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The Impact of the Manufacturer-Hired Sales Agent on a Supply Chain with Information Asymmetry

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This paper studies the impact of a manufacturer-hired sales agent on a supply chain comprising a manufacturer and a retailer. The sales agent is working mainly at the retailer's location to boost demand. We focus on a wholesale price contract, under which the retailer decides how much to order from the manufacturer. The information structure within the supply chain and the efficiency of the sales agent affect the supply chain members' expected profits. We show that, because of the agency issue between the sales agent and the manufacturer, when the retailer's demand forecast accuracy is similar to the manufacturer's and the wholesale price is fixed, the retailer's profit decreases as his demand forecast accuracy improves. We also illustrate that when the retailer's forecast accuracy is much better than the manufacturer's and the wholesale price is endogenous, his expected profit decreases as his forecast accuracy improves. Moreover, we demonstrate that having a more efficient sales agent is beneficial for the retailer when the wholesale price is fixed, whereas this is not always the case when the wholesale price depends on the efficiency of the sales agent.

Key words: game theory; incentives and contracting; supply chain management
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1. Introduction

Upstream manufacturers often sell their products to consumers through downstream retailers. Many factors influence this relationship between a manufacturer and a retailer in a supply chain. One such factor is a sales agent who functions as an independent entity that can substantially alter the dynamics within the supply chain. Sales agents are widely employed in the industry. According to Zoltners et al. (2001), nearly 12% of the total workforce in the United States is employed in full-time sales occupations. Furthermore, firms' average expenditure on a sales force typically ranges between 10% and 40% of their sales revenues (Albers and Mantrala 2008). In addition, an enhanced sales force management often can increase sales revenue by more than 10% (Zoltners et al. 2008).

There are different types of sales agents depending on who hires them within a supply chain. In this paper, we focus on sales agents hired by upstream manufacturers. U.S. Department of Labor (2012b) has estimated that wholesale and manufacturing sales representatives held about two million jobs in the United States in 2010. Specifically, in the automobile industry, sales agents are often hired by auto manufacturers to boost demand at the dealer site. For example, these sales agents are called area sales managers at Toyota. Based on the job description of these sales agents in Toyota Financial Services (2012) and U.S. Department of Labor (2012a), the manufacturer-hired sales agents increase demand by improving the sales techniques of the retailer and/or marketing. In this paper, we focus on the impact of a manufacturer-hired sales agent on the supply chain in which the primary task of the sales agent is to boost demand.

We focus on two influential factors: (i) the sales agent's efficiency and (ii) the accuracy of the available demand information at the downstream level. The first factor deals with how efficient the sales agents are in fostering demand. A more efficient sales agent can increase demand by the same amount as the less efficient agent with a smaller amount of effort. The second factor is the degree to which information about local demand is available at the downstream level (e.g., at the retailer site) and not available to the manufacturer. Our primary research question is how the expected profits of the manufacturer and the retailer depend on these two factors. For example, do the manufacturer and the retailer always benefit

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from a more efficient sales agent or more informed downstream parties?

To answer this research question, we examine a supply chain in which a manufacturer employs a wholesale price contract with a retailer for a single product and hires a sales agent to boost consumer demand. In this paper, we study both a fixed wholesale price model and an endogenous wholesale price model in which the manufacturer sets the wholesale price optimally.

We first characterize the optimal linear compensation contract for the manufacturer-hired sales agent and then demonstrate that even though more accurate demand information at the downstream level has a direct benefit to the supply chain, it can sometimes hurt the manufacturer, the retailer, or both because of strategic interaction between the manufacturer and the sales agent. Furthermore, we show that the impact of demand forecast accuracy at the downstream level on the retailer's expected profit depends critically on whether the wholesale price is fixed or set endogenously. In addition, we illustrate that the retailer benefits from a more efficient sales agent if the wholesale price is fixed. However, under an endogenous wholesale price model, the retailer may be hurt by a more efficient sales agent.

This paper proceeds as follows: In §2, we review related literature. We then present the model in §3. We analyze the model with exogenous wholesale price and endogenous wholesale price in §§4 and 5, respectively. Furthermore, we discuss extensions of our paper in §6. Finally, we provide our concluding remarks in §7.

2. Literature Review

Our paper explores the impact of a sales agent on operational decisions within a supply chain. One of the important problems related to a sales agent is how to structure the compensation scheme, which has been studied in marketing and economics literature. Coughlan (1993) provides a comprehensive review of sales force management and compensation. For the compensation of the sales agent, we consider a menu of linear contracts and focus on the impact of sales agent contracting on the firm's operational decisions, i.e., production and inventory choices, which has been underexplored in the literature of marketing and economics.

The operations literature related to sales agents has studied the impact of sales agent compensation on a firm's operational decisions, e.g., inventory planning. Chen (2000) proposes a sales agent compensation package to induce the agent to exert an effort in a way that smoothes consumer demand across time. In practice, particularly at IBM, the compensation scheme proposed by Gonik (1978) has been implemented. This scheme intends to provide incentives to the agent to truthfully reveal what it knows about demand, based on the premise that the sales agent has more accurate demand information, and to also work hard. Studying Gonik's scheme and comparing it with a menu of contracts, Chen (2005) shows that Gonik's solution can be dominated by a menu of linear contracts when the firm also determines the inventory level. Analyzing sales agent contracting when demand information is censored by the inventory level, Chu and Lai (2013) demonstrate that the optimal contract with the agent takes the form of a sales-quota-based bonus contract, and the optimal service level under this contract is always higher than the first-best level.

The new angle that we take in this paper is to understand *the impact of a manufacturer-hired sales agent on a supply chain*, whereas the previous literature has focused mostly on the impact to a single member of a supply chain (either a manufacturer or a retailer). One exception is Chen and Xiao (2012), who study the impact of the retailer's forecasting accuracy on both the manufacturer and the retailer in the presence of a sales agent. They focus on a *retailer-hired* sales agent without inventory consideration, whereas we analyze a *manufacturer-hired* sales agent with consideration of the retailer's inventory decision.

Among the few works that study the impact of a manufacturer-hired sales agent on the supply chain, Hopp et al. (2010) is the most relevant paper to this study. They consider a supply chain with a manufacturer-hired sales agent in a setting in which demand is *deterministic*. We also study the impact of a manufacturer-hired sales agent, which corresponds to their wholesale salesperson, but under *stochastic* demand. Considering the demand uncertainties and information asymmetry, we can then answer our research question, which cannot be answered using the prior model in Hopp et al. (2010). Thus, we specifically develop a model to investigate how the impact of the sales agent depends on the forecast accuracy of uncertain demand.

3. The Model

We consider a supply chain in which a manufacturer (she) employs a wholesale price contract with a retailer (he), and she hires a sales agent (it) to boost demand. In §4, we study the fixed wholesale price case (e.g., because of a prior long-term contract between the manufacturer and the retailer, or because of competition among potential manufacturers). In §5, we extend the model to allow the manufacturer to set the wholesale price optimally. We restrict attention to a wholesale price contract between the manufacturer and the retailer, which is common and the simplest contract form employed between firms.

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3.1. Demand and Information Structure

Consumer demand is random and depends on the market condition Θ and the effort e of the sales agent. Specifically, consumer demand D is given as $D = \Theta + e$, where market condition Θ is normally distributed with mean θ and variance σ^2 (or, accuracy $h \equiv 1/\sigma^2$), i.e., $\Theta \sim N(\theta, \sigma^2)$. Furthermore, the sales effort e can be interpreted as the amount of work that a sales agent needs to exert to increase demand by e units.

