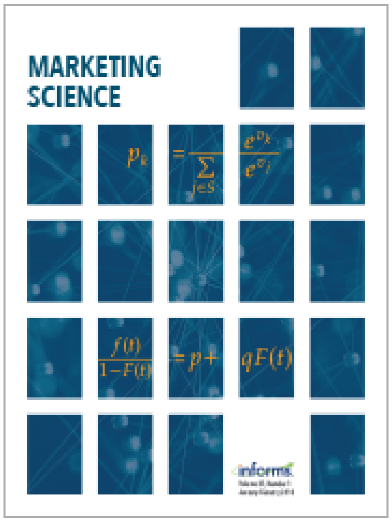

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Service Failure Recovery and Prevention: Managing Stockouts in Distribution Channels

Yan Dong
Darla Moore School of Business, University of South Carolina, Columbia, South Carolina 29208, yan.dong@moore.sc.edu

Kefeng Xu
College of Business, University of Texas at San Antonio, San Antonio, Texas 78249, kefeng.xu@utsa.edu

Tony Haitao Cui
Carlson School of Management, University of Minnesota, Minneapolis, Minnesota 55455, tcui@umn.edu

Yuliang Yao
College of Business and Economics, Lehigh University, Bethlehem, Pennsylvania 18015, yuy3@lehigh.edu

In managing service failures such as stockouts, most research has emphasized preventive mechanisms, whereas stockout recovery mechanisms have been largely ignored. We propose and examine a failure-recovery mechanism (i.e., contractual stockout recovery) in the presence of demand uncertainty and compare it with failure-prevention mechanisms in a dyadic distribution channel.

We find that stockout recovery mechanisms can improve channel profitability under certain conditions. More importantly, we find that stockout recovery may outperform stockout prevention mechanisms such as return policy and vendor managed inventory in improving manufacturer and channel profitability. This is because stockout recovery reduces channel-wide stockout risks and allows benefits from the reduced risks to be shared between the manufacturer and the retailer, helping alleviate double marginalization. Although return policy also reduces stockout risks, it does so by increasing inventory risks in the channel without reducing channel exposure to demand uncertainty. Thus, our research suggests that stockout recovery can be an effective alternative in managing stockouts to those common methods of stockout prevention mechanisms.

Keywords: service failure prevention and recovery; stockouts; distribution channel governance
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1. Introduction

An important customer service in a distribution channel is to make products available to end users. If the quantity prepared is greater than the demand, the channel bears extra cost from unsold inventory. On the other hand, failing to satisfy the demand causes stockouts that lead to customer dissatisfaction and lower brand loyalty (Fitzsimons 2000), lost sales, negative word of mouth, and/or lower long-term value of customers (Anderson et al. 2006, Musalem and Joshi 2009, Kuksov and Xie 2010). For example, when HP's TouchPad tablet debuted in the middle of 2011 with heavy promotion, the product was oversold, leading to serious stockouts, negative publicity, and outraged customers (Hazelton 2011).

Firms keep a high level of inventory as a preventive, but often costly, measure to reduce stockouts. Alternatively, firms could use a service failure recovery mechanism, such as backorders, to "recapture" customers (Thomas et al. 2004, Anderson et al. 2006). In the case of HP, although HP and its channel partners were clearly unprepared for the surge in demand of TouchPad, some of its retailers offered apologies, free future deliveries, and future deals and discounts, to recover the potential damages by the stockouts (Hazelton 2011, Downes 2012). Although stockout recovery can be valuable, it takes coordinated efforts in the channel to capitalize on its value. A key challenge is the misaligned interests between channel members because stockout recovery activities are performed by retailers who directly interact with consumers and bear the costs, whereas manufacturers benefit from recovered stockouts. The costly recovery efforts are unobservable by the manufacturers, which introduces moral hazard that would require properly designed incentive mechanisms to overcome.[1] To align the divergent interests, manufacturers may offer noncontract prices and minimum order fees as "stockout compensation" to retailers for their recovery efforts (Barlow 2008). Samsung, for example,

[1] We thank the editor for this point.

when anticipating a similar stockout situation at Best Buy on its Galaxy Tab, provided sample products at Best Buy and trained Best Buy sales representatives to use the products. When stockouts actually happened, Best Buy staff were able to demonstrate the products to the disappointed customers and convince some of them to place backorders (Van Camp 2012).

Surprisingly, little has been done in understanding stockout recovery mechanisms in distribution channels. Few studies have compared stockout recovery with prevention methods, even though its significance has been well recognized (e.g., Anderson et al. 2006). To close the gap in the literature, we propose the following research questions: *How can stockout recovery be implemented in channels to improve the manufacturer's and channel profitability? Under what conditions can stockout recovery outperform common stockout prevention methods?* We address these research questions by developing analytical models to examine stockout recovery and prevention mechanisms in distribution channels. In particular, we compare stockout recovery (as a failure-recovery mechanism) with return policy and vendor-managed inventory (VMI) (as failure-prevention mechanisms), with a focus on their abilities to improve channel profitability.

The key findings are as follows. First, the manufacturer profit may be higher with stockout recovery than with return policy when the equilibrium involves understocking, but it may be lower when the equilibrium involves overstocking. Importantly, when the channel's long-term customer value is not very high, stockout recovery leads to a higher manufacturer profit than return policy does regardless of inventory equilibria.[2] Second, stockout recovery can yield a higher channel profit than return policy. This may occur when the equilibrium involves understocking and the retailer customer value is sufficiently low. This is the case where double marginalization is sufficiently mitigated under stockout recovery with a low retailer customer value, and this benefit of stockout recovery is large enough to offset the cost of recovery effort. Double marginalization refers to the double price distortion that occurs when two independent firms stack their (distorted) price-cost margins when a transfer price is introduced between them (Jeuland and Shugan 1983). A low customer value implies a small stockout cost for the retailer, which aligns the retailer's preference with the manufacturer's choice of the equilibrium involving understocking with less inventory held in the system. When the equilibrium with stockout recovery involves overstocking, channel profit may still be higher than the equilibrium with return policy. This is because return policy applies only to the unsold product and therefore has a limited impact on reduction in channel-wide risks and double marginalization. Third, VMI consolidates product ownership and inventory decisions to facilitate stockout prevention. As such, VMI may lead to a lower manufacturer profit but a higher channel profit than stockout recovery when the equilibrium involves overstocking. However, it may lead to a lower channel profit than stockout recovery when the retailer's long-term customer value is sufficiently low.

The intuition behind the findings is as follows. Stockout recovery retains unmet demand and long-term customer value and therefore reduces channel-wide stockout risks. Shared between the manufacturer and the retailer, the reduction in stockout risks and costs, and recovered sales further contribute to the reduction of double marginalization. This additional benefit from reduced double marginalization complements the direct benefit of stockout recovery from retained customer value and leads to higher channel profit. In comparison, return policy prevents stockout and reduces stockout risks; however, it does so by inducing overstocking, which increases channel risks of holding inventory as a result from shifting inventory risks from the retailer to the manufacturer. This shift of inventory risks may lead to a higher wholesale and retail price, and therefore a lower demand and channel profit. For the manufacturer, stockout recovery may be more profitable than return policy even if stockout recovery leads to more costs than benefits to the integrated channel. This is because the equilibrium is more likely involving understocking with stockout recovery in a decentralized channel than it is in the integrated channel. Under such circumstances, stockout recovery may extract more retailer profit than return policy, leading to a higher manufacturer profit even if stockout recovery is not cost efficient in the integrated channel.

