{3(1+\sigma)}{8}$	$\frac{5(1+\sigma)}{8}$	0	
$\sigma > \frac{3}{5}$	$\frac{1+\sigma}{4}$	$\frac{1+\sigma}{4}$	$\frac{3(1+\sigma)}{4}$	0	$\frac{1+\sigma}{4}$	$\frac{3(1+\sigma)}{8}$	$\frac{5(1+\sigma)}{8}$	0	
	$p_{1L}^{\dot{N}}$	$r_{1L}^{\dot{N}}$	$w_{2L}^{\dot{N}}$	$q_{2L}^{\dot{N}}$	$p_{2L}^{\dot{N}}$	$r_{2L}^{\dot{N}}$	$\pi_M^{\dot{N}}$	$\pi_R^{\dot{N}}$	$\pi_S^{\dot{N}}$
$\sigma \le \sigma^N$	$\frac{3-4\sigma}{4}$	0	$\frac{1}{2}$	$\frac{1-2\sigma}{4}$	$\frac{3-2\sigma}{4}$	0	$\frac{1}{4}$	$\frac{1+2\sigma^2}{8}$	$\frac{3+2\sigma^2}{8}$
$\sigma^N < \sigma \le \frac{3}{5}$	$\frac{1-\sigma}{2}$	$\frac{3\sigma-1}{4}$	$\frac{1+\sigma}{4}$	$\frac{3-5\sigma}{8}$	$\frac{5-3\sigma}{8}$	0	$\frac{5+6\sigma+\sigma^2}{32}$	$\frac{19-18\sigma+27\sigma^2}{64}$	$\frac{29-6\sigma+29\sigma^2}{64}$
$\sigma > \frac{3}{5}$	$\frac{1-\sigma}{2}$	$\frac{3\sigma-1}{4}$	$\frac{1+\sigma}{4}$	0	NA	0	$\frac{7(1+\sigma)^2}{64}$	$\frac{29-6\sigma+29\sigma^2}{128}$	$\frac{43+22\sigma+43\sigma^2}{128}$

Table 4. Equilibrium Under Scenario $\ddot{N}$

	$w_1^{\ddot N}$	$q_1^{\ddot N}$	$p_{1H}^{\ddot N}$	$r_{1H}^{\ddot N}$	$w_{2H}^{\ddot N}$	$q_{2H}^{\ddot N}$	$p_{2H}^{\ddot N}$	$r_{2H}^{\ddot N}$	
$\sigma \le \sigma^N$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3+4\sigma}{4}$	0	$\frac{1+\sigma}{2}$	$\frac{1+\sigma}{4}$	$\frac{3(1+\sigma)}{4}$	0	
$\sigma > \sigma^N$	$\frac{1+\sigma}{4}$	$\frac{1+\sigma}{4}$	$\frac{3(1+\sigma)}{4}$	0	$\frac{1+\sigma}{2}$	$\frac{1+\sigma}{4}$	$\frac{3(1+\sigma)}{4}$	0	
	$p_{1L}^{\ddot N}$	$r_{1L}^{\ddot N}$	$w_{2L}^{\ddot N}$	$q_{2L}^{\ddot N}$	$p_{2L}^{\ddot N}$	$r_{2L}^{\ddot N}$	$\pi_M^{\ddot N}$	$\pi_R^{\ddot N}$	$\pi_S^{\ddot N}$
$\sigma \le \sigma^N$	$\frac{3-4\sigma}{4}$	0	$\frac{1-\sigma}{2}$	$\frac{1-\sigma}{4}$	$\frac{3(1-\sigma)}{4}$	0	$\frac{2+\sigma^2}{8}$	$\frac{2+\sigma^2}{16}$	$\frac{3(2+\sigma^2)}{16}$
$\sigma > \sigma^N$	$\frac{1-\sigma}{2}$	$\frac{3\sigma-1}{4}$	$\frac{1-\sigma}{2}$	$\frac{1-\sigma}{4}$	$\frac{3(1-\sigma)}{4}$	0	$\frac{3+2\sigma+3\sigma^2}{16}$	$\frac{7-6\sigma+7\sigma^2}{32}$	$\frac{13-2\sigma+13\sigma^2}{32}$

path, we identify four effects of quick response from the retailer's perspective. Figure 4 illustrates the four effects, and Table 6 provides numerical quantifications for the four effects. We discuss each of these effects in detail:

i. Demand learning. Clearly, this is a positive effect for the retailer and can be captured by $\pi_R^{\dot N} - \pi_R^N$. The conventional wisdom about quick response is that it helps the retailer mitigate demand risk through demand learning. In particular, quick response enables the retailer to adjust the total order quantity based on information learned from early sales. Given identical wholesale prices for scenarios $\dot N$ and N, the effect of demand learning always benefits the retailer, and such a benefit becomes greater when demand uncertainty increases. We also note that the manufacturer is hurt because the expected total order quantity is less than that under scenario N.

ii. Replenishment wholesale price flexibility. This effect is captured by the profit difference $\pi_R^{\ddot N} - \pi_R^{\dot N}$, which is negative for the retailer. When the manufacturer is able to change the wholesale price for the second order, the wholesale price is contingent on the realized market state: if the state is high (low), the manufacturer prices high (low) for replenishment. With such flexibility in replenishment wholesale pricing, a large portion of the retailer's surplus obtained from demand learning is extracted by the manufacturer. The extent of extraction grows as demand becomes more uncertain, especially at the switching point $\sigma = \sigma^N$. This is because σ^N is the point at which the manufacturer switches from conservative to aggressive wholesaling; the latter scheme takes greater advantage of the retailer's need for safety stock.

iii. Strategic inventory. This positive effect is captured by $\pi_R^{\dddot N} - \pi_R^{\ddot N}$. When the retailer can carry leftover inventory to the second-period, the retailer strategically orders more for the regular quantity to reduce reliance on rapid replenishment, which hedges against the manufacturer's flexibility in adjusting the replenishment wholesale price. Figure 4 shows that this effect is most significant at $\sigma = \sigma^N$. That is, the manufacturer's great benefit at this point is recaptured by the retailer. This is because, under the retailer's aggressive ordering, it is more difficult for the manufacturer to distinguish between the safety stock and the strategic inventory; it, thus, has to yield more surplus to the retailer.

iv. Regular wholesale price flexibility. This is a negative effect for the retailer, captured by $\pi_R^Q - \pi_R^{\dddot N} \le 0$. The manufacturer's final weapon is to adjust the regular wholesale price in anticipation of the strategic interactions after demand realization. Two movements are in order. First, the regular wholesale price is raised. Second and more impactfully, the manufacturer encourages less aggressive ordering, which assists strategic inventory: it changes the threshold of switching wholesaling scheme from σ^N to σ^Q, which requires demand uncertainty to be more significant to trigger aggressive wholesaling. Consequently, we observe a sharp loss for the retailer when σ falls between σ^N and σ^Q because of regular wholesale price flexibility.