At the retail site, information about regional demand is available because of direct contact with consumers and the potential availability of past sales data (see, e.g., Lee et al. 2000). Because this information is often not available upstream, the retailer and the sales agent, who works closely with the retailer to boost demand at the retail site, have an informational advantage about regional demand compared with the manufacturer. For example, according to the job description of the sales agent at Toyota, sales agents spend 75% of their work hours at the dealer site (Toyota Financial Services 2012). Consequently, the retailer's demand forecast is likely to be shared with the sales agent. To model this informational advantage, we assume that the sales agent and the retailer observe a private signal of demand, Ψ, that the manufacturer cannot obtain. Specifically, the retailer and the sales agent observe a noisy signal that is normally distributed with a mean equal to the market condition, i.e., $\Psi \mid (\Theta = \hat{\theta}) \sim N(\hat{\theta}, \tilde{\sigma}^2)$. We define *the accuracy of this signal for the downstream parties* as $\tilde{h} \equiv 1/\tilde{\sigma}^2$.[1] Lastly, all parameter values and the information structure are common knowledge, and ψ is the only private information in our model.

3.2. The Sales Agent's Cost and Payoff

We assume an increasing and convex cost function for the sales agent's effort, reflecting the increasing marginal cost of effort. Specifically, the cost of the effort is $C(e) = (1/2k)e^2$, with $k > 0$ (see, e.g., Chen and Xiao 2012). Note that k can be interpreted as the *efficiency*, or the competency, of the sales agent. If k is higher, the sales agent can boost demand at a lower cost. Without loss of generality, we normalize the sales agent's reservation payoff to zero.

The effort of the sales agent includes improving the sales techniques of the retailer by providing him with (i) more detailed product information and (ii) marketing recommendations such as how to lay out advertising materials within the retail location (Toyota Financial Services 2012). Note that the sales agent's effort directly involves or requires the permission of the retailer. As a result, this effort becomes observable by the retailer.[2]

For the compensation scheme of the sales agent, we focus on the form of a linear commission in the observed outcome combined with a constant salary. This form of payment is (i) widely used in practice (U.S. Department of Labor 2012b) and research (see, e.g., Chen 2005) for sales agent compensation schemes, (ii) easy to implement, and (iii) an optimal contract form in a range of circumstances, as McAfee and McMillan (1987) have shown.

We consider the sales agent's compensation to be contingent on the manufacturer's demand (i.e., on the order quantity of the retailer). Note that the sales agent's effort is usually not contractible, which precludes the manufacturer from making the sales agent's compensation directly contingent on the effort.[3] Specifically, in this paper, a sales agent's compensation can be written as $P(q) = \alpha q + \beta$, where q is the retailer's order quantity, α is the commission rate, and β is the constant salary. Moreover, the manufacturer may offer a menu of linear contracts, $\{P_\psi(q) = \alpha_\psi q + \beta_\psi \colon \forall \psi\}$, which will be self-selected by the sales agent, where ψ is the realization of the noisy signal Ψ. One way to implement a menu of contracts is to employ a nonlinear compensation scheme, which has been observed in practice (see, e.g., Oyer 2000). Furthermore, the sales agent has the option not to engage in a contract.

3.3. The Retailer's and the Manufacturer's Profit Functions

We consider a single-period problem in which the manufacturer produces each unit of product at a constant unit-production cost c and sells it to the retailer at a wholesale price w. The product is sold in the consumer market at retail price p and has zero salvage value. The insights in the paper are preserved under a positive salvage value as long as it is less than the wholesale price. We assume that $p > w > c > 0$.

The retailer's profit under order quantity q and realized demand x is $\Pi_R = p\min\{x, q\} - wq = (p-w)q - p(q-x)^+$, where $y^+ \equiv \max\{y, 0\}$. Similarly, the manufacturer's profit can be written as $\Pi_M = (w-c)q - P_\psi(q)$, where $P_\psi(q)$ is the compensation to the sales agent when she observes signal ψ and the retailer orders q. We refer to the sum of the retailer's and the manufacturer's profits as the supply chain's profit.

[1] We acknowledge that our model and the results are limited to the normal distribution for signals.

[2] However, in §A.2 of the online supplement (available at http://dx.doi.org/10.1287/msom.2013.0452), we provide a formal analysis of the case in which the effort of the sales agent is not observable by the retailer. We show that, in such a case, the sales agent does not exert any effort, and hence it does not have any impact on the supply chain.

[3] This assumption is also consistent with the field study of Hopp et al. (2010).

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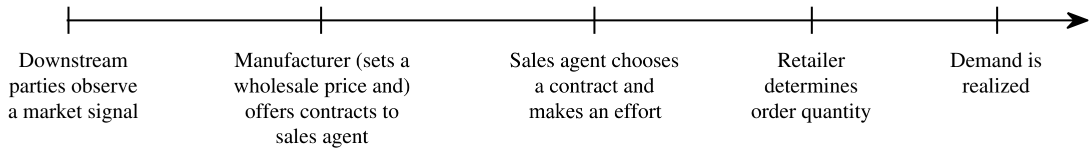
Figure 1 **Sequence of Events**



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3.4. Sequence of Events

As illustrated in Figure 1, at the beginning, the downstream parties, i.e., the retailer and the sales agent, observe a signal Ψ of the market condition and update their belief about the market condition Θ. Then, the manufacturer offers a menu of linear contracts to the sales agent (and a wholesale price contract to the retailer under endogenous wholesale pricing in §5). The sales agent subsequently chooses a contract from the menu or declines to participate. Next, the sales agent attempts to increase consumer demand. After observing the sales agent's effort, the retailer submits his order quantity to the manufacturer.[4] The manufacturer then compensates the sales agent and delivers the order quantity to the retailer, and lastly, demand is realized.

4. Exogenous Wholesale Price

In this section, we focus on the case in which it is very costly for the manufacturer to change the terms of her contract with the retailer; that is, we assume that the wholesale price is fixed at $\bar{w}$. We relax this assumption in §5 and explore the case in which the wholesale price is set by the manufacturer.

4.1. Equilibrium Analysis

We use backward induction to obtain the equilibrium. First, we analyze the retailer's problem of his optimal order quantity. Note that because the retailer and the sales agent observe a signal of the market condition, their belief about the market condition is updated according to Bayes' rule. Specifically, from the retailer's and the sales agent's perspectives, given their observed signal ψ, the market condition is $\Theta \mid (\Psi = \psi) \sim N((h\theta + \tilde{h}\psi)/(h + \tilde{h}), 1/(h + \tilde{h}))$.

The retailer observes the effort of the sales agent e. Therefore, the retailer's expected profit can be written as

$$\mathbb{E}[\Pi_R(q)] = (p - \bar{w})q - p\int_{-\infty}^{q} \Phi\left(\frac{y - e - (h\theta + \tilde{h}\psi)/(h + \tilde{h})}{1/\sqrt{h + \tilde{h}}}\right) dy,$$

where $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution. The retailer's objective function is concave in q. Thus, from the first-order condition, we obtain the retailer's optimal order quantity as $q^*(\psi, e) = q_0 + e + (h\theta + \tilde{h}\psi)/(h + \tilde{h})$, where q_0 satisfies $\Phi(q_0\sqrt{h + \tilde{h}}) = (p - \bar{w})/p$.