This research contributes to the literature in the following ways. First, it is built on a recent empirical research stream showing that recovery methods can help reduce stockouts that bring significant loss to firms (Anderson et al. 2006, Musalem et al. 2010, Jing and Lewis 2011). Despite such important empirical findings, to the best of our knowledge, little theoretical research has been conducted to develop further understanding in stockout recovery. Our research develops a contractual stockout recovery mechanism, which may improve channel profitability. Second, we compare the proposed stockout recovery with several commonly used stockout prevention mechanisms. Stockout prevention has been the focus of stockout reduction research, and the value of stockout recovery versus stockout prevention has never been studied from the perspective of distribution channels.

[2] We also call the equilibrium involving understocking (overstocking) the understocking (overstocking) equilibrium as in Iyer et al. (2007).

We show that stockout recovery offers an effective alternative to stockout prevention mechanism and may outperform it. To the best of our knowledge, this study represents a first effort to formulate service failure recovery in distribution channels and to compare stockout recovery with prevention methods.

The rest of the paper is presented as follows. Section 2 establishes and analyzes the models of stockout recovery, return policy, and VMI. Section 3 compares stockout recovery and prevention mechanisms, from both the manufacturer's and the channel's perspective. Section 4 concludes with future research. All proofs are provided in the online appendix (available as supplemental material at http://dx.doi.org/10.1287/mksc.2015.0924).

2. The Models

We model a distribution channel where a single manufacturer sells its product to consumers through a single retailer. The downstream firm, or the retailer, performs service recovery tasks contracted by the manufacturer.[3] The retailer's effort in stockout recovery determines the extent to which stockouts are converted back to sales (e.g., backorders), and thus the extent to which customers are eventually recovered from stockouts and retained. However, the retailer effort is usually not known or verifiable by the manufacturer. Thus, we assume that the retailer's effort to recover stockouts, $e \in \{1, 0\}$ where $e = 1$ refers to making an effort and $e = 0$ refers to no effort, is not observable by the manufacturer or contractible. Stockout recovery rate is defined as a ratio of recovered stockouts to total stockouts, $\theta \in \{\bar{\theta}, \underline{\theta}\}$ with $0 < \underline{\theta} < \bar{\theta} \le 1$, and is unknown ex ante. Although the manufacturer cannot observe the retailer's effort, the manufacturer can learn total stockouts and recovered stockouts from data shared by the retailers.[4]

Given the retailer's effort level, θ follows a conditional distribution: $\Pr(\bar{\theta} \mid e = j) = P_j$ and $\Pr(\underline{\theta} \mid e = j) = 1 - P_j$, where $j \in \{0, 1\}$, which is common knowledge. We assume a high effort is always better than a low effort in stockout recovery, i.e., first-order stochastic dominance holds, $P_1 > P_0$. Let $\theta_j = E(\theta \mid e = j) = P_j \bar{\theta} + (1 - P_j)\underline{\theta}$, where $j \in \{0, 1\}$. Thus θ_j is the expected recovery rate based on an effort level j. The retailer incurs an effort cost, $c(e)$, and $c(e = 1) = c > c(e = 0) = 0$ (Simester and Zhang 2010). This level of effort is determined ex ante before stockouts happen. Demand distribution, production, and inventory related costs are all common knowledge.

Following Iyer et al. (2007), we assume that the retailer faces a downward sloping, stochastic demand of $y = x - p$, where p is the retail price and x represents the market demand potential. In addition, x is a random variable with two states, $x = \bar{\alpha}$ at a probability of γ and $x = \underline{\alpha}$ at a probability of $1 - \gamma$. We denote l_M and l_R as the long-term customer value to the manufacturer and the retailer, respectively; that is, the "goodwill" cost of stockouts such as the loss of sales from negative word of mouth due to stockout (Pasternack 1985). They represent the notion of customer lifetime value (CLV) (Dwyer 1989, Fader et al. 2005). Negative effects of stockouts on the CLV may be calculated based on reduced future orders, fewer items in an order, and lower spending on future orders (Anderson and Simester 2004, Venkatesan and Kumar 2004, Anderson et al. 2006). If a customer ends the relationship with a firm because of stockouts, the firm will lose the customer's CLV, unless the stockouts are recovered to retain the customer.

The manufacturer sells the product to the retailer at price w for regular orders and price $\delta \in \{\bar{\delta}, \underline{\delta}\}$ for recovered sales at the retailer, in which $\bar{\delta}$ corresponds to a recovery rate of $\bar{\theta}$ and $\underline{\delta}$ corresponds to a recovery rate of $\underline{\theta}$. The marginal production cost for the manufacturer is given by $v > 0$. Define $a^+ = \max[a, 0]$ for any measure a. The expected profit function for the manufacturer at a retailer purchase quantity q is then given by

$$E\pi_M(\theta) = (w - v)q + [(\delta - v)\theta - l_M(1 - \theta)]E(x - p - q)^+. \qquad (1)$$

The second term captures both the net profit of recovered sales and the loss in the long-term customer value due to unrecovered stockouts. Note that $\theta E(x - p - q)^+$ is the recovered stockout and $l_M(1 - \theta)E(x - p - q)^+$ is the lost long-term customer value.

Our stockout recovery mechanism resembles a contract with a simple wholesale price without recovery prices, recognizing that a complete pricing structure, one that leads to the outcome of an integrated channel, will eliminate double marginalization and reduce stockout recovery to an efficiency trade-off (its cost versus direct benefit from recovered customer value).

The retailer's expected profit based on its recovery effort level $e \in \{1, 0\}$ is given by

$$E\pi_R(\theta \mid e) = p[q - E(q - (x - p))^+] - wq + [(p - \delta)\theta - l_R(1 - \theta)]E(x - p - q)^+ - c(e). \qquad (2)$$

[3] It is possible that complete demand information is available for contracting at some retailers, such as online retailers, furniture stores, and auto dealers, where consumer orders are made in advance or generated through direct customer interaction. In the case of Best Buy, for example, online shoppers of Galaxy Tab were directed to pick up the product at a retail store, where product samples were provided to retain the customer in the case of stockouts.

[4] For example, in EDI 852 transaction set, the retailer records both backorder quantity and lost sales quantity. (See, for example, http://www.hdexchange.com/852ProductActivity.html, accessed August 10, 2012.)

Table 1 Stockout Reduction Contracts

	Equilibrium	
Contracts	Understocking (U)	Overstocking (O)
Stockout recovery	M decides the wholesale price along with a pair of recovery prices when implementing U; R decides retail price and order quantity.	M decides the wholesale price without a return policy when implementing O; R decides retail price and order quantity.
Return policy	M decides the wholesale price; R decides retail price and order quantity.	M decides the wholesale price and a return price when implementing O; R decides retail price and order quantity.
VMI	M decides the wholesale price and order quantity to R; R decides retail price.	M decides the wholesale price, order quantity to R (with any unsold products belonging to M), when implementing O; R decides retail price.

Note. M, Manufacturer; R, retailer.