In sum, these four effects delineate the increasingly complex strategic interactions between the manufacturer and the retailer: demand learning and strategic inventory are positive effects (for the retailer) that represent how the retailer can take advantage of the second ordering opportunity, whereas the flexibilities of

Table 5. Equilibrium Under Scenario $\dddot{N}$

	$w_1^{\dddot N}$	$q_1^{\dddot N}$	$p_{1H}^{\dddot N}$	$r_{1H}^{\dddot N}$	$w_{2H}^{\dddot N}$	$q_{2H}^{\dddot N}$	$p_{2H}^{\dddot N}$	$r_{2H}^{\dddot N}$	
$\sigma \le \sigma^N$	$\frac{1}{2}$	$\frac{5}{12}$	$\frac{42+52\sigma}{56}$	$\frac{7-3\sigma}{42}$	$\frac{7+12\sigma}{21}$	$\frac{7+12\sigma}{42}$	$\frac{28+33\sigma}{42}$	0	
$\sigma > \sigma^N$	$\frac{1+\sigma}{4}$	$\frac{5(1+\sigma)}{12}$	$\frac{3(1+\sigma)}{4}$	$\frac{1+\sigma}{6}$	$\frac{1+\sigma}{3}$	$\frac{1+\sigma}{6}$	$\frac{2(1+\sigma)}{3}$	0	
	$p_{1L}^{\dddot N}$	$r_{1L}^{\dddot N}$	$w_{2L}^{\dddot N}$	$q_{2L}^{\dddot N}$	$p_{2L}^{\dddot N}$	$r_{2L}^{\dddot N}$	$\pi_M^{\dddot N}$	$\pi_R^{\dddot N}$	$\pi_S^{\dddot N}$
$\sigma \le \sigma^N$	$\frac{42-52\sigma}{56}$	$\frac{7+3\sigma}{42}$	$\frac{7-12\sigma}{21}$	$\frac{7-12\sigma}{42}$	$\frac{28+33\sigma}{42}$	0	$\frac{931+576\sigma^2}{3,528}$	$\frac{49+24\sigma^2}{336}$	$\frac{2,891+1,656\sigma^2}{7,056}$
$\sigma > \sigma^N$	$\frac{1-\sigma}{2}$	$\frac{11\sigma-1}{12}$	N/A	0	$\frac{1-\sigma}{2}$	$\frac{17\sigma-7}{12}$	$\frac{19(1+\sigma)^2}{144}$	$\frac{31-34\sigma+31\sigma^2}{96}$	$\frac{131-34\sigma+131\sigma^2}{288}$

Figure 4. (Color online) Retailer Profit Comparison Across Intermediate Scenarios (from N to Q)

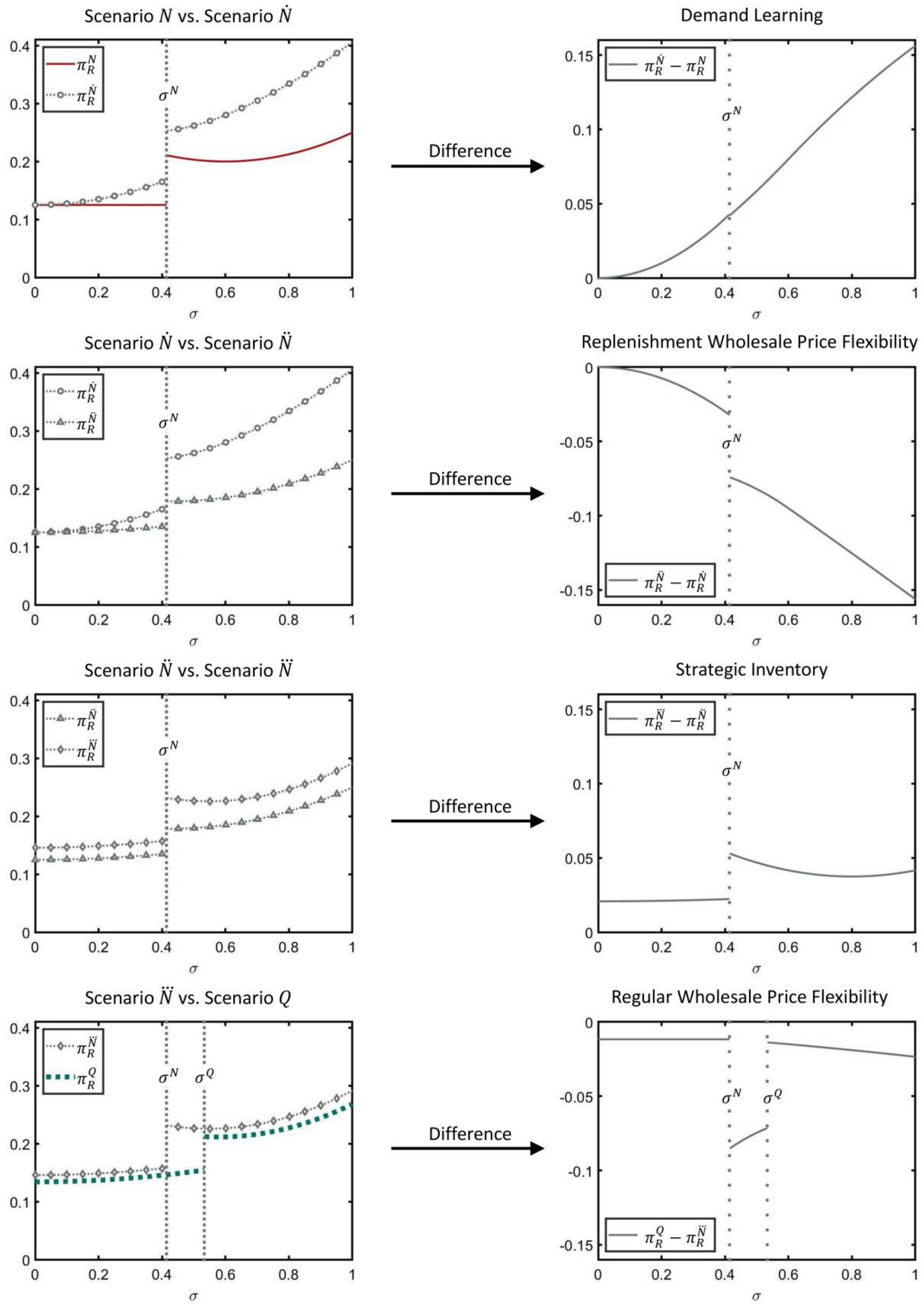


Table 6. Quantification of the Four Effects from Scenario N to Scenario Q

σ	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Demand learning	0	0.003	0.010	0.022	0.040	0.059	0.080	0.100	0.120	0.140	0.160
Repl. whol. price flex.	0	−0.002	−0.008	−0.017	−0.030	−0.082	−0.095	−0.110	−0.130	−0.140	−0.160
Strategic inventory	0.021	0.021	0.021	0.022	0.022	0.047	0.042	0.039	0.037	0.039	0.042
Regular whol. price flex.	−0.012	−0.012	−0.012	−0.012	−0.012	−0.075	−0.015	−0.017	−0.019	−0.021	−0.024
Total	0.009	0.010	0.012	0.016	0.021	−0.051	0.012	0.013	0.015	0.016	0.018

Note. The effects of demand learning, replenishment wholesale price flexibility, strategic inventory, and regular wholesale price flexibility are gradually and respectively quantified by $\pi_R^{\dot{N}} - \pi_R^N$, $\pi_R^{\ddot{N}} - \pi_R^{\dot{N}}$, $\pi_R^{\dddot{N}} - \pi_R^{\ddot{N}}$, and $\pi_R^Q - \pi_R^{\dddot{N}}$. We vary demand uncertainty σ from zero to one to observe these quantifications.

replenishment and regular wholesale prices are negative effects that represent how the manufacturer counters the retailer's strategy and extracts surplus under quick response.

