Optimal ordering decision and information leakage preference under asymmetric forecast signal

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Abstract
This work investigates the retailers’ sourcing decisions with or without information leakage and studies the impact of the forecasting accuracy on supply chain members’ preferences for information leakage. To derive the retailers’ optimal sourcing quantities under two scenarios, one without and one with information leakage, we formulate a supply chain in which a common manufacturer offers a wholesale price contract to two competing retailers, one of whom (the incumbent) has private forecasting information about the market demand and the other one (the entrant) does not. We find that the incumbent with information advantage may have a worse profit and lower market share than the entrant under no information leakage. We show that the incumbent has an incentive to impact the entrant’s sourcing decision by managing her own sourcing quantity reflecting private forecasting information under information leakage. Then, we compare the supply chain members’ performances under different conditions; counterintuitively, the result shows that information leakage may benefit the manufacturer when the prior probability of the booming market is low enough or the forecasting signal is not sufficiently accurate even if the incumbent’s forecasts that the market will be slack; we show that the information leakage will benefit the incumbent when the forecasting information is not sufficiently accurate and the prior probability of the booming market is high enough even if she forecasts that the market will be booming; we find that information leakage will hurt the entrant’s profit when the incumbent forecasts that the market will be slack, or when the market will be booming under the condition of the forecasting information is not sufficiently accurate and the prior probability of the booming market is high enough. Meanwhile, we find that the many-win condition will never occur in our model setting, and the preferences of all three supply chain members for information leakage will never become concert.

Keywords Supply chain management · Forecasting signal · Asymmetric information · Ordering quantity · Signaling game

1 Introduction

Within an already fast-moving economy track, the business environment has become increasingly complicated and ever-changing. With the development of information technologies, firms can observe and utilize forecasting information guiding them in operating efficiently. Thus, some large retailing firms have taken advantage of being closer to the end market than other supply chain members (Taylor and Xiao 2010; Li and Zhang 2021) and have gradually established demand information system to forecast the uncertain market (Fisher et al. 1994). For example, the fast-fashion clothing brand Zara adopted a sophisticated information system to forecast market demand to guide its stores’ sourcing decisions and warehouse inventory stocking levels (Jiang et al. 2016). Moreover, some well-funded firms have spent con-
siderable money to purchase relevant services or software from third-party companies to forecast uncertain demand. For instance, a maker of designer USB flash drives, Mimoco, cooperated with Nielsen Consumer Neuroscience to predict market demand before introducing its products to the market.1

However, the firm’s prediction is not always completely accurate, which is alien between the retailers. According to Dassault Systemes, the industry-leading software firm in planning and optimizing the world’s supply chains, more than 50% of companies doubt the accuracy of their demand prediction information, because forecast results which are based on historical data are not completely accurate.2 And the forecasting accuracy indeed has a vital influence on the firm’s sourcing decision and performance (Cederlund et al. 2007). Additionally, abilities and expertise in forecasting future market demand are different among the various competing retailers in practice, which means that the competing retailers’ forecast information is asymmetric. For instance, in the retail electronics industry, Best Buy had better forecasting ability than Circuit City, which led Circuit City to trail behind its peer retailer Best Buy (Taylor and Xiao 2010). This is mainly because the cost of developing an information forecasting system or outsourcing relevant forecasting services from third parties may be very high for the small, new, or regional businesses, e.g., investing in data mining and data analysis or software.

Under the condition of asymmetric forecasting information, direct or indirect information revelation among the competing retailers in a supply chain is universal; this has been proved by many scholars over the past decades. For instance, Anand and Goyal (2009) show that the downstream retailer’s order information which can reflect its private information is always leaked to its competitor by the upstream manufacturer. They cite an example of Newbury Comics to describe such an information leakage phenomenon among supply chain members with asymmetric information indeed existing in the real world. Kong et al. (2013) report that the downstream retailer has an incentive to share its revenue with the upstream manufacturer in order to deter the upstream manufacturer from leaking information. These authors indicate that private information revelation in a supply chain indeed exists especially when the information is asymmetric among the supply chain members, and the upstream supply chain member’s information management strategy will indeed impact the supply chain members’ sourcing decisions. But, they do not consider the influence of the forecasting accuracy.