Specifically, $p[q - E(q-(x-p))^+]$ represents the sales revenue from the initially ordered products, and the second term wq is the respective purchase cost. The third term captures the net profit of the recovered sales minus the loss in long-term customer value due to uncovered stockouts. The excess product at the retailer has no salvage value.

The manufacturer observes actual stockouts, as discussed above, but does not observe the retailer's recovery effort. As a result, the manufacturer compensates the retailer based on the ex post stockout recovery rate θ.[5] After establishing stockout recovery and return policy, we extended the models to allow the manufacturer to assume ownership of the product and inventory at the retailer's, as often observed in practice under VMI. Table 1 summarizes the three stockout reduction contracts that are studied in the paper.

2.1. A Stockout Recovery Mechanism

Because the manufacturer relies on the retailer to make efforts to recover stockouts, a manufacturer contract is offered to the retailer that includes both the standard wholesale price, w, for the product and terms, $(\bar{\delta}, \underline{\delta})$, that compensate for the retailer's stockout recovery effort.

The sequence of events is as follows. First, the manufacturer (principal) offers a contract $\{w, \bar{\delta}, \underline{\delta}\}$ to the retailer (agent). If the retailer rejects the offer, it receives a reserved profit of zero. If the retailer accepts the offer, it decides on the retail price p, the purchase order quantity q, and a recovery effort level e. Second, demand is realized. If the demand exceeds the initial order quantity, the stockout recovery rate θ based on the recovery effort (e) is realized. The price for the recovered stockouts δ is then paid accordingly.

The retailer is induced to exert recovery effort $e=1$ leading to $\theta=\theta_1$ in expectation, through the following stockout recovery mechanism:[6]

$$\max_{w,\bar{\delta},\underline{\delta}} \left\{P_1 E\pi_M(\bar{\theta}) + (1-P_1)E\pi_M(\underline{\theta})\right\} \tag{3}$$

$$\text{subject to: } (p,q)^* = \arg\max_{p,q} E\pi_R; \tag{4}$$

$$\max_{p,q} E\pi_R(e=1) \geq \max_{p,q} E\pi_R(e=0); \tag{5}$$

$$\max_{p,q} E\pi_R(e=1) \geq 0. \tag{6}$$

Constraint (5) is the incentive compatibility (IC) constraint, which requires that the retailer must exert recovery effort. Satisfaction of the IC constraint allows the stockout recovery mechanism "implementable." Constraint (6) is the individual rationality (IR) constraint, indicating the minimum retailer profit at which the retailer will exert recovery effort.

The problem solution allows two exclusive types of feasible equilibria based on the independent inventory choices at the downstream party of the channel as a result of constraint (4)—an understocking equilibrium $q = \underline{\alpha} - p$ with an order quantity equal to the low state of demand, and an overstocking equilibrium $q = \bar{\alpha} - p$ with an order quantity equal to the high state of demand. In the understocking equilibrium, there is no inventory left after demand is realized, and therefore stockout recovery is relevant. In this case, the equilibrium involves understocking only when the retailer agrees to order an amount leading to understocking, with no incentive to place a larger order quantity leading to overstocking. Therefore, a self-selection or deviation constraint in the form of $E\pi_R \geq E\pi_R^d$, as indicated in constraint (4), needs to be assessed so that the retailer profit $E\pi_R$ from the manufacturer's understocking equilibrium is at least

[5] This is equivalent to contract on the expected recovered quantity, $\theta E(x-p-q)^+$.

[6] Conditions can be developed such that it is in the principal's best interest to induce the retailer's stockout recovery effort. Detailed proofs are available from the authors on request.

as high as that from its best possible deviation $E\pi_R^d$, which is overstocking in this case.

This constraint implies that, to implement a particular equilibrium, the manufacturer relies on the retailer to install the appropriate inventory policy consistent with the equilibrium. The retailer, on the other hand, may have sufficient incentive to deviate from the intended equilibrium, particularly when the manufacturer may be able to eliminate all of the retailer's profit from double marginalization if the retailer complies. In fact, the choice to deviate allows the retailer a profit from its necessary compliance to implement the equilibrium. For instance, if the retailer could deviate from understocking to prevent its profit from being fully extracted by the manufacturer, the subsequent binding deviation constraint leaves the retailer with a profit from double marginalization at overstocking that the retailer would otherwise choose. By the same token, when the manufacturer intends to implement the equilibrium involving overstocking, the retailer may choose the profit either from double marginalization if it does not deviate, or from the possibility of deviating to understocking, where the manufacturer pays a single recovery price with no stockout recovery effort.[7]

A binding deviation constraint leads to a positive retailer profit, highlighting the manufacturer's dependency on the retailer's compliance to the inventory equilibrium. The existence of double marginalization and the dependency on retailer compliance leads to channel inefficiencies. The following lemma demonstrates the conditions under which the optimal solution involving either understocking or overstocking is obtained.

First, we rewrite the retailer's and the channel's profit functions in a generic form as

$$E\pi = (p-K_1)q - (p-K_4)E(q-(x-p))^+ + [pK_2+K_3]E(x-p-q)^+ - c(e), \qquad (7)$$

where K_i $(i=1,2,\ldots,4)$ can be considered as given parameters unrelated to the decision variables p and q. For instance, K_4 can be the return price for the unsold item at the retail level. Also, applying this to (2) leads to $K_1=w$, $K_2=\theta<1$, $K_3=-l_R(1-\theta)-\delta\theta$, and $K_4=0$.

Lemma 1. *When $K_2<1$ and $K_1\geq K_4$, the optimal solution is* (a) *an understocking equilibrium where $p^*=[K_1+\underline{\alpha}+K_2(\bar{\alpha}-\alpha)\gamma]/2$, and $q^*=[\underline{\alpha}-K_1-K_2(\bar{\alpha}-\underline{\alpha})\gamma]/2$; or* (b) *an overstocking equilibrium where $p^*=[K_1+\underline{\alpha}+(\bar{\alpha}-\underline{\alpha})\gamma]/2$, and $q^*=[\bar{\alpha}-K_1+(\bar{\alpha}-\underline{\alpha})(1-\gamma)]/2$.*

[7] A steep recovery price higher than the regular wholesale price can be offered at overstocking. This price may lower the retailer's incentive to deviate to understocking, but would not alter the qualitative results of our model.

This lemma provides the basis for our focal manufacturer decisions in stockout recovery and prevention mechanisms. Next, we apply Lemma 1 to examine the optimal decisions in an integrated channel as our baseline case. In an integrated channel, retail price and order quantity decisions, along with stockout recovery effort, are made jointly and no pricing mechanism is necessary. Specifically, the decisions are made to maximize channel profit

$$E\pi_M(\theta) = (p-v)q - pE(q-(x-p))^+ + [(p-v)\theta - (l_M+l_R)(1-\theta)]E(x-p-q)^+ - c(e).$$

Based on Lemma 1, there are two types of feasible but mutually exclusive optimal outcomes: overstocking $(q=\bar{\alpha}-p)$ and understocking $(q=\underline{\alpha}-p)$. At understocking, the expected profit is $E\pi_{Mu}(e) = [\underline{\alpha}+\theta_e(\bar{\alpha}-\underline{\alpha})\gamma-v]^2/4-(l_M+l_R)(1-\theta_e)(\bar{\alpha}-\underline{\alpha})\gamma - c(e)$, where the expected amount of shortage is $E(x-p-q)^+=(\bar{\alpha}-\underline{\alpha})\gamma$. At overstocking, the expected profit is $E\pi_{Mo}=[\underline{\alpha}+(\bar{\alpha}-\underline{\alpha})\gamma-v]^2/4-v(\bar{\alpha}-\underline{\alpha})\cdot(1-\gamma)$, where the expected amount of overstock is $E(q-(x-p))^+=(\bar{\alpha}-\underline{\alpha})(1-\gamma)$.