Next, given the retailer's optimal order quantity and the compensation scheme (α, β), we then derive the sales agent's optimal effort level e^*. The sales agent's net payoff when exerting effort e is

$$\pi_s(e, \alpha, \beta \mid \Psi = \psi) = \alpha\left(q_0 + e + \frac{h\theta + \tilde{h}\psi}{h + \tilde{h}}\right) + \beta - \frac{1}{2k}e^2. \quad (1)$$

This is a concave function of e; consequently, the sales agent's optimal effort is $e^*(\alpha) = k\alpha$.

Finally, we study the manufacturer's problem of designing an optimal menu of linear contracts to offer to the sales agent. Let $(\alpha_\psi, \beta_\psi)$ be the designated contract from the menu for the sales agent who observes $\Psi = \psi$ as a signal of the market condition. Then, we can write the manufacturer's problem as follows:

$$\max_{\alpha_\psi \geq 0,\, \beta_\psi} \mathbb{E}_\psi\left[(\bar{w} - c - \alpha_\psi)\left(q_0 + k\alpha_\psi + \frac{h\theta + \tilde{h}\psi}{h + \tilde{h}}\right) - \beta_\psi\right]$$

$$\text{s.t.}\quad \pi_s(k\alpha_\psi, \alpha_\psi, \beta_\psi \mid \Psi = \psi) \geq \pi_s(k\alpha_{\psi'}, \alpha_{\psi'}, \beta_{\psi'} \mid \Psi = \psi), \quad \forall\psi, \forall\psi', \quad \text{(IC)}$$

$$\pi_s(k\alpha_\psi, \alpha_\psi, \beta_\psi \mid \Psi = \psi) \geq 0, \quad \forall\psi. \quad \text{(IR)}$$

Constraint (IC) is the incentive-compatibility constraint to ensure that the sales agent with signal ψ chooses the designated contract; i.e., contract $(\alpha_\psi, \beta_\psi)$ is preferred over any other contract $(\alpha_{\psi'}, \beta_{\psi'})$ by the sales agent when observing signal ψ. Constraint (IR) is the individual-rationality constraint that requires the sales agent to gain at least as much as its reservation value. We now present the optimal menu of linear contracts to offer to the sales agent:

Proposition 1. *Denote $\underline{\psi}$ as the unique solution to $k(\bar{w} - c)H(\underline{\psi}) = A$, where $A \equiv \sqrt{\tilde{h}/(h(h + \tilde{h}))}$. Then, the optimal menu of linear contracts offered to the sales agent is $\{P_\psi(q) = \alpha_\psi q + \beta_\psi \colon \forall\psi\}$, where*

$$\alpha_\psi = \frac{A}{k}\left(\frac{1}{H(\underline{\psi})} - \frac{1}{H((\psi - \theta)/\sqrt{\sigma^2 + \tilde{\sigma}^2})}\right)^+ \quad \textit{and} \quad (2)$$

$$\beta_\psi = \frac{\tilde{h}}{h + \tilde{h}}\int_{-\infty}^{\psi} a_y\, \mathrm{d}y - \alpha_\psi\left(q_0 + \frac{h\theta + \tilde{h}\psi}{h + \tilde{h}} + \frac{k}{2}a_\psi\right), \quad (3)$$

[4] In §6, we discuss the case in which the sales agent makes an effort after the retailer places his order to the manufacturer.

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in which $H(\cdot) \equiv \phi(\cdot)/(1-\Phi(\cdot))$ is the hazard rate of the standard normal distribution, and $\phi(\cdot)$ is the probability density function of the standard normal distribution.

Given the market signal ψ, the corresponding order quantity of the retailer q_ψ, the effort level e_ψ, and the expected effort of the sales agent $\mathbb{E}_\psi[e_\psi]$, the expected profits of the retailer $\mathbb{E}[\Pi_R]$ and the manufacturer $\mathbb{E}[\Pi_M]$, in equilibrium, are as follows:

$$q_\psi = q_0 + \frac{h\theta + \tilde{h}\psi}{h+\tilde{h}} + k\alpha_\psi, \quad e_\psi = k\alpha_\psi, \tag{4}$$

$$\mathbb{E}[e_\psi] = k(\bar{w}-c)(1-\Phi(\underline{\psi}))(1-H(\underline{\psi})^2 + \underline{\psi}H(\underline{\psi})), \tag{5}$$

$$\mathbb{E}[\Pi_R] = (p-\bar{w})(q_0+\theta+\mathbb{E}[e_\psi]) - p\int_{-\infty}^{q_0} \Phi(\sqrt{h+\tilde{h}}y)\,\mathrm{d}y, \tag{6}$$

$$\mathbb{E}[\Pi_M] = (\bar{w}-c)(q_0+\theta) + \frac{1}{2k}\mathbb{E}[e_\psi^2]. \tag{7}$$

As shown in (2), the commission rate α_ψ of the sales agent depends on both how well it knows consumer demand, which is measured by $h+\tilde{h}$, and how much better it knows demand than the manufacturer, which is measured by $\tilde{h}/h$. The commission rate α_ψ is increasing in the absolute measure of the sales agent's information (i.e., $h+\tilde{h}$), whereas it is decreasing in the relative measure of the sales agent's information to the manufacturer (i.e., $\tilde{h}/h$). Furthermore, the more efficient the sales agent is (the larger k), the higher the sales agent's commission rate.

When there is information asymmetry between the manufacturer and the sales agent, the manufacturer does not induce the sales agent who observes a signal of a very poor market condition to exert any effort. This is because the manufacturer cannot verify whether the sales agent is truthful in selecting a contract that is designed for a poor market condition signal. It could be that the sales agent who observes a prosperous market condition signal selects a contract designed for a poor market condition signal so that it can collect a larger payoff after the retailer's order quantity is realized. Therefore, there is a threshold such that the commission rate of the sales agent is zero if it observes a market condition signal lower than that threshold. From Proposition 1, this threshold on ψ is given by $\theta + \underline{\psi}\sqrt{\sigma^2+\tilde{\sigma}^2}$.

Note that from (4), the retailer orders what he would have ordered if there had been no sales agent, $q_0 + (h\theta + \tilde{h}\psi)/(h+\tilde{h})$, plus the extra demand that the sales agent has promoted, $k\alpha_\psi$. The effort of the sales agent is proportional to the commission rate and is increasing as it becomes more efficient (larger k). In the following sections, we discuss the expected effort of the sales agent and the expected profits of the manufacturer and the retailer in detail.

4.2. Impact of Downstream Signal Accuracy on Supply Chain

In this section, we analyze how the decisions and expected profits of supply chain members depend on the accuracy of the downstream parties' signal of demand. More specifically, in the presence of a manufacturer-hired sales agent, we study how the expected profits of the manufacturer and retailer depend on the availability of market demand information at the downstream level.

4.2.1. Impact on the Effort of the Sales Agent. First, we examine how the sales agent's effort changes if the downstream parties observe a more accurate demand forecast.