5.2. Comparison Between Scenarios *N* and *Q*

After introducing these four effects, we are ready to present the following proposition and compare the equilibria under scenarios N and Q.

Proposition 2. *By comparing different parties' profits under scenarios N and Q, we find that quick response*

i. *Makes the manufacturer better off for any* $\sigma \in [0, 1]$.

ii. *Makes the retailer better off for* $\sigma \in [0, \sigma^N] \cup (\sigma^Q, 1]$ *and worse off for* $\sigma \in (\sigma^N, \sigma^Q]$.

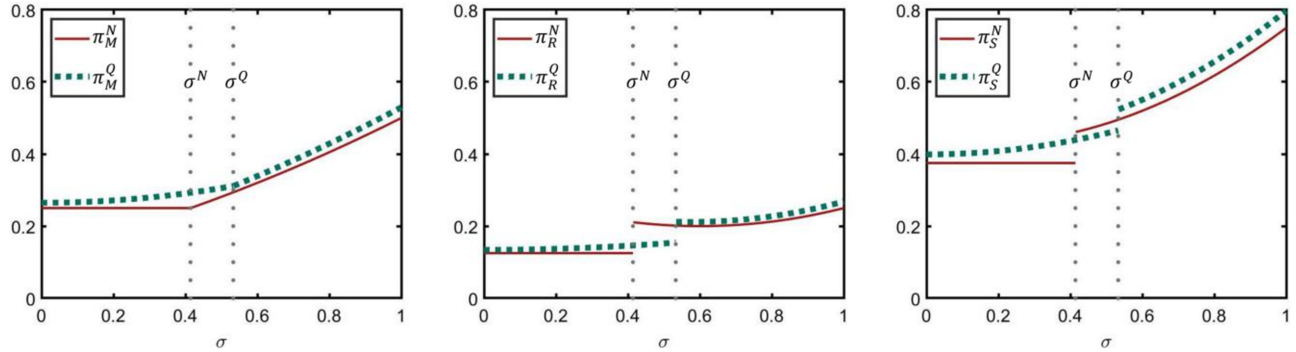
iii. *Makes the supply chain better off for* $\sigma \in [0, \sigma^N] \cup (\sigma^Q, 1]$ *and worse off for* $\sigma \in (\sigma^N, \sigma^Q]$.

The results of Proposition 2 are depicted in Figure 5. The manufacturer, who makes the first move in the game, always enjoys a higher profit under scenario Q than scenario N because it can leverage, more or less, the retailer's benefit from quick response. The retailer, who acts in response to the manufacturer's wholesaling scheme, is more profoundly influenced by the interplay of the four effects. We observe the retailer benefiting from quick response when σ falls within the ranges of $[0, \sigma^N]$ (0 to 0.414) and $(\sigma^Q, 1]$ (0.533 to 1) but losing from quick response when σ falls within the intermediate range of $(\sigma^N, \sigma^Q]$ (0.414 to 0.533). When the retailer gets worse off under quick response, the loss offsets the manufacturer's gain such that total supply chain performance is also worse off. According to the classic article by Fisher (1997), innovative (such as fashion) products are associated with unpredictable demand and could have forecast errors ranging from 40% to 100%. Similarly, in our problem setting, the CV ranges $(0.414, 0.533]$ and $(0.533, 1]$ correspond to the high demand uncertainty situations that are of particular interest to SME fashion retailers.

For easy reference and comparison, we define $\sigma \in [0, \sigma^N]$ as the low demand uncertainty range and $\sigma \in (\sigma^Q, 1]$ as the significantly high demand uncertainty range. Numerically, these definitions are consistent with the classification of demand uncertainties introduced in Fisher (1997). In these situations, although the manufacturer and the retailer strategically counter each other via the four effects, their conflict only involves how to share the benefit of quick response and can be viewed as nonfundamental. The final outcome is win–win, for example, both enjoy a fraction of quick response's benefit.

When $\sigma \in (\sigma^N, \sigma^Q]$, we define demand uncertainty as moderately high. This is a situation in which the manufacturer and the retailer act inconsistently: the retailer considers demand uncertainty to be high enough to warrant an aggressive ordering decision (as the retailer does in the benchmark scenario N), but the manufacturer still prefers conservative ordering from the retailer and sets wholesale prices to counter the retailer's

Figure 5. (Color online) Profit Comparison Between Scenarios N and Q



ordering strategy. The manufacturer does so (for regular wholesale price) to counter the retailer's strategic inventory, which counters the manufacturer's replenishment wholesale price flexibility, which counters the retailer's demand learning. In this situation, the back-and-forth interaction of the four effects leads to a fundamental conflict between the manufacturer and the retailer. The powerful manufacturer is still better off under quick response, but the weak retailer suffers from the distortion of quick response. The entire supply chain also becomes worse off because of the two members' strategic mismatch.

6. Wholesale Price Commitment

Given this analysis, a natural question arises: can we modify the quick response arrangement to eliminate the detrimental effect on the retailer and the supply chain? A seemingly apparent approach is commitment, which has proven effective in mitigating unfavorable strategic behavior in many settings (see, e.g., Maggi 1999, Su and Zhang 2009, Nasser and Turcic 2016). In this section, we explore two commitment mechanisms: in the first mechanism, the manufacturer commits to a wholesale price for the replenishment order before the selling season, whereas in the second mechanism, the manufacturer commits to a uniform wholesale price for both regular and replenishment orders. However, the following analysis shows that neither mechanism is effective in resolving the problem in our setting. To delineate the effect underlying this result, we define two additional scenarios.

Scenario $\bar{Q}$*:* Replenishment wholesale price commitment. The manufacturer sets both the regular wholesale price $w_{1\bar{Q}}$ and the replenishment wholesale price $w_{2\bar{Q}}$ before the selling season. The retailer's decision sequence is the same as in scenario Q.

Scenario $\bar{\bar{Q}}$*:* Uniform wholesale price commitment. The manufacturer sets a uniform wholesale price $w^{\bar{\bar{Q}}}$ for both the regular and the replenishment order before the selling season. The retailer's decision sequence is the same as in scenario Q.

Next, we analyze these two scenarios in turn.

6.1. Commitment to Replenishment Wholesale Price

We start with the scenario $\bar{Q}$ in which the manufacturer commits to the replenishment wholesale price up front. Define a threshold $\sigma^{\bar{Q}} = (2\sqrt{6} - 3)/3$. We then have the following.

Lemma 5. *Under scenario* $\bar{Q}$*, the equilibrium can be summarized by Table 7.*

The manufacturer's pricing strategy is given by Table 7 when it commits to a replenishment wholesale price before the selling season. For demand uncertainty within the range $[0, 1/3]$, the manufacturer sets $w_2^{\bar{Q}} > w_1^{\bar{Q}}$ to encourage a large regular order. In response, however, the retailer orders conservatively and leaves no ending inventory under either market state. Under the high market state, the retailer uses the first period leftover inventory $\left(r_{1H}^{\bar{Q}} = (1 - 3\sigma)/4\right)$ and the replenishment order $\left(q_{2H}^{\bar{Q}} = \sigma\right)$ jointly to fulfill second-period demand; under the low market state, the first period leftover inventory $\left(r_{1L}^{\bar{Q}} = (1 - \sigma)/4\right)$ is just enough to cover second-period demand. For demand uncertainty within the range $(1/3, \sigma^{\bar{Q}}]$, the wholesaling scheme remains the same as in the previous case, but the retailer's response is different: under the high market state, the retailer clears inventory at the end of the first period and fulfills second-period demand completely with the replenishment order. This is because the two market states are more differentiated such that the two periods' quantity for the low state can cover only one period's demand for the high state. For demand uncertainty within the range $(\sigma^{\bar{Q}}, 1]$, the manufacturer discounts the regular wholesale price, which is aggressive wholesaling. The retailer then clears inventory under the high market state but withholds ending inventory under the low market state.