A comparison of the optimal channel profits $E\pi_{Mu}$ and $E\pi_{Mo}$ indicates that, in the integrated channel, stockout recovery leads to a higher channel profit at understocking than at overstocking when the long-term customer value of the channel is not too high (i.e., $l_M+l_R<\bar{l}^I$), where $\bar{l}^I = v(1-\theta_1\gamma)/[(1-\theta_1)\gamma] - c/[(1-\theta_1)(\bar{\alpha}-\underline{\alpha})\gamma]-[2(v+\underline{\alpha})+(1+\theta_1)(\bar{\alpha}-\underline{\alpha})\gamma)]/4$ is the maximum long-term customer value in the integrated channel at understocking. Furthermore, for stockout recovery to be *efficiently* implemented, compared with "without stockout recovery," the direct benefit should also outweigh the direct cost in the integrated channel, which is equivalent to $l_M+l_R>\underline{l}$, or that the long-term customer value is higher than a minimum benchmark $\underline{l}$, where $\underline{l}=v+c/[(\theta_1-\theta_0)\cdot(\bar{\alpha}-\alpha)\gamma]-[2(\underline{\alpha}+v)+(\theta_1+\theta_0)(\bar{\alpha}-\underline{\alpha})\gamma]/4$ $(<\bar{l}^I)$. Therefore, the combination of the two conditions, $\underline{l}<l_M+l_R<\bar{l}^I$, serves as an efficiency benchmark for stockout recovery—a condition under which stockout recovery is optimally implemented to achieve the maximum channel profit at understocking. Extending this notion to the analysis of the decentralized channel, stockout recovery solutions satisfying (not satisfying) this condition are referred to as "*channel efficient*" ("*channel inefficient*") solutions. We discuss our results assuming that this condition is satisfied so that stockout recovery is a valid choice by the channel.

A contrast of the stockout recovery pricing mechanism and traditional nonlinear pricing mechanism is warranted here as the latter is commonly studied in channel. Recovery pricing is different from a standard nonlinear pricing mechanism because: first, δ is not based on actual sales but on a value from customer loyalty; and second, w and δ do not cover all of the demand—δ is not always engaged, and when it is, there is usually a part of the demand that is not satisfied given w. The timing of the two price components (w, δ) is different despite the structure resembling a volume-based nonlinear pricing scheme such as two-part tariff.[8] However, the role of the recovery price is critical in inducing the retailer's recovery effort and cannot be replaced by a nonlinear pricing scheme, such as volume discount, because the volume discount is based on order quantity and does not capture the recovered sales. One key reason is the large slack in the purchase timing commitment permitted by volume discount contract, leading to various opportunistic retailer behaviors that defeat the manufacturer's intention (such as motivating high recovery effort). The interactions between retail price, order quantity, and recovery effort make the final sales-based volume discount very difficult, if not entirely impossible, to implement.

A two-part tariff without the IC constraint can be shown to lead to pricing and order decisions significantly different from stockout recovery.[9] In particular, at the equilibrium involving overstocking, the order quantity under two-part tariff is higher than stockout recovery. However, at the equilibrium involving understocking, this is not necessarily true, especially when the retailer's long-term customer value l_R is sufficiently high.

2.2. Stockout Prevention Mechanisms

Despite the potential benefit of stockout recovery in increasing channel profit, it is often overshadowed in practice and research by stockout prevention. An important question, therefore, is whether stockout recovery can outperform stockout prevention from the perspectives of manufacturer's profit and channel profitability, respectively.

2.2.1. Return Policy. We first consider return policy, a common stockout prevention method involving a return price for unsold products (Pasternack 1985). Return policy is known to allow channel members to share risks of holding inventory, thereby encouraging channel members to keep high inventory levels to prevent stockouts. We compare the optimal outcomes from models with stockout recovery and return policy to gain insight into the two contrasting approaches of stockout reduction. It is further extended to include VMI that may also be used as a stockout prevention.

When return policy with a nonnegative return price $r \geq 0$ is adopted, the retailer's risk from overstocking is mitigated. The retailer is therefore more willing to increase order quantity, leading to a lower level of stockouts. For the sake of consistency, we assume that a portion of the stockouts, $\theta_0 = \bar{\theta}P_0 + \theta(1-P_0)$, is retained without retailer's effort, and that the retailer is compensated by the same fixed amount, $\delta_0 = w$, for the retained sales as wholesale price without incentive contract for stockout recovery.[10] The manufacturer and retailer profit functions are

$$\begin{aligned} E\pi_M &= (w-v)q + [(\delta_0 - v)\theta_0 - l_M(1-\theta_0)]E(x-p-q)^+ \\ &\quad - rE(q-(x-p))^+, \\ E\pi_R &= (p-w)q - (p-r)E(q-(x-p))^+ \\ &\quad + [(p-\delta_0)\theta_0 - l_R(1-\theta_0)]E(x-p-q)^+. \end{aligned}$$

Solving the manufacturer's problem of maximizing $E\pi_M$ subject to the retailer's independent optimal retail pricing and order quantity decisions $(p, q)^* = \arg\max_{p,q} E\pi_R$ leads to two types of feasible equilibria involving either understocking or overstocking. Again, we need to evaluate the effect of double marginalization in relation to retailer compliance based on the deviation constraint. The deviation constraint assures that the retailer must comply with the equilibrium that the manufacturer intends to implement, because the retailer's profit $E\pi_R$ in this equilibrium is at least as high as that from its best possible deviation $E\pi_R^d$. As such, a return policy can be shown to lead to a higher manufacturer profit (than without a return policy), though not necessarily a higher retailer profit. Thus whether it offers any higher channel profit is not clear a priori.

2.2.2. Vendor Managed Inventory. An important development in channel inventory management involves ownership of products under VMI or consignment inventory, which allows the manufacturer to maintain product ownership before the product is sold to consumers. In the entire distribution process, the retailer never owns the product, and the manufacturer controls order and fulfillment decisions. This program is relevant to managing stockouts because the manufacturer has a lower cost of overstocking in the form of production cost (v) than the overstocking cost incurred to the retailer in the form of wholesale price $(w > v)$. As a result, VMI may potentially serve as a stockout prevention program when the

[8] We thank the associate editor and an anonymous reviewer for the suggestion of pointing out the pricing similarity between the stockout recovery contract and a nonlinear contract such as two-part tariff or volume discount.

[9] Technical details are available from the authors on request.

[10] This is similar to the case of overstocking with stockout recovery. In both mechanisms, a steep recovery price offered at overstocking, which is higher than the regular wholesale price, would lower the retailer's incentive to deviate to understocking, but would not alter the qualitative results of our model. Detailed proofs are available from the authors on request.