Proposition 2. *The expected effort of the sales agent decreases as the accuracy of the downstream signal of demand $\tilde{h}$ improves.*

As the accuracy of downstream signal improves, the retailer relies more on the demand signal when he decides his order quantity. Specifically, from the retailer's perspective, the expected demand is written as $(h/(h+\tilde{h})\theta) + (\tilde{h}/(h+\tilde{h}))\psi$. As the accuracy $\tilde{h}$ increases, the weight $\tilde{h}/(h+\tilde{h})$ that the retailer puts on his signal ψ in calculating the expected demand increases, whereas the weight $h/(h+\tilde{h})$ that he puts on the prior expected demand θ decreases. As a result, the order quantity of the retailer is influenced more by his forecast. In other words, because the manufacturer does not know the downstream forecast, she sees greater variability in the retailer's order quantity. Given that the payment of the sales agent depends on the order quantity of the retailer, when the manufacturer decides on the menu of contracts to offer to the sales agent, it becomes more difficult for the manufacturer to determine how the sales agent values a certain contract and whether that contract satisfies the agent's reservation utility. Consequently, the manufacturer has to pay a larger information rent to incentivize the sales agent to participate. Therefore, the marginal cost of inducing the sales agent to put a certain amount of effort increases for the manufacturer; thus, in equilibrium, the manufacturer offers a contract that induces less effort.

4.2.2. Impact on the Retailer's Expected Profit. If we consider the relationship between the manufacturer and the retailer under the fixed wholesale price contract, ignoring the presence of a manufacturer-hired sales agent, a retailer should benefit from having more accurate demand information because he can better match his order quantity with demand. In this section, we show that if we take the manufacturer-hired sales agent into consideration, the retailer's expected profit can decrease as the accuracy of his

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demand forecast improves. Proposition 3 characterizes how the retailer's expected profit changes as a function of his forecast accuracy $\tilde{h}$ and provides conditions under which the retailer's expected profit decreases as more information about demand becomes available at the downstream level.

Proposition 3. *There exists a threshold $\tilde{h}_1$ such that the retailer's expected profit is decreasing in $\tilde{h}$, if and only if $\tilde{h} < \tilde{h}_1$. Furthermore, $\tilde{h}_1$ is the unique solution to*

$$\sqrt{\frac{h}{\tilde{h}_1}} \int_{v(\tilde{h}_1)}^{\infty} (1-\Phi(x))\,\mathrm{d}x = \frac{p}{p-\bar{w}} \phi\left(\Phi^{-1}\left(\frac{p-\bar{w}}{p}\right)\right),$$

and

$$v(y) = H^{-1}\left(\frac{1}{k(\bar{w}-c)} \cdot \sqrt{\frac{y}{h(h+y)}}\right).$$

If the supply chain is integrated, the supply chain surplus would be higher as more information becomes available at the downstream level. However, this proposition implies that when supply chain is disintegrated, it may not be beneficial for the retailer to know more about market demand, especially if the downstream parties do not know much more about demand than the manufacturer. This insight is particularly helpful when the wholesale price is fixed, for example, due to competition among manufacturers.

The drivers of this result are (i) the lower expected effort of a sales agent with a more accurate demand forecast and (ii) better demand predictions. The retailer's expected profit depends on both the effort of the sales agent and his ability to predict demand. When more information about demand is available at the downstream level, the sales agent's effort decreases, as shown in Proposition 2. Therefore, the retailer's expected profit can decrease because of the reduced sales agent's effort. On the other hand, a retailer with a more accurate demand forecast can better predict demand and, thus, better match his order quantity with demand; that is, the retailer's expected profit can increase if he knows more about demand. When the downstream signal of demand is less accurate and below a threshold ($\tilde{h} < \tilde{h}_1$), the first driver (lower effort of the sales agent) dominates the tradeoff; in other cases ($\tilde{h} \geq \tilde{h}_1$), the second driver (a better demand prediction) dominates.

Furthermore, the reason the first driver (the effect of sales effort) dominates the second driver (the effect of a better demand predictor) under less forecast accuracy, i.e., $\tilde{h} < \tilde{h}_1$, can be explained as follows. When $\tilde{h}$ is very small, there is very little information asymmetry between the manufacturer and the sales agent; thus, the information rent paid to the sales agent is small. By increasing $\tilde{h}$, this information rent increases considerably. Consequently, as $\tilde{h}$ increases, the manufacturer reduces the commission rate paid to the sales agent substantially to avoid paying a higher information rent. This strategy results in a significant decrease in the sales agent's effort. The ability of the retailer to predict demand, however, does not change much if $\tilde{h}$ increases in this range. Hence, when $\tilde{h}$ is small, the impact of lower effort dominates the impact of a better prediction.

Taylor and Xiao (2010) show that the retailer's expected profit can decrease as the accuracy of retailer's demand forecast improves. Their reason is that as downstream parties learn more about demand the manufacturer increases the wholesale price, which hurts the retailer. We complement this work by providing another reason why the retailer may be unwilling to invest in improving his demand forecast. In our model, although the wholesale price is fixed, the retailer's expected profit can decrease as his forecasting accuracy improves because of contracting considerations involving the sales agent's effort.

4.2.3. Impact on the Manufacturer's Expected Profit. Does the manufacturer benefit from the retailer's more accurate demand forecast? In a supply chain without a sales agent, one can show that when the wholesale price is fixed, the manufacturer's expected profit is monotone (increasing or decreasing) with the accuracy of the retailer's demand forecast. In this section, we show that in the presence of a manufacturer-hired sales agent, a threshold exists above which the manufacturer's expected profit increases with the accuracy of the downstream parties' signal of demand and below which it decreases.

Proposition 4. *The manufacturer's expected profit is quasi-convex with respect to the accuracy of the downstream parties' demand signal. Technically, there exists a threshold $\tilde{h}_2$, such that the manufacturer's expected profit decreases in $\tilde{h}$, if and only if $\tilde{h} < \tilde{h}_2$. Furthermore, for $\bar{w} > p/2$, $\tilde{h}_2 < \infty$ is the unique solution of*

$$\int_{v(\tilde{h}_2)}^{\infty} \sqrt{\frac{h}{\tilde{h}_2}} (1-\Phi(x)) \left(k(\bar{w}-c) - \sqrt{\frac{\tilde{h}_2}{h(h+\tilde{h}_2)}} \frac{1}{H(x)}\right) \mathrm{d}x$$
$$= -k(\bar{w}-c)\Phi^{-1}\left(\frac{p-\bar{w}}{p}\right),$$

and for $\bar{w} < p/2$, the manufacturer's expected profit monotonically decreases as the accuracy of the downstream signal (i.e., $\tilde{h}_2 = \infty$) improves.

When the wholesale price is small (precisely, when $\bar{w} < p/2$), the expected profit of the manufacturer decreases as the accuracy of the downstream signal improves for the following two reasons. First, the safety stock of the retailer, i.e., the quantity ordered above the expected demand, decreases. Specifically, when the retailer's demand forecast is normally distributed with mean μ and standard deviation σ, the

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order quantity of the retailer is $\mu + z \times \sigma$, where z is a fractile solution that depends on the underage and overage costs. The value of z is positive when $\bar{w} < p/2$ and does not change as the accuracy of the demand forecast improves. Therefore, as the standard deviation of the demand forecast decreases (i.e., the demand forecast improves), $z \times \sigma$ decreases; thus, the retailer orders less safety stock. Second, the manufacturer has to pay a larger information rent to the sales agent, which leads to a smaller demand-promoting effort on the part of the sales agent as the information accuracy of the downstream parties' signal improves, as discussed in §4.2.1. In summary, when the wholesale price is low, the manufacturer's expected profit decreases both because of the decrease in the retailer's safety stock and the decrease in the expected demand as a result of the decrease in the resulting effort of the sales agent.