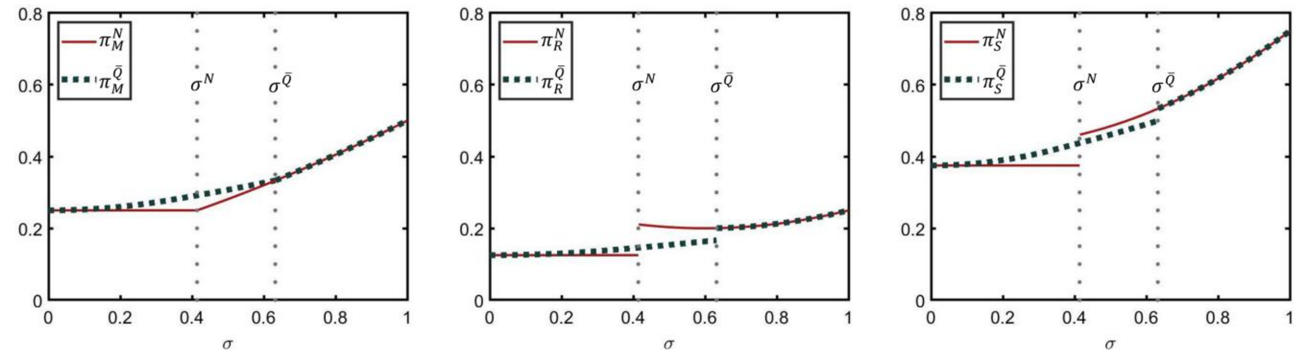
Combining Lemmas 1 and 5, we obtain the following.

Proposition 3. *By comparing the firms' profits under scenarios N and* $\bar{Q}$*, we can show that quick response with replenishment wholesale price commitment*

Table 7. Equilibrium Under Scenario $\bar{Q}$

	$w_1^{\bar{Q}}$	$w_2^{\bar{Q}}$	$q_1^{\bar{Q}}$	$p_{1H}^{\bar{Q}}$	$r_{1H}^{\bar{Q}}$	$q_{2H}^{\bar{Q}}$	$p_{2H}^{\bar{Q}}$	$r_{2H}^{\bar{Q}}$
$\sigma \le \frac{1}{3}$	$\frac{1}{2}$	$\frac{1+\sigma}{2}$	$\frac{1-\sigma}{2}$	$\frac{3+3\sigma}{4}$	$\frac{1-3\sigma}{4}$	σ	$\frac{3+3\sigma}{4}$	0
$\frac{1}{3} < \sigma \le \sigma^{\bar{Q}}$	$\frac{1}{2}$	$\frac{1+\sigma}{2}$	$\frac{1}{3}$	$\frac{3+3\sigma}{4}$	0	$\frac{1+\sigma}{4}$	$\frac{3+3\sigma}{4}$	0
$\sigma > \sigma^{\bar{Q}}$	$\frac{1+\sigma}{4}$	$\frac{1+\sigma}{2}$	$\frac{1+\sigma}{4}$	$\frac{3+3\sigma}{4}$	0	$\frac{1+\sigma}{4}$	$\frac{3+3\sigma}{4}$	0
	$p_{1L}^{\bar{Q}}$	$r_{1L}^{\bar{Q}}$	$q_{2L}^{\bar{Q}}$	$p_{2L}^{\bar{Q}}$	$r_{2L}^{\bar{Q}}$	$\pi_M^{\bar{Q}}$	$\pi_R^{\bar{Q}}$	$\pi_S^{\bar{Q}}$
$\sigma \le \frac{1}{3}$	$\frac{3-3\sigma}{4}$	$\frac{1-\sigma}{4}$	0	$\frac{3-3\sigma}{4}$	0	$\frac{1+\sigma^2}{4}$	$\frac{1+\sigma^2}{8}$	$\frac{3+3\sigma^2}{8}$
$\frac{1}{3} < \sigma \le \sigma^{\bar{Q}}$	$\frac{5-6\sigma}{6}$	$\frac{1}{6}$	0	$\frac{5-6\sigma}{6}$	0	$\frac{11+6\sigma+3\sigma^2}{48}$	$\frac{11+6\sigma+3\sigma^2}{96}$	$\frac{11+6\sigma+3\sigma^2}{32}$
$\sigma > \sigma^{\bar{Q}}$	$\frac{1-\sigma}{2}$	$\frac{3\sigma-1}{4}$	0	$\frac{1-\sigma}{2}$	$\frac{5\sigma-3}{4}$	$\frac{(1+\sigma)^2}{8}$	$\frac{5-6\sigma+5\sigma^2}{16}$	$\frac{7-2\sigma+7\sigma^2}{16}$

Figure 6. (Color online) Profit Comparison Between Scenarios N and $\bar{Q}$



i. *Makes the manufacturer better off for any* $\sigma \in [0,1]$.

ii. *Makes the retailer better off for* $\sigma \in [0,\sigma^N] \cup (\sigma^{\bar{Q}},1]$ *and worse off for* $\sigma \in (\sigma^N,\sigma^{\bar{Q}}]$.

iii. *Makes the supply chain better off for* $\sigma \in [0,\sigma^N] \cup (\sigma^{\bar{Q}},1]$ *and worse off for* $\sigma \in (\sigma^N,\sigma^{\bar{Q}}]$.

The results of Proposition 3 are depicted in Figure 6. We can see that the detrimental impact of quick response remains—and could be even worse. Now, within the range of $\sigma \in (\sigma^N,\sigma^{\bar{Q}}]$ (0.414 to 0.633), the retailer is better off to be aggressive, but the manufacturer encourages the retailer to be conservative. Note that this is a wider range than that in the Q-versus-N comparison (0.414 to 0.533). In fact, commitment enhances the manufacturer's power because the retailer cannot counter the replenishment wholesale price flexibility with strategic inventories. The manufacturer is more willing to encourage a conservative regular order because, if the market state turns out to be high, it can benefit more from the replenishment order with a higher wholesale price. The retailer's benefit from demand learning is, therefore, more severely leveraged. We also note that, for $\sigma \in (\sigma^{\bar{Q}},1]$, the manufacturer (retailer) earns the same profit under the two scenarios (in other words, better off in the weak sense), which is due to our zero production cost normalization. Given a positive production cost, we verify that, within this demand-uncertainty range, both firms' profits are strictly higher under scenario $\bar{Q}$ than under scenario N.

6.2. Commitment to Uniform Wholesale Price

We now investigate scenario $\bar{\bar{Q}}$, in which the manufacturer commits to a uniform wholesale price for both orders, which weakens the manufacturer's pricing flexibility. Define thresholds $\sigma_1^{\bar{\bar{Q}}} = (2\sqrt{33}-11)/3$ and $\sigma_2^{\bar{\bar{Q}}} = (2\sqrt{165}-11)/21$. We then have the following.