Table 2 Summary of Results—Stockout Reduction Contracts and Channel Profit

Contracts	Equilibrium: Understocking (U)	Equilibrium: Overstocking (O)
Stockout recovery	U is the equilibrium in both the integrated and the decentralized channel, if (a) $\underline{l} < l_M + l_R < \bar{l}^I$; and is the equilibrium in the decentralized channel (but not in the integrated channel) if (b) $\bar{l}^I < l_M + l_R < \bar{l}$ and $l_R < l_{Ro}$. Channel profit is improved over no stockout recovery if (a) and (b) are satisfied, and may hold even if (a) or (b) is not true.	O is the equilibrium in the integrated channel if (a) is not satisfied, and is the equilibrium in the decentralized channel if (a) and (b) are not satisfied. Channel profit is higher than no stockout recovery.
Return policy	U is the equilibrium in the decentralized channel if $l_R < l_{Ru}$ and $l_M < \underline{l}_M$. Channel profit under stockout recovery is higher than that under return policy given (a), and may still be so if (b) and $l_R < l_{Ro}$ is satisfied.	O is the equilibrium in both the integrated and the decentralized channel, if $l_M > \underline{l}_M$; but is the equilibrium in the decentralized channel only (not in the integrated channel), if (c) $l_R < l_{Ru}$ and $l_M > \underline{l}_M$; or (d) $l_R \geq l_{Ru}$. Channel profit under stockout recovery is higher than return policy if $l_R < l_{Ru}$ is true.
VMI	The results are intractable.	O in VMI leads to both higher order quantity and higher channel profit than O in stockout recovery or return policy, if $l_R > l_R^V$. Stockout recovery may lead to higher channel profit than VMI otherwise.

Note. $\underline{l}_M = \{4(1-\gamma)v - 2(\underline{\alpha} - v)\gamma(1-\theta_0) - (\bar{\alpha} - \underline{\alpha})\gamma^2(1-\theta_0^2)\}/[4(1-\theta_0)\gamma] - l_R$.

manufacturer places a larger order for the retailer (Yao et al. 2010).

Reflecting such changes, two major components of the previous model need to be modified. First, the order decision, q, is no longer made by the retailer but by the manufacturer who owns the product. Second, consequently, the retailer no longer incurs costs associated with overstocking—it can just return any unsold products to the manufacturer. These new components eliminate the relevance of return policy. More importantly, unlike return policy, which transfers inventory risks from the retailer to the manufacturer without reducing the channel's exposure to such risks, VMI consolidates overstocking risks to the manufacturer along with product ownership and order decisions. By doing so, VMI creates a new incentive for the retailer to deviate to overstocking, making understocking more difficult to implement. The manufacturer's and retailer's profits for given recovery price $\delta = w$ and $e = 0$ are, respectively, given by

$$E\pi_M = (w-v)q + [(w-v)\theta_0 - l_M(1-\theta_0)]E(x-p-q)^+ - wE(q-(x-p))^+, \quad \text{and}$$

$$E\pi_R = (p-w)[q - E(q-(x-p))^+] + [(p+l_R)\theta_0 - l_R - w\theta_0]E(x-p-q)^+.$$

With VMI, the manufacturer solves the following problem:

$$\max_{w,q} E\pi_M, \quad \text{subject to} \quad \begin{cases} p^* = \arg\max_p E\pi_R; \\ \max_p E\pi_R \geq 0. \end{cases}$$

3. Results and Analysis

3.1. Stockout Recovery vs. Return Policy

3.1.1. The Manufacturer's Perspective. As shown above, both stockout recovery and return policy can be used as alternatives to reduce stockouts. Although stockout recovery is engaged exclusively when the equilibrium involves understocking, the effect of stockout recovery may extend to overstocking. This is because by preventing some sales from being lost because of stockout, stockout recovery may discourage overstocking with high inventory costs. Similarly, the effect of return policy also extends to understocking even though return price is only engaged at the equilibrium involving overstocking. It is therefore important to understand when stockout recovery outperforms return policy, or vice versa, at the equilibrium involving understocking or overstocking. Please see Table 2 for the summary of results for stockout reduction contracts and channel profits.

Proposition 1. (a) *In the equilibrium involving understocking, stockout recovery leads to a higher manufacturer profit than return policy does; and it may do so even when stockout recovery is not channel efficient, i.e.,* $l_M + l_R < \underline{l}$. (b) *In the equilibrium involving overstocking, return policy leads to a higher manufacturer profit than stockout recovery does.* (c) *For* $l_M + l_R < \bar{l}^I$, *stockout recovery leads to a higher manufacturer profit than return policy does regardless of inventory equilibria.*

This result highlights the distinctive yet interactive roles of stockout recovery and return policy, as a stockout prevention method. Stockout recovery dominates return policy when the equilibrium involves understocking from the manufacturer's point of view. The reason behind this alignment (i.e., understocking with stock recovery versus understocking with return policy) is as follows: in the equilibrium involving understocking, the manufacturer can use the high-low stockout recovery prices to reduce the retailer profit achievable from double marginalization to that achievable from deviating to overstocking. By contrast, the manufacturer is subject to a nonbinding deviation constraint under return policy with only a single flat recovery price that is limited in its ability to minimize the retailer's profit through double marginalization. In this circumstance, the equilibrium involving understocking with stockout recovery allows the retailer to earn a lower profit, leaving the manufacturer a higher profit. For return policy, the return price is never engaged in understocking even when it is available, and thus does not help reduce the retailer's profit. The key advantage of stockout recovery is therefore the high effort extracted under stockout recovery, versus the low effort under return policy.

What is more interesting, however, is the possibility that stockout recovery may outperform return policy to generate a higher profit for the manufacturer, even if stockout recovery is not channel efficient—stockout recovery creates more costs than benefits to the channel as a whole. This may seem counterintuitive, given that an inefficient mechanism of stockout recovery in the integrated channel only becomes more inefficient in a decentralized one. However, this happens because the equilibrium is more likely involving understocking with stockout recovery in a decentralized channel than it is in the integrated channel. The ability of stockout recovery to extract the retailer's profit to a level allowed by deviation constraint, and the inability of return policy in the same circumstance, contribute to such performance disparity.