On the other hand, when the wholesale price is high (i.e., $\bar{w} > p/2$), the retailer orders less than the expected demand (i.e., $z < 0$). Consequently, as the downstream parties learn more about the demand, (i) the retailer orders more, given the effort level, and (ii) the expected demand decreases because of the smaller induced effort level as explained previously. The former effect benefits the manufacturer, whereas the latter hurts her. When the information accuracy is large ($\tilde{h} > \tilde{h}_2$), the first driver dominates, so the manufacturer's expected profit increases as the downstream signal becomes more accurate. When the downstream signal is inaccurate ($\tilde{h} < \tilde{h}_2$), the second driver dominates the first one, and a more accurate downstream signal hurts the manufacturer.

4.3. Impact of Sales Agent Efficiency on the Supply Chain

When hiring a sales agent, most companies would seek to hire a more efficient one. As a result, one would expect that the manufacturer's expected profit to increase if a more efficient sales agent is hired. But, would the retailer also benefit from a more efficient sales agent?

Proposition 5. *The expected profits of the retailer and the manufacturer and the demand-promoting efforts of the sales agent increase with the efficiency of the sales agent*, k, *under a fixed wholesale price contract*.

As the agent becomes more efficient, it becomes easier for the sales agent to boost demand. With a specific commission contract, a more efficient sales agent consequently exerts more effort to increase her net payoff. Knowing this behavior of the sales agent, the manufacturer induces the more efficient sales agent to increase effort, while it pays the agent less for each unit of effort. Therefore, demand increases at a lower cost, and both the retailer and the manufacturer benefit. However, under an endogenous wholesale price model, the manufacturer's optimal wholesale price may differ for sales agents with different efficiencies. In §5, we study the impact of an endogenous wholesale price on the supply chain.

Remark 1. Based on Propositions 3 and 4, we find that when $\tilde{h} < \min\{\tilde{h}_1, \tilde{h}_2\}$, both the retailer and the manufacturer's expected profits decrease in $\tilde{h}$.

When the contract between the manufacturer and the retailer is fixed due to long-term contracts or competitive factors, the above remark implies that if the downstream forecast information lacks accuracy substantially, the manufacturer should not provide her retailer or sales agent with technology/training to improve the forecast because it can hurt both the manufacturer and the retailer. Rather, as Proposition 5 demonstrates, the manufacturer should focus more on hiring a cost-efficient sales agent in this case.

5. Endogenous Wholesale Price

If the manufacturer hires a more efficient sales agent, she may charge a higher wholesale price to the retailer because the sales agent may increase the retailer's demand. To incorporate this decision of the manufacturer, in this section, we allow the manufacturer to set the wholesale price optimally.

Proposition 6. *The equilibrium wholesale price w^* is the solution to the following equation*:

$$q_0(w^*) + \theta + \mathbb{E}_\psi[e_\psi(w^*)] + \frac{\partial q_0(w^*)}{\partial w}(w^* - c) = 0, \quad (8)$$

where

$$\mathbb{E}_\psi[e_\psi(w)] = k(w-c)(1-\Phi(\underline{\psi}(w))) \cdot \big(1 - H(\underline{\psi}(w))^2 + \underline{\psi}(w)H(\underline{\psi}(w))\big), \quad (9)$$

$$\underline{\psi}(w) = H^{-1}\left(\frac{A}{k(w-c)}\right), \quad \textit{and}$$

$$q_0(w) = \frac{1}{\sqrt{h+\tilde{h}}}\Phi^{-1}\left(\frac{p-w}{p}\right). \quad (10)$$

The expression $q_0(w^*) + \theta + \mathbb{E}_\psi[e_\psi(w^*)]$ in (8) is the expected order quantity of the retailer from the manufacturer's perspective, and $\partial q_0(w^*)/\partial w$ is the marginal change in the order quantity of the retailer if the wholesale price increases, which is negative. The manufacturer sets the wholesale price in such a way that the marginal expected profit gain from charging a higher wholesale price on the order quantity of the retailer, i.e., $q_0(w^*) + \theta + \mathbb{E}_\psi[e_\psi(w^*)]$, offsets the marginal expected profit loss from the decrease in the retailer's order quantity. Equation (9) shows the expected effort of the sales agent given the wholesale price w, and Equation (10) illustrates the safety stock of the retailer given the wholesale price w.

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5.1. Impact of Downstream Signal's Accuracy on the Supply Chain

When the wholesale price is fixed, we demonstrated that the retailer's expected profit is quasi-convex with respect to the accuracy of his forecast. However, in this section, we illustrate that the opposite holds if the manufacturer sets the wholesale price endogenously. We further investigate how the wholesale price, the demand-promoting effort of the sales agent, and the manufacturer's expected profit change as the downstream parties learn more about demand.

5.1.1. Impact on the Wholesale Price and Expected Effort. The effort of the sales agent and the wholesale price of the manufacturer affect the expected profits of all supply chain members. For example, a larger demand-promoting effort on the part of the sales agent may result in larger profits for the manufacturer and the retailer. To gain insights into how the accuracy of the downstream signal impacts the retailer and the manufacturer, we first investigate how these decisions (the manufacturer's wholesale price and the sales agent's effort) change as the accuracy of the downstream signal improves.

Proposition 7. (i) *There exists a threshold $\underline{T}_0$ such that if $\tilde{h} < \underline{T}_0$, the optimal wholesale price and the expected effort of the sales agent decrease as the accuracy of the downstream parties' demand forecast improves* (*i.e., as $\tilde{h}$ increases*).

(ii) *There exists another threshold $\bar{T}_0$ such that if $\tilde{h} > \bar{T}_0$, the optimal wholesale price and the expected effort of the sales agent increases as the accuracy of the downstream parties' demand forecast improves*.

Two different factors determine the optimal wholesale price as $\tilde{h}$ increases: (i) The order quantity of a retailer with a more accurate demand forecast is less sensitive to the wholesale price; therefore, the manufacturer would be willing to charge a higher wholesale price to a retailer with a more accurate demand forecast. (ii) The information rent paid to a sales agent with a more accurate forecast is substantially larger when $\tilde{h}$ is small, which creates an incentive for the manufacturer to charge a lower wholesale price for small values of $\tilde{h}$.

With respect to the second factor, the optimal contract to be offered to the sales agent depends on both the profit margin of the manufacturer and on the information rent. A manufacturer with a larger profit margin has a greater incentive to pay a higher commission rate to the sales agent. In this case, the sales agent exerts more effort; consequently, the demand increases. This incentive of the manufacturer does not directly depend on the accuracy of the downstream parties' demand forecast. However, with a higher commission rate offered to the sales agent, the manufacturer also pays a larger information rent; this information rent depends on $\tilde{h}$. When downstream parties do not know much more about demand than the manufacturer (i.e., for small $\tilde{h}$), the sales agent cannot collect large information rents. However, in this case, a small change in $\tilde{h}$ affects the information rent considerably. Hence, a decrease in the wholesale price reduces the commission rate, which in turn, substantially decreases the information rent that needs to be provided. Therefore, when $\tilde{h}$ is small, the manufacturer has a large incentive to decrease the wholesale price.