Lemma 6. *Under scenario* $\bar{\bar{Q}}$*, the equilibrium can be summarized by Table 8.*

It can be readily shown by Table 8 that, under scenario $\bar{\bar{Q}}$, the retailer never carries inventory from the first to the second-period if the market state is high ($r_{2H}^{\bar{\bar{Q}}}$ for any σ). It implies that carrying inventory across the two periods is purely for countering demand uncertainty but not for the strategic purpose. For demand uncertainty within the range $[0,\sigma_1^{\bar{\bar{Q}}}]$, the manufacturer sets a wholesale price that induces the retailer to place a replenishment order under both market states ($q_{2H}^{\bar{\bar{Q}}} \geq q_{2L}^{\bar{\bar{Q}}} > 0$). For demand uncertainty within the range $(\sigma_1^{\bar{\bar{Q}}},\sigma_2^{\bar{\bar{Q}}}]$, the manufacturer raises the wholesale price, and the retailer responds with zero replenishment order under the low market state ($q_{2L}^{\bar{\bar{Q}}} = 0$). These two demand uncertainty ranges both lead to conservative wholesaling. For demand uncertainty within the range $(\sigma_2^{\bar{\bar{Q}}},1]$, the manufacturer switches

Table 8. Equilibrium Under Scenario $\bar{\bar{Q}}$

	$w^{\bar{\bar{Q}}}$	$q_1^{\bar{\bar{Q}}}$	$p_{1H}^{\bar{\bar{Q}}}$	$r_{1H}^{\bar{\bar{Q}}}$	$q_{2H}^{\bar{\bar{Q}}}$	$p_{2H}^{\bar{\bar{Q}}}$	$r_{2H}^{\bar{\bar{Q}}}$	
$\sigma \leq \sigma_1^{\bar{\bar{Q}}}$	$\frac{1}{2}$	$\frac{1+2\sigma}{4}$	$\frac{3+2\sigma}{4}$	0	$\frac{1+2\sigma}{4}$	$\frac{3+2\sigma}{4}$	0	
$\sigma_1^{\bar{\bar{Q}}} < \sigma \leq \sigma_2^{\bar{\bar{Q}}}$	$\frac{11+3\sigma}{22}$	$\frac{11-3\sigma}{33}$	$\frac{22+36\sigma}{33}$	0	$\frac{11+19\sigma}{44}$	$\frac{33+25\sigma}{44}$	0	
$\sigma > \sigma_2^{\bar{\bar{Q}}}$	$\frac{3(1+\sigma)}{10}$	$\frac{1+\sigma}{5}$	$\frac{4(1+\sigma)}{5}$	0	$\frac{7(1+\sigma)}{20}$	$\frac{13(1+\sigma)}{20}$	0	
	$p_{1L}^{\bar{\bar{Q}}}$	$r_{1L}^{\bar{\bar{Q}}}$	$q_{2L}^{\bar{\bar{Q}}}$	$p_{2L}^{\bar{\bar{Q}}}$	$r_{2L}^{\bar{\bar{Q}}}$	$\pi_M^{\bar{\bar{Q}}}$	$\pi_R^{\bar{\bar{Q}}}$	$\pi_S^{\bar{\bar{Q}}}$
$\sigma \leq \sigma_1^{\bar{\bar{Q}}}$	$\frac{3-2\sigma}{4}$	σ	$\frac{1-6\sigma}{4}$	$\frac{3-2\sigma}{4}$	0	$\frac{1}{4}$	$\frac{1+4\sigma^2}{8}$	$\frac{3+4\sigma^2}{8}$
$\sigma_1^{\bar{\bar{Q}}} < \sigma \leq \sigma_2^{\bar{\bar{Q}}}$	$\frac{55-63\sigma}{66}$	$\frac{11-3\sigma}{66}$	0	$\frac{55-63\sigma}{66}$	0	$\frac{(11+3\sigma)^2}{528}$	$\frac{121+66\sigma+105\sigma^2}{1{,}056}$	$\frac{121+66\sigma+41\sigma^2}{352}$
$\sigma > \sigma_2^{\bar{\bar{Q}}}$	$\frac{1-\sigma}{2}$	$\frac{7\sigma-3}{10}$	0	$\frac{1-\sigma}{2}$	$\frac{6\sigma+1}{5}$	$\frac{9(1+\sigma)^2}{80}$	$\frac{53-54\sigma+53\sigma^2}{160}$	$\frac{71-18\sigma+71\sigma^2}{160}$

to aggressive wholesaling, and the retailer carries ending inventory under the low market state ($r_{2L}^{\bar{\bar{Q}}} > 0$).

Let $\sigma_1' = (-33 + 8\sqrt{66})/57$ and $\sigma_2' = (77 - 8\sqrt{11})/75$. Combining Lemmas 1 and 6 gives the following result.

Proposition 4. *By comparing different parties' profits under scenarios N and $\bar{\bar{Q}}$, we can show that quick response with uniform wholesale price commitment*

i. *Makes the manufacturer better off for $\sigma \in [0, \sigma_1']$ and worse off for $\sigma \in (\sigma_1', 1]$.*

ii. *Makes the retailer better off for $\sigma \in [0, \sigma^N] \cup (\sigma_2', 1]$ and worse off for $\sigma \in (\sigma^N, \sigma_2']$.*

iii. *Makes the supply chain better off for $\sigma \in [0, \sigma^N] \cup (\sigma_2^{\bar{\bar{Q}}}, 1]$ and worse off for $\sigma \in (\sigma^N, \sigma_2^{\bar{\bar{Q}}}]$.*

Figure 7 provides an illustration of Proposition 4. Two observations are worth highlighting. First, unlike scenarios Q and $\bar{Q}$, the manufacturer may be worse off under scenario $\bar{\bar{Q}}$ compared with the benchmark scenario N. The manufacturer loses because of the retailer's demand learning, which prevents the retailer from overordering. For a sufficiently high demand uncertainty ($\sigma \in (\sigma_1', 1]$), such a loss prevails over the gain of leveraging the benefit of quick response. Second, uniform wholesale price commitment does not resolve quick response's detrimental impact either. In the demand uncertainty range of (σ^N, σ_2'] (0.414 to 0.673), the retailer is still worse off. In fact, by comparing scenario $\bar{\bar{Q}}$ with scenario Q, we find that uniform wholesale price commitment indeed mitigates the drawback of quick response ($\pi_R^{\bar{\bar{Q}}} > \pi_R^Q$) for the focal demand uncertainty range (σ^N, σ^Q]; nevertheless, such mitigation is insufficient to let quick response beat the no-quick-response benchmark.

In sum, for the retailer, letting the manufacturer commit to the replenishment wholesale price is even worse than dynamic wholesale pricing because it amplifies the manufacturer's power and reduces its willingness to collaborate. Letting the manufacturer commit to a uniform wholesale price can mitigate quick response's drawback to some extent but not completely; moreover, the manufacturer has no incentive to do so because it hurts its own profit. We conclude that mechanisms involving commitment to wholesale prices, although intuitive, are not effective in improving quick response.

7. Retailer-Proposed Rapid Replenishment

We continue to search for mechanisms that can resolve the negative effect of quick response. In Online Supplements B.2 and B.3, we show that classic supply contracts, such as buyback and revenue sharing, also fail to make quick response more favorable to the retailer because they give the manufacturer more power to exploit retailer profit. An effective mechanism should satisfy the following three criteria: first, it should lead to a win–win outcome for both firms compared with the benchmark scenario; second, it should not require a dominant power from the SME retailer; third, it should be simple and intuitive to implement. Based on these criteria, we consider a mechanism in which the retailer proposes take-it-or-leave-it terms for rapid replenishment. We refer to this mechanism as retailer-proposed rapid replenishment.