At overstocking, the performance disparity is reversed. Return policy outperforms stockout recovery when the equilibrium involves overstocking because, with return policy engaged, the manufacturer is able to determine a return price to increase retailer's purchase quantity, reduce stockouts, and maximize profit. The manufacturer is subject to the deviation constraint with low effort at understocking with either stockout recovery or return policy. This eliminates the benefit of stockout recovery from inducing high effort in stockout reduction. Both policies therefore offer a similar retailer profit at deviation (to understocking) but differ in their ability to reduce the retailer's profit from double marginalization. On the other hand, with return policy engaged when the equilibrium involves overstocking, the manufacturer could benefit from shared inventory risks and subsequent lower stockouts. A special case is when the retailer's long-term customer value is large, resulting in an "ineffective" return price ($r = 0$), the same retailer profit achievable from double marginalization (higher than that from deviating to understocking), and thus the same profit the manufacturer yields with stockout recovery. Return price is not needed as it would require the manufacturer to take an unnecessary amount of inventory risk with an understocking alternative unfavorable to the retailer. However, when the retailer's long-term customer value is small, an effective return price ($0 < r < w$) would allow the manufacturer to engage the retailer at overstocking without the retailer deviating to the now attractive option of understocking. When stockout recovery is implemented, without the option of return price as an additional pricing instrument to coordinate the channel, the manufacturer would be forced to use a lower wholesale price to keep the retailer at overstocking inventory position, thus earning less profit. For both stockout recovery and return policy, a recovery price that is marginally higher than the wholesale price under overstocking does not change the qualitative results in our model. If a steep recovery price is allowed instead, the return price is bounded at $r = 0$, i.e., the manufacturer's and retailer's profits are the same for both stockout recovery and return policy.[11]

Interestingly, when the long-term customer value in the integrated channel is not too high, the manufacturer's profit under stockout recovery is greater than under return policy regardless of whether the inventory equilibrium involves understocking or overstocking. This is because, based on Proposition 1(b), for return policy to yield a higher manufacturer profit than stockout recovery, the inventory equilibrium has to be overstocking. However, when the retailer's long-term customer value is large, overstocking leads to the same inventory level and manufacturer profit for return policy as it does for stockout recovery where return price is not engaged ($r = 0$). In this case, stockout recovery facilitates an equilibrium involving understocking and dominates return policy. When the retailer's long-term customer value is small, the manufacturer allows a higher retailer profit under return policy in the form of return price ($r > 0$), but gains

[11] Retailer deviation from overstocking to understocking without recovery effort is considered because there is no recovery contract offered at overstocking. Retailer deviation from overstocking to understocking with recovery effort is not necessary because the manufacturer implements overstocking with a single steep recovery price. The effects of allowing a steep recovery price at overstocking are investigated in the online appendix. We thank an anonymous reviewer for this point.

from the retailer through recovery prices under stockout recovery. This indicates an advantage of stockout recovery over return policy within an appropriate range of the channel's long-term customer value.

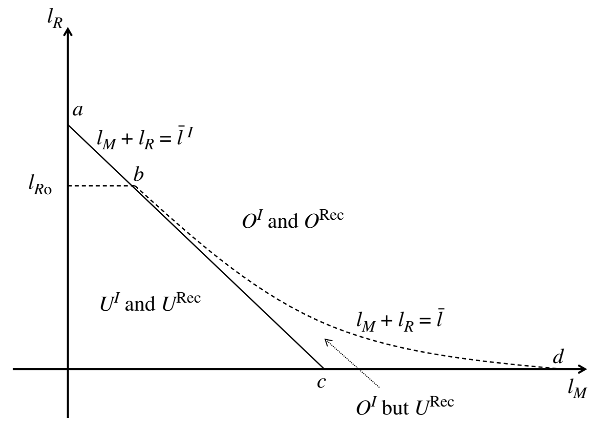
Despite the similar roles of stockout recovery and return policy in reducing stockouts and improving manufacturer's profit, whether they improve channel profit and how they fare against each other are open questions. We address them in the next several subsections.

3.1.2. The Channel Perspective. The existence of double marginalization in the channel is often a main source of efficiency loss with a wholesale price contract. The stockout recovery mechanism offers an opportunity to contain the adverse impact of double marginalization and to reduce channel inefficiencies, by involving the recovered stockout price, δ. However, such a contract $\{w, \bar{\delta}, \underline{\delta}\}$ is still limited, since the recovered stockout price is only applicable to recovered sales at understocking. In addition, the retailer deviation constraint introduces channel inefficiency because of the dependency of the manufacturer's inventory decisions on the retailer's compliance.

Interestingly, when the retailer's long-term customer value is sufficiently *small* ($l_R < l_{Ro}$),[12, 13] the equilibrium more likely involves understocking than in the integrated channel. This is because at overstocking, deviating to understocking becomes more profitable for the retailer, with a smaller l_R. The manufacturer has to take this into account when choosing overstocking, and as a result, it has to compensate the retailer more for staying at overstocking. By contrast, at understocking, the manufacturer could benefit from a smaller l_R by charging higher recovery prices to the retailer, leading to the same retailer profit as if the retailer deviates to overstocking.

Figure 1 illustrates the differing equilibria with stockout recovery in the integrated channel and the decentralized channel. In particular, when $l_M + l_R < \bar{l}^I$, the equilibrium involves understocking in both the integrated channel and the decentralized channel (labeled as U^I and U^{Rec}, respectively). When $l_M + l_R > \bar{l}^I$, the optimal solution in the integrated channel involves overstocking as the case with "channel inefficiency" (labeled as O^I). However, as long as $l_R < l_{Ro}$ and $l_M + l_R < \bar{l}$ as in the semitriangular area

Figure 1 **Equilibria with Stockout Recovery in the Integrated and Decentralized Channels**



Notes. Letters U and O represent equilibrium involving understocking and overstocking, respectively. Superscript "I" and "Rec" represent stockout recovery in the integrated channel and decentralized channel, respectively.

"b-d-c," the equilibrium in the decentralized channel involves understocking (labeled as U^{Rec}).[14] The following lemma shows how implementing stockout recovery may increase the profit of a decentralized channel.

Lemma 2. *When implementing stockout recovery in a decentralized channel leads to the equilibrium involving understocking, it can increase the channel profit when the equilibrium without stockout recovery involves either understocking or overstocking, even if stockout recovery does not improve channel efficiency with a sufficiently large retailer's customer value (i.e., $l_M + l_R < \underline{l}$ and $l_R > l_{Ro}$).*

Stockout recovery may increase channel profit only when the equilibrium involves understocking with stockout recovery, since stockout recovery alleviates double marginalization by adding recovered sales and reducing stockout risks. However, the equilibrium may still involve overstocking even with the addition of stockout recovery because when the channel's long-term customer value is sufficiently high, such that $l_M + l_R > \bar{l}$, it is more profitable for the manufacturer to avoid stockouts completely than to engage in stockout recovery.

The intuition of this result comes from three cases of changes in equilibrium outcome when stockout recovery is implemented. First, when the equilibrium involves only overstocking with or without stockout recovery, the channel profit remains the same after stockout recovery is implemented. This is because recovery price is not applicable and the retailer is not

[12] $l_{Ro} = \{\underline{\alpha}[2 + \theta_0\gamma - 3\gamma] + v(2 - \theta_0\gamma - \gamma) + (\bar{\alpha} - \underline{\alpha})[(2 - \gamma)(2 - \gamma(1+\theta_0)) - \gamma^2(1-\theta_0^2)]\}/[4\gamma(1-\theta_0)]$.

[13] A small retailer's long-term customer value might be cases where a nonexclusive retailer has other substitutable products and suffers less if there is a shortage for the product. For example, an alternative for Samsung's Galaxy Tab at Best Buy is iPad 2, and a stockout of Galaxy Tab may lead to increased sales of iPad 2, which causes little damage to Best Buy's long-term customer value. We thank an anonymous reviewer for pointing out this possibility.