These two factors also explain why the expected effort of the sales agent decreases in $\tilde{h}$ for small values of $\tilde{h}$ and increases for large values of $\tilde{h}$. For small values of $\tilde{h}$, the substantial increase in the information rent by an increase in $\tilde{h}$ motivates the manufacturer to decrease the commission rate; consequently, the expected effort of the sales agent decreases. For large values of $\tilde{h}$, the first factor, the order quantity effect, dominates, so the wholesale price increases. As a result, the expected effort of the sales agent increases in $\tilde{h}$.

One of the interesting implications is that the sales agent's effort can increase as the accuracy of the downstream demand forecast improves; in other words, larger information asymmetry increases the agent's effort. This result seems counterintuitive based on the result of a typical principal-agent model. However, our model includes the retailer in addition to the principal (the manufacturer) and the agent (the sales agent). Furthermore, the relationship between the manufacturer and the retailer through an endogenous wholesale price also affects the dynamics between the principal and the agent to reverse the conventional result.

5.1.2. Impact on the Retailer's Expected Profit. In the fixed wholesale price model, we showed that the expected profit of the retailer is quasi-convex with respect to the accuracy of his demand signal ($\tilde{h}$). This implies that if the retailer knows only a little more than the manufacturer about demand (under small $\tilde{h}$), he should not invest in improving his forecast accuracy. The following proposition, however, demonstrates that this result dramatically changes if the wholesale price is endogenously set by the manufacturer.

Proposition 8. *Under the endogenous wholesale price model*,

(i) *there exists a threshold $\bar{T}_r$ such that if $\tilde{h} > \bar{T}_r$, the retailer's expected profit decreases as the accuracy of the downstream demand forecast $\tilde{h}$ increases;*

(ii) *there exists another threshold $\underline{T}_r$ such that if $\tilde{h} < \underline{T}_r$, the retailer's expected profit is monotone* (*increasing or decreasing*)*, as the accuracy of the downstream demand forecast $\tilde{h}$ increases.*

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Unlike the exogenous wholesale price model, for broad parameter ranges, the retailer's expected profit is quasi-concave in $\tilde{h}$. This implies that a retailer with less accurate demand information is better off compared with a retailer with more accurate demand information if he already knows much more than the manufacturer about demand (under a large $\tilde{h}$). In Proposition 8, we demonstrate this result analytically under a small $\tilde{h}$ and a large $\tilde{h}$. However, for intermediate $\tilde{h}$ regions, the retailer's expected profit remains quasi-concave in $\tilde{h}$, as suggested by our extensive numerical studies. Similar arguments also apply to the manufacturer's expected profit being quasi-convex in §5.1.3.

When the downstream demand forecast is accurate (i.e., when $\tilde{h}$ is large), the manufacturer charges a higher wholesale price, as discussed previously. This increase in the wholesale price has a significant, adverse effect on the retailer's expected profit. Hence, the retailer's expected profit decreases as the forecast accuracy improves.

When the downstream demand forecast is less accurate (i.e., under a small $\tilde{h}$), with an increase in $\tilde{h}$, the retailer can better match his order quantity with demand. Moreover, as seen in Proposition 7, the optimal wholesale price and the expected effort of the sales agent decrease in $\tilde{h}$ because of the agency issue between the manufacturer and the sales agent. The effects of the order quantity and the lower wholesale price favor the retailer, whereas the lower sales agent's effort hurts the retailer. Therefore, when $\tilde{h}$ is small, the expected profit of the retailer can either increase or decrease as the accuracy of the downstream parties' forecast improves, depending on which effect dominates. When the forecast accuracy of the retailer is similar to that of the manufacturer, the wholesale price decreases as the retailer's forecast accuracy improves because of a more severe agency issue between the sales agent and the manufacturer. This decrease in the wholesale price can in turn increase the retailer's profit. Consequently, the retailer can actually benefit from the agency issue between the manufacturer and the sales agent.

This result provides managerial implications on the impact of the retailer's forecast accuracy. The direct benefit of more accurate forecasting for the retailer is that he can better match his order quantity with demand. However, the retailer should be also aware that (i) the sales agent working with him will also have more accurate demand forecast, which implies reduced effort by the sales agent, and hence the benefit of the sales agent to the retailer is smaller, and (ii) with a more accurate demand forecast, he faces a higher wholesale price. These two intricate implications of a more accurate demand forecast having a negative impact on the retailer convey that a net loss can result.

5.1.3. Impact on the Manufacturer's Expected Profit. We showed in Proposition 4 that the manufacturer's expected profit is quasi-convex with respect to the accuracy of the downstream parties' forecast if the wholesale price is fixed. Would an endogenous wholesale price change the impact of the accuracy of the downstream parties' forecast on the manufacturer's expected profit? The following proposition answers this question:

Proposition 9. *Under the endogenous wholesale price model,*

(i) *there exists a threshold $\underline{T}_m$ such that if $\tilde{h} < \underline{T}_m$, the manufacturer's expected profit decreases as the accuracy of the downstream demand forecast improves;*

(ii) *there exists another threshold $\bar{T}_m$ such that if $\tilde{h} > \bar{T}_m$, the manufacturer's expected profit increases as the accuracy of the downstream demand forecast improves.*

From Proposition 7 and our extensive numerical study, we demonstrated that under the endogenous wholesale price model, the wholesale price and the sales agent's effort are quasi-convex with respect to the accuracy of downstream parties' demand forecast. Because the manufacturer's expected profit is increasing with respect to the wholesale price and the sales agent's effort, we must have that the manufacturer's expected profit is also quasi-convex with respect to the accuracy of the downstream demand forecast. In other words, when the forecast of the downstream parties is less accurate ($\tilde{h}$ is small), the manufacturer's expected profit decrease as the accuracy of the downstream parties' forecast improves. In addition, when the forecast of the downstream parties is more accurate ($\tilde{h}$ is large), the manufacturer's expected profit increases as the accuracy of the downstream parties' forecast improves.

This result addresses the question of how the manufacturer should perceive an improvement in the retailer's forecast, or equivalently, when the manufacturer should provide her retailers with technology/training that improve their forecast accuracy. The forecast accuracy of the retailer directly impacts the forecast accuracy of the sales agent who is assigned to him by the manufacturer. Consequently, the improvement in the forecast accuracy of the retailer can impact the manufacturer directly through the retailer as well as indirectly through the sales agent. Specifically, the improvement in the accuracy of the downstream demand forecast has the following impact on the manufacturer:

(i) If the wholesale price is high, the order quantity of the retailer increases, and if the wholesale price is low, the order quantity of the retailer decreases.

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(ii) The retailer's order quantity depends more on his forecast and, consequently, less on the wholesale price. Thus, the manufacturer can charge a higher wholesale price.

(iii) As information asymmetry between the manufacturer and the sales agent increases, it becomes more expensive for the manufacturer to encourage the sales agent to exert effort.

The last effect is exclusively relevant when the manufacturer employs sales agents who work at the retail location. For low retail margin products, i.e., for products with a profit margin for the manufacturer that is higher than the profit margin of the retailer, the first two effects suggest that the manufacturer should be willing to provide the retailer with the training and technology support to improve the retailer's forecasts. However, in doing so, the manufacturer should not ignore the indirect consequence of the third effect. Proposition 9 suggests that if the improvement in the forecast is substantial enough, then the benefits of improving the retailer's forecast outweigh the indirect negative impacts stemming from sales agent contracting.