The timeline of the new mechanism is as follows: first, the manufacturer sets the wholesale price for the regular order; then, the retailer proposes the terms for the replenishment order; finally, the manufacturer decides whether to accept or reject those terms. If the manufacturer accepts the terms, then the two firms essentially agree to adopt the quick response strategy; otherwise, the firms proceed without quick response. Note that even a weak SME retailer can take the initiative to propose the replenishment terms because the retailer can always choose to forgo the replenishment opportunity, that is, give up the quick response strategy. Nevertheless, this natural power of the retailer is not utilized in the previous scenarios Q, $\bar{Q}$, and $\bar{\bar{Q}}$. Next, we introduce two scenarios under the new mechanism to facilitate the subsequent analysis. Figure 8 depicts the sequence of events for these scenarios.

Figure 7. (Color online) Profit Comparison Between Scenarios N and $\bar{\bar{Q}}$

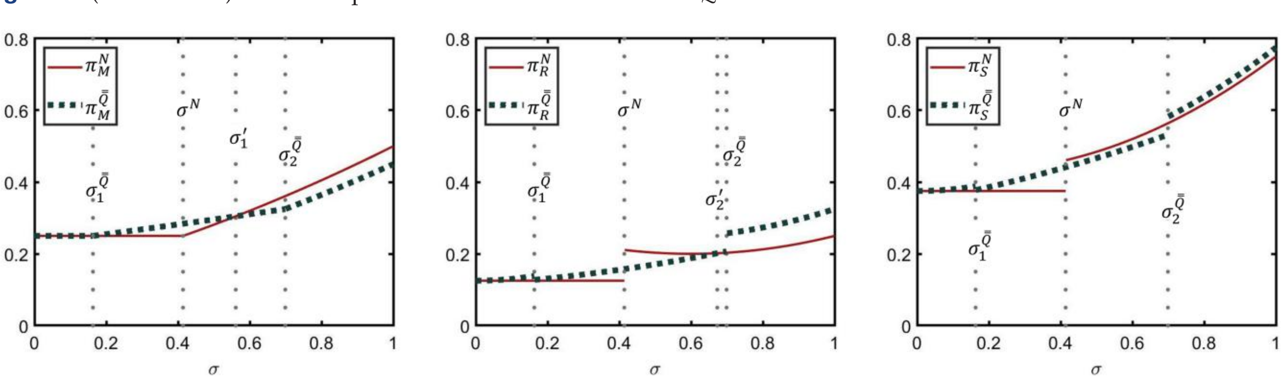
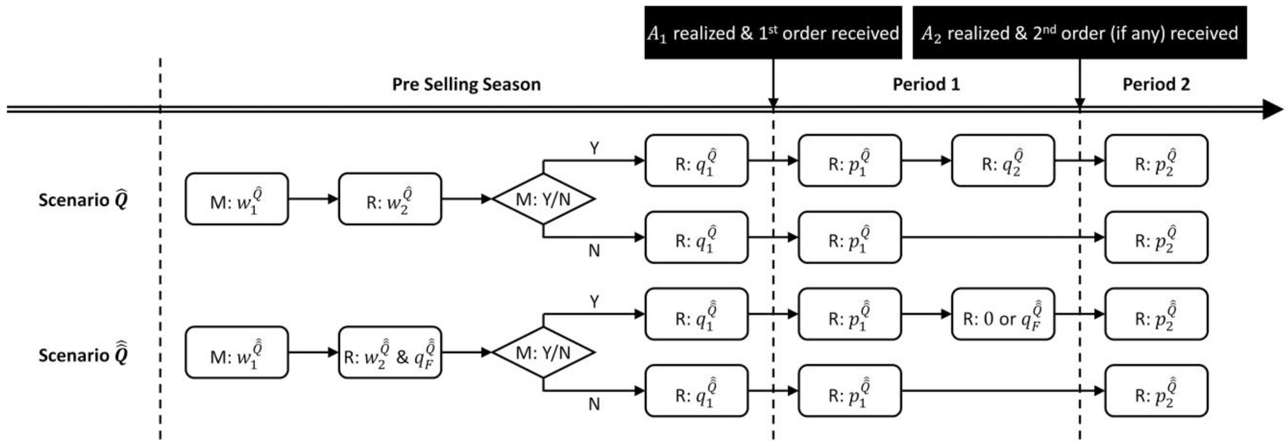


Figure 8. Sequence of Events in Retailer-Proposed Rapid Replenishment



Scenario $\hat{Q}$: Retailer-proposed replenishment price. In this scenario, the retailer proposes a wholesale price $w_2^{\hat{Q}}$ for the replenishment order.

Scenario $\hat{\hat{Q}}$: Retailer-proposed replenishment price and quantity. In this scenario, the retailer proposes both a wholesale price $w_2^{\hat{\hat{Q}}}$ and a quantity $q_F^{\hat{\hat{Q}}}$-or-zero for the replenishment order. That is, during the selling season, the retailer can order either $q_F^{\hat{\hat{Q}}}$ or zero at the price $w_2^{\hat{\hat{Q}}}$.

7.1. Retailer-Proposed Replenishment Price

The following lemma presents the equilibrium outcome for scenario $\hat{Q}$.

Lemma 7. *Under scenario $\hat{Q}$, the equilibrium can be summarized by Table 9.*

Table 9 illustrates the retailer's equilibrium strategy under scenario $\hat{Q}$. When σ is low ($\sigma \le \sigma^N$), the retailer uses a conservative strategy to clear all the leftover inventory regardless of the market state. In this situation, the retailer proposes a $w_2^{\hat{Q}}$ that equals $w_{1\hat{Q}}$, under which the retailer's expected total order quantity is the same as in scenario N, and the manufacturer accepts it. The retailer does not need to hold any inventory for the strategic purpose and benefits directly from the second ordering opportunity in the second-period. When σ is moderately high $(\sigma^N < \sigma \le 3/5)$, the manufacturer switches to an aggressive regular wholesale price, anticipating that the retailer will propose a high replenishment wholesale price to induce its participation. The retailer can still clear the ending inventory regardless of the market state. Finally, when σ is significantly high, the retailer has to make differentiated ex post decisions contingent on the market state. In this situation, a predetermined $w_2^{\hat{Q}}$, though proposed by the retailer, cannot make both the retailer and the manufacturer satisfied; that is, if the proposed $w_2^{\hat{Q}}$ is low, the manufacturer rejects it; if the proposed $w_2^{\hat{Q}}$ is high, the retailer orders nothing during the selling season. Therefore, the game collapses into the no-quick-response scenario.

Based on Lemmas 1 and 7, we can derive the following proposition.