[14] Parameter $\bar{l}$ is the maximum long-term customer value in the decentralized channel when the equilibrium is an understocking equilibrium for such a sufficiently low l_R that $l_R < l_{Ro}$, $\bar{l} = \bar{l}^I + (\{[2(\underline{\alpha} + 2l_R)\gamma(1-\theta_0) + (\bar{\alpha} - \underline{\alpha})\gamma^2(1-\theta_0^2)] - (2-\gamma(1+\theta_0))[\underline{\alpha} + (\bar{\alpha} - \underline{\alpha})(2-\gamma) + v]\}^2)/(8(2-\gamma(1+\theta_0))^2(1-\theta_1)(\bar{\alpha} - \underline{\alpha})\gamma)$.

better off deviating under overstocking. Second, when the equilibrium without stockout recovery involves understocking, the addition of stockout recovery may not change the equilibrium. This is also the case when stockout recovery lowers stockout risks for the manufacturer and the channel, whereas having no effect on the retailer's incentive to deviate to overstocking. The retailer also has no incentive to deviate to understocking without recovery effort, because the manufacturer offers a pair of recovery prices $\{\bar{\delta}, \underline{\delta}\}$ that are sufficiently differentiated to compensate for the retailer's effort cost. Stockout recovery adds value to the channel in two ways. First, when the recovered customer value is greater than the costs of recovery effort, stockout recovery may increase channel profit as the channel becomes more efficient. Second and more importantly, when the recovered sales and reduced stockout risks contribute to the reduction of double marginalization, stockout recovery reduces channel risks of stockout and shares the benefit between the manufacturer and the retailer by applying a recovery price as compensation for the retailer's recovery effort. This may reduce double marginalization and increase profit in the channel because the recovered sales move the demand curve upward.[15]

Third, when $l_R > l_{Ro}$, the equilibrium involves *overstocking* without stockout recovery but switches to *understocking* when stockout recovery is implemented. The shift of equilibrium from overstocking to understocking increases channel profit. There are two reasons for this; one reason is that, when the equilibrium involves overstocking and does not change with stockout recovery, the channel profit remains the same as elaborated earlier in the first scenario. The other reason is that when $l_M + l_R < \bar{l}^I$, stockout recovery implements the equilibrium involving understocking, which implies that the alternative, the equilibrium involving overstocking, leads to a lower manufacturer profit whereas the retailer profit stays the same.

In sum, the effect of stockout recovery on channel profit depends on the channel efficiency of the stockout recovery effort. Surprisingly and interestingly, channel profit increases even if channel efficiency is not improved with stockout recovery: when stockout recovery can be implemented to reduce stockout risks, retain lost sales from stockouts, and sufficiently alleviate double marginalization, the recovery effort improves channel profit even when the recovery efforts are quite costly (i.e., $l_M + l_R < \underline{l}$). In this case, the positive effect of stockout recovery in alleviating double marginalization dominates its negative effect in reducing channel efficiency.

The comparison in channel profit between stockout recovery and return policy also involves the extent of stockout risks, the extent of double marginalization, and the role of the retailer.

Proposition 2. (a) *When* $\max(\underline{l}_M, 0) < l_M < \underline{l}^I_M$ *and* $l_R < l_{Ru}$ *the equilibrium with return policy involves overstocking in the decentralized channel but involves understocking in the integrated channel*; (b) *Channel profit is higher under stockout recovery than under return policy when the equilibrium involves understocking*; *and this is true even when stockout recovery does not improve channel efficiency with a sufficiently low customer value* (*i.e.*, $\bar{l}^I < l_M + l_R < \bar{l}$ *and* $l_R < l_{Ro}$); (c) *Channel profit is higher under stockout recovery than under return policy when the equilibrium involves overstocking with a sufficiently low customer value.*

In the above proposition, $\underline{l}^I_M = v(1-\theta_0\gamma)/[(1-\theta_0)\gamma] - [2(v + \underline{\alpha}) + (1 + \theta_0)(\bar{\alpha} - \underline{\alpha})\gamma]/4 - l_R$ and $\underline{l}_M = \{4(1 - \gamma)v - 2(\underline{\alpha} - v)\gamma(1 - \theta_0) - (\bar{\alpha} - \underline{\alpha})\gamma^2(1 - \theta_0^2)\}/[4(1 - \theta_0)\gamma] - l_R(< \underline{l}^I_M)$ are the manufacturer's minimum long-term customer values in the integrated channel and the decentralized channel, respectively, above which the equilibrium with return policy involves overstocking.

Proposition 2(a) identifies conditions under which the introduction of return policy leads to overstocking, whereas understocking is more efficient for the channel. Specifically, it shows that when the equilibrium involves overstocking, the retailer has a sufficiently high profit drawn from double marginalization, and therefore the deviation constraint is nonbinding. This is the case when the retailer's long-term customer value is high because deviating to understocking with a fixed recovery rate θ_0 (and a retained sales price $\delta_0 = w$) is not a competitive alternative to overstocking for the retailer. However, the deviation constraint becomes binding with the addition of return price ($r > 0$) when the retailer's long-term customer value is low.

Similarly, when the equilibrium involves understocking, the deviation constraint is binding when l_R is high, and is nonbinding when l_R is sufficiently low. In the case of low l_R, when the manufacturer's long-term customer value is sufficiently high, the manufacturer's profit in understocking is low because of the low contribution from the recovered sales and the strong double marginalization relative to overstocking. Compared with the integrated channel, where return policy is not relevant, the optimal return policy

[15] The stockout recovery mechanism can also be considered a unique form of channel pricing mechanism with a wholesale price and a recovery price limited for only the retained sales from stockouts. When the equilibrium involves understocking, the recovery price is engaged to induce the retailer to perform a beneficial stockout recovery effort that reduces the overall stockout risks, and to reduce double marginalization, which increases channel profit. We thank the associate editor for this point.

in the decentralized channel leads to an equilibrium more likely involving overstocking.

Proposition 2(b) shows that stockout recovery dominates return policy when the equilibrium involves understocking, and stockout recovery is channel efficient since return policy is only engaged at overstocking. As indicated earlier, stockout recovery reduces channel risks in stockouts, retains lost sales, and consequently mitigates double marginalization. Return policy does not change double marginalization when the retailer is compliant with understocking, because return policy does not apply to the case when the retailer deviates to overstocking.

Interestingly, from Proposition 2(c), channel profit can be higher under stockout recovery than under return policy even when the equilibrium involves overstocking where return policy seems to have an advantage relative to stockout recovery. This is because return policy shifts the inventory risk to the manufacturer without lowering the overall channel risk, unlike stockout recovery, which reduces the risk exposure of the whole channel. When applying return policy with a return price, $r > 0$, the manufacturer increases wholesale price to balance the positive return price at the equilibrium involving overstocking. The higher wholesale price increases the possibility of the retailer deviating to understocking (especially when the retailer has a low cost of stockout, $l_R < l_{Ru}$) since it reduces the retailer's risk of deviating to understocking, and therefore limits the extent to which double marginalization can be reduced.

Under stockout recovery, by contrast, retailer deviation is less likely when the wholesale price is lower at equilibrium involving overstocking. This allows a higher retailer profit from double marginalization to match the profit if it were to deviate to understocking. The retailer, in turn, is led to charge a lower retail price, which implies alleviated double marginalization.

3.2. Stockout Recovery vs. Vendor Managed Inventory

We focus on the two equilibria (understocking $q = \underline{\alpha} - p$ and overstocking $q = \bar{\alpha} - p$) established in previous models for meaningful comparisons, and solve the problem following a similar method. The results are discussed in the following proposition.