5.2. Impact of Sales Agent Efficiency on the Supply Chain

When the sales agent is more efficient, each unit of its effort is less costly, and thus, the manufacturer can easily motivate the sales agent to exert more effort. Under the fixed wholesale price contract, we consequently demonstrated that a more efficient sales agent exerts more effort, which benefits both the manufacturer and the retailer. The following proposition demonstrates that when the manufacturer sets the wholesale price, the retailer does not necessarily benefit from a more efficient sales agent.

Proposition 10. *As the sales agent becomes more efficient, i.e., as k increases, the optimal wholesale price, the expected effort of the sales agent, and the manufacturer's expected profit increase. However, the retailer's expected profit increases only when the sales agent is less efficient than a threshold level, and then it decreases afterward.*

As the sales agent becomes more efficient, the manufacturer finds it cheaper to provide the sales agent with an incentive to boost demand than to motivate the retailer to order more by reducing the wholesale price. The manufacturer, therefore, increases the wholesale price to afford offering a higher commission rate to the sales agent.

The efficiency of the sales agent has two effects on the retailer's expected profit. The first effect is the change in the wholesale price. As discussed above, the wholesale price is higher when the sales agent is more efficient. The higher wholesale price leads to a lower retailer's expected profit. Thus, the more efficient sales agent can hurt the retailer because of this higher wholesale price. The second effect is the change in the effort of the sales agent. The more efficient sales agent exerts more effort for two reasons: (i) With the given commission rate, it costs less for the agent to exert effort; thus the more efficient the sales agent, the greater the effort it makes. (ii) Because the manufacturer sets a higher wholesale price under a more efficient sales agent, it can afford to offer a higher commission rate to the sales agent, which increases the effort of the sales agent even further. Hence, a more efficient sales agent can benefit the retailer because of its increased effort.

Considering both effects, whether the retailer prefers a more efficient sales agent or a less efficient one depends on which of the two effects, i.e., the increase in the wholesale price or the increase in the effort of the sales agent, is dominant. When the sales agent is not efficient (i.e., k is less than a threshold), the resulting effort level is small. Consequently, the manufacturer's wholesale price does not change much as a function of the efficiency of the sales agent. Hence, the first effect is negligible, and the second effect becomes dominant, which increases the retailer's expected profit. However, if the sales agent is relatively efficient (i.e., k is greater than the threshold), the wholesale price depends critically on the efficiency of the sales agent. Moreover, this change in the wholesale price impacts the retailer through all his order quantities. Therefore, the first effect dominates, and it decreases the retailer's expected profit as the sales agent becomes more efficient.

In §4.3, we confirmed that the profits of the manufacturer and the retailer increase as the sales agent becomes more efficient when the wholesale price is fixed. However, if the wholesale price depends on the efficiency of the sales agent, e.g., if the contract is short term and changes over time, the benefit that comes with an efficient sales agent is not always greater than the loss due to the higher wholesale price. Our result does *not* suggest that the retailer should choose a less efficient sales agent if he has the option to choose a sales agent *after* he contracts with the manufacturer and/or if the wholesale price is fixed via a long-term contract. The retailer should nonetheless understand the consequences of the contract depending on the efficiency of the manufacturer-hired sales agent.

6. Discussion and Extensions

We have studied the impact of a manufacturer-hired sales agent on the supply chain, focusing on (i) the accuracy of the downstream parties' demand forecast and (ii) the efficiency of the sales agent. We have considered two cases: the exogenous wholesale price

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Table 1 Summary of the Comparative Statics Results

		Expected effort	Wholesale price	Retailer's expected profit	Manufacturer's expected profit
Exogenous wholesale price	Accuracy of downstream forecast increases	↓	—	$\smile$	$\smile$↓
	Sales agent's efficiency increases	↑	—	↑	↑
Endogenous wholesale price	Accuracy of downstream forecast increases	$\smile$	$\smile$	$\frown$↓	$\smile$
	Sales agent's efficiency increases	↑	↑	$\frown$	↑

Note. The symbols $\smile$ and $\frown$ indicate that the corresponding expression is quasi-convex and quasi-concave, respectively.

model in which the wholesale price is fixed and the endogenous wholesale price model in which the manufacturer sets the wholesale price. We illustrated that the retailer's expected profit is quasi-convex (quasi-concave) with respect to the accuracy of the downstream parties' forecast under the exogenous wholesale price model (the endogenous wholesale price model). Furthermore, we demonstrated that the retailer's expected profit increases as the efficiency of the sales agent increases under the fixed wholesale price model, whereas it is quasi-concave under the endogenous wholesale price model. Table 1 summarizes our results.

Our work can be extended in several dimensions. In §6.1, we discuss a different sequence of events. We also compare the impact of a manufacturer-hired sales agent with that of a retailer-hired agent on the supply chain in §6.2. Finally, in §6.3, we study the case in which the sales agent has more accurate demand information than the retailer.

6.1. Different Sequence of Events

We assumed that the sales agent exerts its effort before the retailer places his order to the manufacturer. However, there could be other examples in which the sales agent exerts an effort after the retailer orders. To investigate how robust our results are with respect to this assumption, we analytically study the case in which the effort of the sales agent is made after the retailer determines his order quantity.

In such a setting, if the sales agent is paid based on the retailer's order quantity, it does not have any incentive to exert an effort to boost demand. The reason is that the retailer has already submitted his order before the agent exerts any effort, so the sales agent's effort incurs only the cost without any additional payoff. This finding implies that with this new sequence of events, in order to have any impact on the supply chain, the sales agent's compensation should be based on a criterion other than the retailer's order quantity. For example, consider the case in which the sales agent is paid based on the *realized consumer demand* and it exerts its effort *after* the retailer orders from the manufacturer. In this case, we find that there is no difference in equilibrium–except the fixed salary of the sales agent, which does not play a major role in our analysis–between our original sequence of events and this new sequence of events, and all our results remain valid. (See Proposition A.1 and the corresponding proof in §A.2 of the online supplement, available at http://dx.doi.org/10.1287/msom.2013.0452.)

Intuitively, the reason that the above two different timings result in the same equilibrium is due to two facts: (i) the level of information asymmetry between the manufacturer and the sales agent is the same under the two scenarios, and (ii) the manufacturer can adjust the constant salary of the sales agent (without changing the commission rate and thus incentive of the sales agent) to make any payment scheme based on demand ex ante equivalent to another payment scheme based on the retailer's order quantity. Consequently, the two scenarios result in the same outcome.

6.2. Manufacturer-Hired Sales Agent vs. Retailer-Hired Sales Agent

One question related to our paper is how and whether the impact of a sales agent on the supply chain differs if it is hired by the retailer (see, e.g., Chen and Xiao 2012) compared with the case in which it is hired by the manufacturer. For comparison, we focus on the case in which the primary task of the sales agent, regardless of who hires it, is to boost the market demand. We analytically study a problem (see §A.2 in the online supplement) similar to what we discussed previously, with the difference being that the retailer hires the sales agent and that the compensation of the retailer-hired sales agent is contingent on the retailer's sales quantity, i.e., the actual unit sold by the retailer. After solving the problem, we numerically compare the supply chain under the retailer-hired sales agent with that under the manufacturer-hired sales agent.