Proposition 5. *By comparing the firms' profits under scenarios N and $\hat{Q}$, quick response with retailer-proposed price*

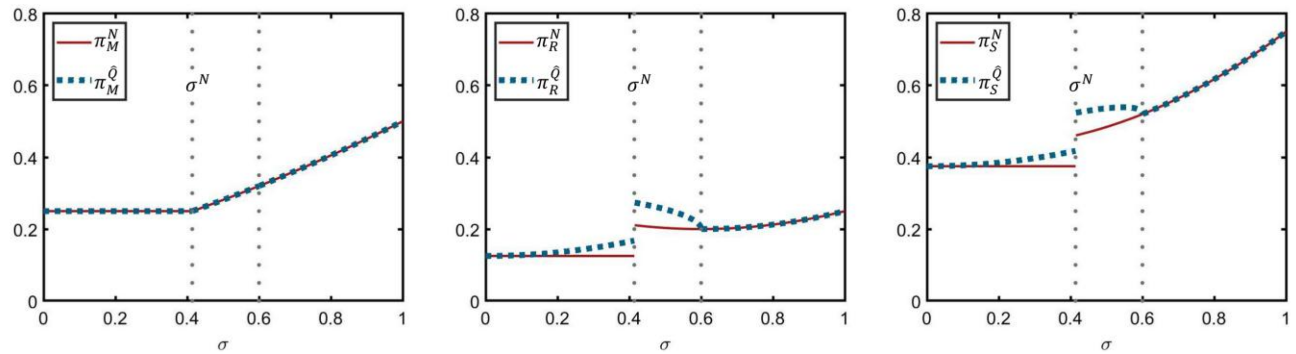
i. *Makes the manufacturer indifferent for any $\sigma \in [0,1]$.*
ii. *Makes the retailer better off for any $\sigma \in [0,1]$.*

Table 9. Equilibrium Under Scenario $\hat{Q}$

	$w_1^{\hat{Q}}$	$w_2^{\hat{Q}}$	$q_1^{\hat{Q}}$	$p_{1H}^{\hat{Q}}$	$r_{1H}^{\hat{Q}}$	$q_{2H}^{\hat{Q}}$	$p_{2H}^{\hat{Q}}$	$r_{2H}^{\hat{Q}}$
$\sigma \le \sigma^N$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3+4\sigma}{4}$	0	$\frac{1+2\sigma}{4}$	$\frac{3+2\sigma}{4}$	0
$\sigma^N < \sigma \le \frac{3}{5}$	$\frac{1+\sigma}{4}$	$\frac{3(1+\sigma)-\zeta}{6}$	$\frac{3-\sigma}{6}$	$\frac{3+7\sigma}{6}$	0	$\frac{3(1+\sigma)-\zeta}{12}$	$\frac{9(1+\sigma)+\zeta}{12}$	0
$\sigma > \frac{3}{5}$	$\frac{1+\sigma}{4}$	N/A	$\frac{1+\sigma}{2}$	$\frac{3+3\sigma}{4}$	$\frac{1+\sigma}{4}$	0	$\frac{3+3\sigma}{4}$	0
	$p_{1L}^{\hat{Q}}$	$r_{1L}^{\hat{Q}}$	$q_{2L}^{\hat{Q}}$	$p_{2L}^{\hat{Q}}$	$r_{2L}^{\hat{Q}}$	$\pi_M^{\hat{Q}}$	$\pi_R^{\hat{Q}}$	$\pi_S^{\hat{Q}}$
$\sigma \le \sigma^N$	$\frac{3-4\sigma}{4}$	0	$\frac{1-2\sigma}{4}$	$\frac{3-2\sigma}{4}$	0	$\frac{1}{4}$	$\frac{1+2\sigma^2}{8}$	$\frac{3+2\sigma^2}{8}$
$\sigma^N < \sigma \le \frac{3}{5}$	$\frac{9-11\sigma}{12}$	$\frac{3-\sigma}{12}$	0	$\frac{9-11\sigma}{12}$	0	$\frac{(1+\sigma)^2}{8}$	$\frac{4(3-\sigma)+(1+\sigma)\zeta}{48}$	$\frac{18+8\sigma+6\sigma^2+(1+\sigma)\zeta}{48}$
$\sigma > \frac{3}{5}$	$\frac{1-\sigma}{2}$	σ	0	$\frac{1-\sigma}{2}$	$\frac{3\sigma-1}{2}$	$\frac{(1+\sigma)^2}{8}$	$\frac{5+2\sigma+5\sigma^2}{16}$	$\frac{14+10\sigma+14\sigma^2}{32}$

Note. $\zeta = \sqrt{3(1+\sigma)(3-5\sigma)}$.

Figure 9. (Color online) Profit Comparison Between Scenarios N and $\hat{Q}$



iii. *Makes the supply chain better off for any $\sigma \in [0,1]$.*

This proposition can be illustrated by Figure 9. Note that, if the manufacturer rejects the retailer's proposal, then scenario $\hat{Q}$ collapses into scenario N. That is, the manufacturer always has the option to choose scenario N. Therefore, the retailer needs to propose a replenishment price such that the manufacturer is not worse off in scenario $\hat{Q}$ than in scenario N. Proposition 5 characterizes an extreme situation in which the retailer extracts all the benefits from quick response and leaves the manufacturer indifferent. In practice, however, it is also plausible for the retailer to share the quick response benefits with the manufacturer. Such sharing schemes can be achieved by simply adjusting the wholesale price for the replenishment order.

For moderately high demand uncertainty $((\sigma^N, \sigma^Q]$ is contained by $(\sigma^N, 3/5])$, the retailer is strictly better off under scenario $\hat{Q}$, which is in contrast with scenario Q in which quick response hurts the retailer. Note that the manufacturer always charges the same regular wholesale price as in scenario N. These observations imply that the focal conflict between the manufacturer and the retailer no longer exists under the retailer-proposed price mechanism. However, for a significantly high market uncertainty $((3/5, 1])$, scenario $\hat{Q}$ collapses into scenario N because of the inconsistency in replenishment wholesale price: the retailer prefers a replenishment price that supports a reasonably large reorder, but the manufacturer is concerned that such a replenishment price will reduce the regular order and harm its own profit. This is a limitation of scenario $\hat{Q}$ because no quick response occurs in the presence of significantly high market uncertainty; nevertheless, this is when scenario Q already performs well, and further improvement is not essential.

7.2. Retailer-Proposed Replenishment Price and Quantity

If the retailer can give up flexibility of the replenishment order, that is, commit to a fixed-or-zero quantity for the replenishment order, the outcome could be even more favorable. We solve the equilibrium under scenario $\hat{\hat{Q}}$.

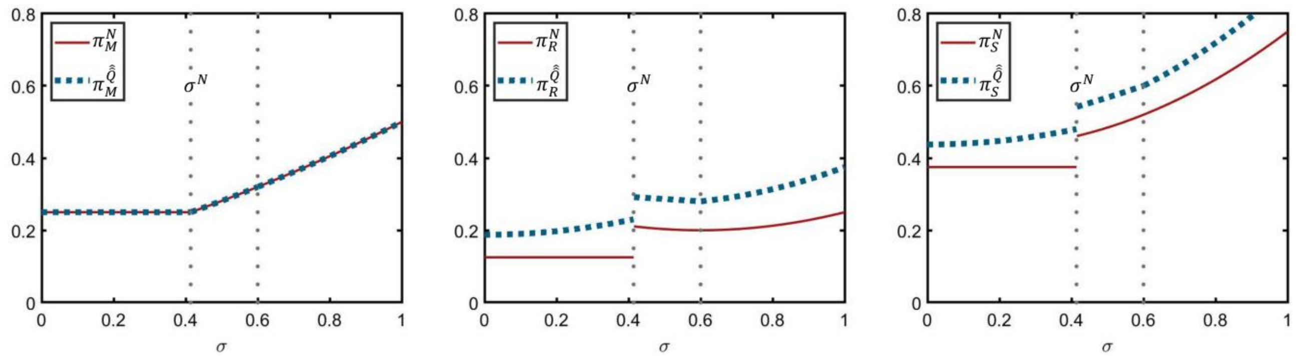
Lemma 8. *Under scenario $\hat{\hat{Q}}$, the equilibrium can be summarized by Table 10.*