Thereupon, it is worthwhile for us to investigate the retailers’ appropriate sourcing decisions when forecasting information is asymmetric and inaccurate under two scenarios, one without and one with information revelation. Under the condition of no information leakage, the retailer who can observe a forecasting signal of uncertain demand, i.e., the incumbent, will make her sourcing decision according to her forecasting information, while, for the retailer who cannot observe the forecasting signal, e.g., a newly established firm (the entrant), he will make his sourcing decision only according to the common information. Under the condition of information leakage, once the incumbent can signal her private forecasting information through her sourcing quantity, and the entrant can make his sourcing decision according to the incumbent’s order information, the two retailers’ sourcing decisions may be very different from the condition of no information leakage. Under no information leakage, the private information security of the incumbent is guaranteed, but she cannot impact the entrant’s sourcing decision through manage her sourcing quantity, while under information leakage, although the incumbent’s order information reflecting private forecasting information will be disclosed by the upstream manufacturer, she can adjust her own strategy to influence the other retailer’s ordering decisions. This indicates that investigating the downstream retailers’ optimal ordering decisions is worthy of the problem.

In what follows, investigating the influence of the downstream retailer’s forecasting accuracy on supply chain members’ preferences for information leakage is a valuable research issue as well. Generally, the retailer with private information does not want its information to be leaked, such that the retailer always has to contract with the upstream manufacturer or distort information to ensure that her private forecasting information remains confidential. For example, Mishra et al. (2007) illuminate that firms have adequate incentives to distort their information and disclose false information intentionally, and Kong et al. (2013) show that a revenue-sharing contract can protect the informed retailer’s information security to realize better performance when forecasting is entirely accurate. However, when the retailer’s forecasting information is inaccurate, the supply chain members’ preference for information management strategy is not clear.

Therefore, some interesting questions are worthy to explore. First, what are the optimal sourcing quantity for the two competing retailers under no order information leakage? Second, what are the optimal sourcing quantity for the two retailers under order information leakage? Third, how does the forecasting accuracy impact the supply chain members’ preference for the two information management strategy?

To describe the above-mentioned issues, we adopted a framework wherein an upstream manufacturer (it) supplies products to two competing retailers to analyze these ques-

### References

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2. [https://discover.3ds.com/scenario-based-demand-planning-key-forecasting-accuracy/](https://discover.3ds.com/scenario-based-demand-planning-key-forecasting-accuracy/)
tions. Based on this framework, to capture the asymmetric and inaccurate information between the two retailers, we assume that the incumbent (she) can observe an inaccurate forecasting signal of market size privately, while the entrant (he) cannot and only knows the prior distribution of market demand. Furthermore, we study the two competing retailers’ sourcing quantities with and without information disclosure. After solving the equilibrium solutions of the two cases, we compare the supply chain members’ preferences with and without information disclosure and find some interesting results in the terms of the impact of the forecasting accuracy to the supply chain members.

Employing a game-theoretic approach which is widely used in the related research stream, the results we found are as follows. First, under no information leakage, when the incumbent forecasts that the market will be slack, she will have a worse payoff and a lower market share than the entrant without any private forecasting information. Second, under information leakage (which means that the manufacturer disclose the incumbent’s order information reflecting private forecasting information to the entrant), the incumbent can influence the entrant’s sourcing decision by managing her own sourcing quantity and the entrant can infer the incumbent’s private forecasting information by analyzing her sourcing quantity the manufacturer disclosed. Under such a condition, in order to ease the competition, the incumbent has an incentive to mimic by distorting her sourcing quantity when she forecasts that the market will be booming, while she has an intention to reveal her information when she forecasts that the market will be slack. Finally, we compare the supply chain members’ payoff under different scenarios and find some novel insights for their preferences to two information management strategies. (1) In order to realize a higher selling quantity, once the incumbent’s order can reflect her forecasting information, it is intuit that information leakage is better-off when the incumbent’s forecasts that the market will be booming, and no information leakage is better-off when the market will be slack. However, in the presence of forecasting accuracy, we find that, under certain conditions (for example, the prior probability of the booming market is low enough or the forecasting signal is not sufficiently accurate), information leakage may benefit the manufacturer even when the incumbent’s forecasts that the market will be slack. (2) In order to ease the competition, it is intuitive that the incumbent will prefer information leakage when she forecasts that the market will be slack, and prefer no information leakage when she forecasts that the market will be booming. But through our analyzing, under the condition that the forecasting information is not sufficiently accurate and the prior probability of the booming market is high enough, we find that the incumbent will prefer information leakage even when she forecasts that the market will be booming. (3) For the entrant, intuitively, knowing more information is better for him. However, the presence of forecasting accuracy may alter this intuition. It is obvious to find that information leakage always hurts the entrant’s profit when the incumbent forecasts that the market will be slack. And when the market will be booming, information leakage will also hurt the entrant payoff under the condition of the forecasting information is not sufficiently accurate and the prior probability of the booming market is high enough. In addition, we find that the many-win condition will never occur in current model setting, which means that the preferences of all three supply chain members will never become concert.