We observe the following: (i) the manufacturer is better off with a manufacturer-hired sales agent than with a retailer-hired agent, as illustrated in Figure 2(b); (ii) the manufacturer's expected profit is

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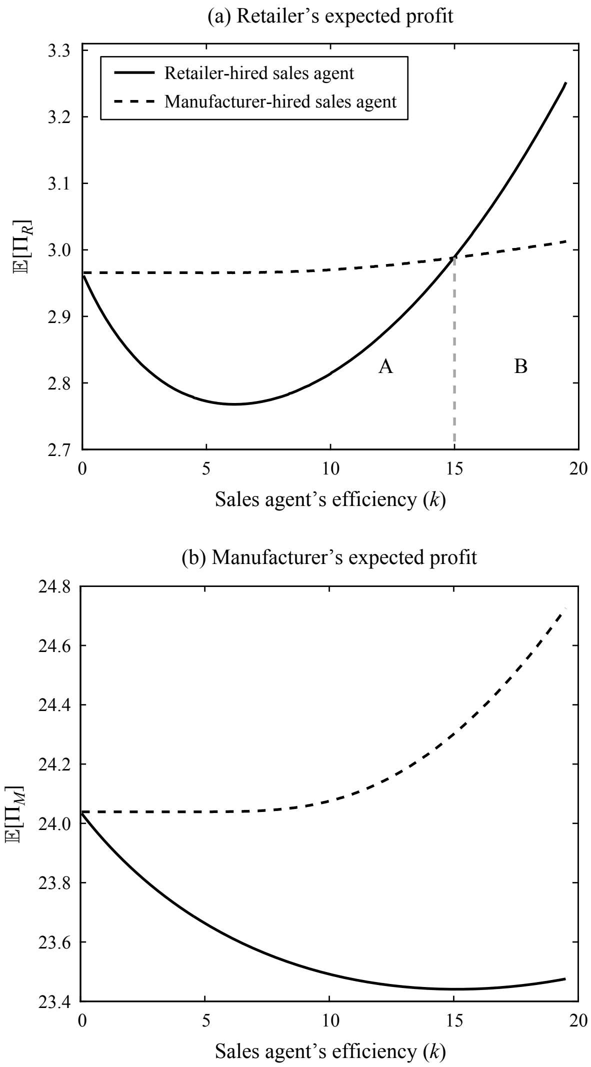
Figure 2 **Expected Profits of the Retailer (a) and the Manufacturer (b) as a Function of the Sales Agent's Efficiency (k) Under the Retailer-Hired Sales Agent and the Manufacturer-Hired Sales Agent**



Note. Parameters values are $p = 10$, $\theta = 50$, $c = 9$, $h = 0.0036$, and $\tilde{h} = 0.0063$.

quasi-convex with respect to the efficiency of the retailer-hired sales agent; and (iii) the retailer is better off under a manufacturer-hired sales agent than a retailer-hired agent when the sales agent is not efficient enough (i.e., in region A of Figure 2(a)).

Interestingly, as also illustrated in Figure 2(a), the retailer's expected profit can decrease as the retailer-hired sales agent becomes more efficient (i.e., as k increases). In this case, the optimal wholesale price set by the manufacturer is quasi-concave in k; as the retailer-hired sales agent becomes more efficient, the sale agent exerts more effort, which increases the marginal benefit of increasing the wholesale price. Consequently, the manufacturer sets a higher wholesale price as k increases. However, as k increases further, the manufacturer decreases the wholesale price to incentivize the retailer to induce more sales agent effort. When the sales agent's efficiency is low (under a small k, i.e., between 0 and 6 in Figure 2(a)), the wholesale price increases in k, which hurts the retailer. This finding interestingly implies that in such a case the retailer is better off if he does not have the option of hiring a sales agent; that is, the retailer's expected profit is higher under the manufacturer-hired sales agent than under the retailer-hired agent in this region.

6.3. Additional Information of the Sales Agent

We assume that the retailer and the sales agent share the same consumer demand information. Because of its job characteristics of gathering market demand information, the sales agent may have a more accurate demand forecast than the retailer (e.g., from the demand of the national market). Even in that case, all our results remain valid. (See §A.2 in the online supplement for the exact statement and the proof.)

To understand this result, note that any information that does not impact the sales agent's payoff cannot impact the sales agent's effort and, consequently, the equilibrium of the game. Given that the sales agent's payoff is based on the retailer's order quantity, if this extra information about demand helps the sales agent to boost the retailer's order quantity, then the equilibrium outcome may change because of this additional information. To impact the retailer's order quantity, the sales agent should credibly communicate its information with the retailer. Unless the retailer trusts the sales agent potentially because of behavioral reasons or repeated interactions, the sales agent cannot credibly communicate its information with the retailer to convince him to order more. The retailer has no reason to believe the sales agent's information about demand because he knows that the sales agent has an incentive to inflate its forecasts to induce the retailer to order more. As a result, the sales agent's additional information does not change the retailer's order quantity, and hence, the equilibrium outcome remains the same.

7. Concluding Remarks

Our paper helps to explain whether a retailer with a more accurate demand forecast is better off compared with a retailer with a less accurate demand forecast, specifically in a supply chain where sales agents are employed by the manufacturer. In this regard, we investigate the impact of improving the retailer's forecast accuracy on his expected profit. The direct benefit for the retailer with more accurate demand forecasting is that he can better match his order quantity with demand. However, more accurate demand forecasting by the retailer impacts him in other, less

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obvious ways: if more information about demand is available at the downstream level, (i) the agency issue between the manufacturer and the sales agent is more severe and thus the manufacturer would not offer a high commission rate to the sales agent, which means the sales agent's effort would be lower, and (ii) the retailer would be less sensitive to the wholesale price, so the manufacturer is more likely to charge a higher wholesale price. These two implications of improved forecasting at the retail level have a negative impact on the retailer and may result in a net loss. Consequently, we suggest that if the manufacturer wants to encourage the retailer to improve his forecast accuracy, she may want to consider committing to a long-term wholesale price contract. In this fashion, the second negative impact of improved forecast accuracy to the retailer can be mitigated.

This paper addresses the question of how a manufacturer should perceive an improvement in the retailer's forecast or, equivalently, when the manufacturer should provide her retailer with technology/ training that improve his forecast. The forecast accuracy of a retailer directly impacts the forecast accuracy of the sales agent who is assigned to him by the manufacturer. Consequently, an improvement in the forecast accuracy of the retailer impacts the manufacturer both through the retailer and through the sales agent. Specifically, an improvement in the accuracy of the retailer's forecast has the following impact on the manufacturer: (i) for low retail margin products, the order quantity of the retailer increases, and vice versa for high retail margin products; (ii) the retailer becomes less sensitive to the wholesale price, and thus the manufacturer charges a higher wholesale price; and (iii) information asymmetry between the manufacturer and the sales agent increases, and as a result, the manufacturer induces less effort from the sales agent.

This paper discusses the impact of an improvement in the efficiency of a manufacturer-hired sales agent on the retailer and the manufacturer. We confirm that the manufacturer always benefits from a more efficient sales agent. However, we show that the retailer can be hurt by the presence of such a sales agent in the supply chain. With a more efficient sales agent, the manufacturer also charges the retailer a higher wholesale price, which can lead to a net loss for the retailer. The implication of this result is that if the efficiency of the sales agent can be improved by collaborating with the retailer, commitment to a long-term contract, i.e., to a fixed wholesale price, by the manufacturer can help encourage this collaboration and lead to better outcomes for the entire supply chain.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/msom.2013.0452.

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