We observe clean results in Table 10. The retailer always proposes a fixed quantity of $q_F^{\hat{\hat{Q}}} = (1+\sigma)/2$ for any σ, and the manufacturer always accepts it. This is the optimal quantity for second-period sales if the market state is high. During the selling season, the retailer replenishes $q_F^{\hat{\hat{Q}}}$ when and only when the retailer does not carry any inventory from the first to the second-period (under high and low market states with $\sigma \in [0, \sigma^N]$). That

Table 10. Equilibrium Under Scenario $\hat{\hat{Q}}$

	$w_1^{\hat{\hat{Q}}}$	$w_2^{\hat{\hat{Q}}}$	$q_F^{\hat{\hat{Q}}}$	$q_1^{\hat{\hat{Q}}}$	$p_{1H}^{\hat{\hat{Q}}}$	$r_{1H}^{\hat{\hat{Q}}}$	$q_{2H}^{\hat{\hat{Q}}}$	$p_{2H}^{\hat{\hat{Q}}}$	$r_{2H}^{\hat{\hat{Q}}}$
$\sigma \le \sigma^N$	$\frac{1}{2}$	$\frac{1}{4(1+\sigma)}$	$\frac{1+\sigma}{2}$	$\frac{1}{4}$	$\frac{3+4\sigma}{4}$	0	$q_F^{\hat{\hat{Q}}}$	$\frac{1+\sigma}{2}$	0
$\sigma^N < \sigma \le \frac{3}{5}$	$\frac{1+\sigma}{4}$	$\frac{2\sigma}{3}$	$\frac{1+\sigma}{2}$	$\frac{3-\sigma}{6}$	$\frac{3+7\sigma}{6}$	0	$q_F^{\hat{\hat{Q}}}$	$\frac{1+\sigma}{2}$	0
$\sigma > \frac{3}{5}$	$\frac{1+\sigma}{4}$	$\frac{1+\sigma}{4}$	$\frac{1+\sigma}{2}$	$\frac{1+\sigma}{4}$	$\frac{3(1+\sigma)}{4}$	0	$q_F^{\hat{\hat{Q}}}$	$\frac{1+\sigma}{2}$	0
	$p_{1L}^{\hat{\hat{Q}}}$	$r_{1L}^{\hat{\hat{Q}}}$	$q_{2L}^{\hat{\hat{Q}}}$	$p_{2L}^{\hat{\hat{Q}}}$	$r_{2L}^{\hat{\hat{Q}}}$	$\pi_M^{\hat{\hat{Q}}}$	$\pi_R^{\hat{\hat{Q}}}$	$\pi_S^{\hat{\hat{Q}}}$	
$\sigma \le \sigma^N$	$\frac{3-4\sigma}{4}$	0	$q_F^{\hat{\hat{Q}}}$	$\frac{1-\sigma}{4}$	$\frac{1+3\sigma}{4}$	$\frac{1}{4}$	$\frac{3+4\sigma^2}{16}$	$\frac{7+4\sigma^2}{16}$	
$\sigma^N < \sigma \le \frac{3}{5}$	$\frac{9-11\sigma}{12}$	$\frac{3-\sigma}{12}$	0	$\frac{9-11\sigma}{12}$	0	$\frac{(1+\sigma)^2}{8}$	$\frac{15-2\sigma-\sigma^2}{48}$	$\frac{21+10\sigma+5\sigma^2}{48}$	
$\sigma > \frac{3}{5}$	$\frac{1-\sigma}{2}$	$\frac{3\sigma-1}{4}$	0	$\frac{1-\sigma}{2}$	$\frac{5\sigma-3}{4}$	$\frac{(1+\sigma)^2}{8}$	$\frac{11-10\sigma+11\sigma^2}{32}$	$\frac{15-2\sigma+15\sigma^2}{32}$	

Figure 10. (Color online) Profit Comparison Between Scenarios N and $\hat{\hat{Q}}$



is, the regular and replenishment quantities are completely separated. The manufacturer maintains the same regular wholesale prices as scenario N, the no quick response benchmark. These observations indicate that, under scenario $\hat{\hat{Q}}$, quick response is deployed purely for the purpose of demand learning and contains no gaming considerations.

Combining Lemmas 1, 3, and 5–8, we obtain the following.

Proposition 6. *Quick response with retailer-proposed replenishment price and quantity*

i. *Leads to the same manufacturer profit as scenario N.*

ii. *Leads to higher retailer profit than scenarios N, Q,* $\bar{Q}$, $\bar{\bar{Q}}$, *and* $\hat{Q}$.

iii. *Leads to higher supply chain profit than scenarios N,* Q, $\bar{Q}$, $\bar{\bar{Q}}$, *and* $\hat{Q}$.

Figure 10 depicts the comparison between scenarios $\hat{\hat{Q}}$ and N. Proposition 6 demonstrates the superiority of $\hat{\hat{Q}}$, that it always leads to the highest retailer profit among all the scenarios (excluding the intermediate ones) studied; moreover, the manufacturer has the incentive to collaborate. We note that, by proposing a replenishment wholesale price in combination with a fixed-or-zero quantity, the retailer essentially commits to a fixed-or-zero total payment to the manufacturer. The fixed payment is a direct transaction that persuades the manufacturer to accept the retailer's proposal. It can be easily adjusted without friction with other decisions, leaving the retailer the full flexibility to take advantage of quick response.

8. Concluding Remarks

This research is motivated by the emergence of SME retailers in the fashion industry. Quick response, which allows a retailer to place a rapid replenishment order after observing early sales, is widely adopted by well-established fashion companies. We revisit the quick response strategy from the perspective of retailers with relatively weak market power, such as SME fashion retailers. We find that an SME retailer should exercise caution when adopting quick response because the retailer's position against the manufacturers is distinct from those of well-established brands. In particular, when the manufacturer can strategically and dynamically adjust the wholesale prices for different orders, the retailer does not necessarily benefit from quick response. An additional ordering opportunity may cause a strategic conflict between the two firms; as a result, the quick response strategy could be detrimental to the retailer when there is a moderately high demand uncertainty.

To restore the benefits of quick response, we recommend a retailer-proposed replenishment mechanism. In this mechanism, the retailer offers the manufacturer a take-it-or-leave-it replenishment wholesale price. Although the manufacturer has the power to determine a regular wholesale price, it is the retailer's choice whether to pursue the replenishment opportunity. Thus, it is feasible for the SME retailer to initiate the replenishment arrangement. We show that such a mechanism resolves the strategic conflict between the firms and leads to a win–win outcome.

These findings complement the conventional understanding of the quick response strategy. Firms evolve and grow. The insights from this research indicate that when and how to implement quick response depends on the life stage of the retailer. At the early stage with little market power, a retailer should be cautious with quick response, especially when market demand uncertainty falls into a certain range. If possible, the retailer should try to initiate the replenishment negotiation by proposing a take-it-or-leave-it replenishment wholesale price, better combined with a fixed-or-zero replenishment quantity. When the retailer eventually grows to dominate the supply chain, the retailer will attain the majority of the surplus from quick response. By showing the potential drawbacks of quick response, this research does not oppose the classic strategy; instead, it shows that quick response can still be an effective strategy when carefully executed.

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