Proposition 3. (a) *When $l_R \geq l_{Ro}$, at the equilibrium involving overstocking, VMI leads to a lower manufacturer profit than stockout recovery.* (b) *When $l_R > l_R^V$, VMI helps prevent stockouts with a greater order quantity; and at the equilibrium involving overstocking, it leads to a higher channel profit than stockout recovery.* (c) *When $l_R < l_R^V$ and at the equilibrium involving overstocking, however, stockout recovery leads to a higher channel profit than VMI.*

This proposition shows that transferring product ownership to the manufacturer under VMI may not always benefit the manufacturer. In particular, when the retailer's long-term customer value is large ($l_R \geq l_{Ro}$) and at the equilibrium involving overstocking, the direct benefit of VMI from the control of the inventory decision may be completely negated by the higher costs associated with the unsold products, which become the manufacturer's responsibility under VMI. As shown earlier, the optimal return price is $r = 0$ in overstocking under return policy, for a large retailer's long-term customer value (in stockout recovery, $r = 0$ too), but $0 < r < w$ for a sufficiently small retailer's long-term customer value. Thus when $r = w$ under VMI, the manufacturer's profit is suboptimal, as compared with stockout recovery and return policy. The reason is that although the increased control under VMI allows the manufacturer to make better decisions, the new product ownership increases the manufacturer's risks at overstocking.

Interestingly, VMI may increase order quantity placed by the manufacturer on behalf of the retailer, instead of by the retailer without VMI, which helps prevent stockouts. This is the case when the retailer's long-term customer value is sufficiently large, such that $l_R > l_R^V$, where $l_R^V = \{(2 - \gamma(1 + \theta_0))(\underline{\alpha} + v) + [2\gamma - \gamma^2(2 + \theta_0 - \theta_0^2)](\bar{\alpha} - \underline{\alpha})\}/[4\gamma(1 - \theta_0)] - \underline{\alpha}/2$ (note $l_R^V < l_{Ro}$) is the retailer's critical long-term customer value at which the equilibrium retail price under stockout recovery is the same as that under VMI. However, increasing order quantity under VMI is not without cost to the manufacturer since the manufacturer maintains product ownership for the unsold products. This is equivalent to a return policy with a return price fixed at the wholesale price level. In response to such a "return price," the manufacturer balances the increased risks and costs associated with the unsold products by decreasing the wholesale price, which leads to a lower retail price and higher demand at overstocking than stockout recovery. The retailer finds that deviating from overstocking to understocking is less profitable given the wholesale price, since the unsold units at the retailer can be returned to the manufacturer at the same price. These indicate that the double marginalization effect becomes smaller under VMI than under stockout recovery at overstocking.

Under stockout recovery, the opportunity cost for the retailer deviating from the equilibrium involving overstocking to understocking increases with retailer's customer value. Below, we use this critical value l_R^V to facilitate our discussions about how stockout recovery differs from VMI in channel profit performance. First, when $l_R > l_R^V$, a high opportunity cost reduces incentives for the retailer to deviate to understocking, and therefore, allows a higher wholesale price and retail price than VMI, while maintaining the manufacturer's intended equilibrium involving overstocking. Because the channel profit is concave in retail prices under both stockout recovery and VMI that are both higher than the equilibrium retail price in the integrated channel, whichever policy with a higher retail price would lead to a lower channel profit. As a result, the retail price is higher and order quantity is lower with stockout recovery, suggesting that the channel profit is lower than that under VMI at the equilibrium involving overstocking.

When the retailer's customer value is small (i.e., $l_R < l_R^V$), a lower wholesale price with stockout recovery than that under VMI keeps the retailer from deviating from overstocking, leading to a smaller retail price and a higher order quantity. In this case, VMI, as a stockout prevention method, leads to a lower channel profit than stockout recovery.

In sum, VMI could be implemented to prevent stockouts when the manufacturer places a larger order quantity that is made possible by a sufficiently large retailer's long-term customer value, though in this case it may lead to a lower manufacturer's profit than stockout recovery at the equilibrium involving overstocking. However, as such, VMI may lead to a higher channel profit. The intuition is that, by controlling order quantity under VMI, the manufacturer mitigates its dependency on the retailer by removing the retailer's overstock responsibility, and as a result, the retailer profit is higher, contributing to higher channel profit. However, VMI does not necessarily guarantee a higher channel profit with stockout reduction. Stockout recovery may still outperform VMI to increase channel profit when the retailer customer value is low.

Along with Proposition 2, interestingly, this result suggests that stockout recovery may lead to a higher channel profit than both stockout prevention methods—return policy and VMI when the retailer's customer value is sufficiently low and the manufacturer's customer value is sufficiently high. Under such conditions, the manufacturer benefits more from stockout recovery since stockout prevention methods require additional inventory that is costly to the channel.

4. Concluding Remarks

Although managing service failures such as stockouts is critical in providing excellent customer service, marketing managers and researchers have emphasized preventive mechanisms, often by building expensive inventories, to avoid stockouts (Aberdeen Group 2004). In this paper, we study a failure-recovery mechanism (i.e., stockout recovery) and a failure-prevention mechanism (i.e., return policy), and compare their impacts on manufacturer's and channel's profits. We also examine whether and how a change in product ownership in the channel (i.e., under VMI) may prevent stockouts. Under stockout recovery, the retailer directly interacts with customers and performs the tasks of stockout recovery, and the manufacturer offers contracts to induce retailer effort. This idea of service failure recovery focuses on a different type of moral hazard in the presence of demand uncertainty.

We find that stockout recovery can increase both manufacturer's and channel's profit. When stockout recovery leads to the equilibrium involving understocking, which is the more likely equilibrium than that without stockout recovery, channel profit can be increased regardless of the equilibrium without stockout recovery. Interestingly, even when the direct benefit from the recovery sales and customer value is smaller than the direct cost of conducting recovery tasks, implementing stockout recovery can still increase channel profit by alleviating double marginalization. When compared with return policy, stockout recovery may perform better in terms of channel profit when the equilibrium involves either understocking or overstocking. Furthermore, when product ownership is transferred to the manufacturer under VMI, order quantity can be increased to prevent stockouts. However, we find that this channel governance approach may lead to a lower channel profit compared with stockout recovery. Thus, stockout recovery can be more profitable for the channel than common methods of stockout prevention.

This research has limitations in several aspects. The model is based on a dyad channel of manufacturer and retailer, which can be extended to include competition in either upstream or downstream or both (Bandyopadhyay and Paul 2010). Adding competition may improve our understanding of the strategic effect of service failure prevention and recovery. In addition, the manufacturer has all of the bargaining power to decide on the contract for the retailer to choose. It would be interesting to study whether the results may be different when the retailer has more bargaining power to design the contract (Iyer and Villas-Boas 2003) or the retailer is responsible for both acquiring new and retaining old customers (Dong et al. 2011). Finally, the dynamic aspect of service failure recovery is not directly captured and should be a natural avenue for future research. Notwithstanding these limitations, we hope that this research will inspire more studies in pursuing the interesting and understudied line of research on service failure prevention and recovery in distribution channels.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/mksc.2015.0924.

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