The rest of our paper is organized as follows. In Section 2, we briefly summarize the related literature. In Section 3, we describe our model setting. In Section 4, we study the scenario in which the manufacturer does not disclose the incumbent retailer’s orders to the entrant retailer. In Section 5, we analyze the scenario that the manufacturer discloses the incumbent’s order information reflecting private forecasting information. In Section 6, we discuss both manufacturer and retailers’ preferences. In Section 7, we conclude our main findings and suggestions for future work.

2 Literature review

Our paper is primarily related to three research streams on ordering decision, asymmetric forecasting information of market demand, and information revelation and information sharing in a supply chain problems.

2.1 Ordering decision

Supply chain members’ sourcing decisions, as a key problem in supply chain management, have attracted a lot of scholars’ attention (Kim et al. 2011; Jaber et al. 2014; Niu et al. 2019; Khalilpourazari et al. 2019; Jiao et al. 2020). Chen and Guo (2014) consider a model in which a manufacturer with uncertain supply and two competing retailers to evaluate the combined effects of uncertain supply and retail competition on retailers’ sourcing decisions. Jain and Sohoni (2015) examine a supply chain with a supplier and two competing retailers endowed with private information, and they study the combined effects of information revelation and moving sequence to retailers’ ordering decisions. They find that the downstream retailer can prevent the upstream supplier from leaking its information by using a confidentiality agreement, which will weaken the firm’s ability to dampen competition by adjusting sourcing quantity. Yan et al. (2017) consider a supply chain with a common supplier and two competing retailers, and they analyze the influence of purchase ways (group buying versus individual purchasing) and moving sequences to the retailers’ sourcing decisions under a quantity discount contract. They find that both the two retailers
would not prefer group buying even if the wholesale price is lower, and the informed retailer has an incentive to source less to mimic a low state demand if the demand uncertainty is low. Huang et al. (2019) consider a supply chain in which an upstream supplier offers a quantity discount contract to downstream retailer facing uncertain demand, and they investigate the optimal contract and the retailer’s optimal order quantity under endogenous demand information acquisition.

Although ordering quantity has been investigated under various uncertainties, our paper differs from Chen and Guo (2014), Jain and Sohoni (2015), and Huang et al. (2019), and we consider that the downstream retailer’s order decision which may be revealed can reflect its private information about the market demand. In contrast to Yan et al. (2017) in what the retailers make their sourcing decisions under a quantity discount contract, our study focuses on the retailers’ sourcing decisions under a wholesale price contract.

### 2.2 Asymmetric forecasting information of the market demand

There have been a number of studies considering asymmetric forecasting information of market demand in a supply chain. Chen and Xiao (2012) consider two competing supply chains, each consisting of one manufacturer and one retailer, and only the retailers can observe the asymmetric and inaccurate forecasting information. They find that the competition between the supply chains can lead the downstream retailers have incentive to share their information with their upstream manufacturers, but not with each other. Wu and Zhang (2014) assume that the upstream suppliers have asymmetric forecasting information of market demand, and the retailers can obtain supplier’s private information by sourcing products from them. They find that the retailers prefer sourcing from the supplier with more forecasting information and higher sourcing cost under certain conditions. Jiang et al. (2016) consider a supply chain wherein an upstream manufacturer sells its products through a downstream retailer under a wholesale price contract, and the manufacturer has a better demand-forecast information than the retailer. They find that the risk-neutral retailer may prefer no-sharing format and the manufacturer may prefer mandatory-sharing format. Nasser and Turcic (2019) consider a supply chain consisting of a manufacturer and a retailer with private forecasting information of the uncertain demand, which incurs a hidden information cost to the manufacturer, and they explore a mechanism to help the manufacturer to weaken or eliminate such an information disadvantage. Meanwhile, Chen and Ozer (2019) assume the downstream retailers with different forecasting abilities of market demand source products from a common supplier, and they study a contract which can promote vertical information sharing in a supply chain while avoiding horizontal information leakage between competing retailers.

Compared with the literature we mentioned, although asymmetric forecasting information on market demand in a supply chain has been allowed, in contrast to Wu and Zhang (2014) and Jiang et al. (2016), we consider the downstream retailer has private forecasting information rather than the upstream supplier. Furthermore, differing from Chen and Xiao (2012) who analyze forecasting information asymmetric between supply chains and Nasser and Turcic (2019) who study information asymmetric between supplier and retailer, we consider forecasting information asymmetric between retailers. Additionally, differing from Chen and Ozer (2019) who consider the retailer only can forecast its own demand, our paper considers the retailer has the forecasting information of the whole market demand.

### 2.3 Information revelation and information sharing in a supply chain

In recent years, information revelation and information sharing has attracted considerable attention. Li (2002) shows that the downstream retailers with private signals have no incentive to voluntarily share their information with the upstream manufacturer for the information leakage will hurt their profits, but the manufacturer can obtain their private information to realize a larger profit by compensating them. Zhang (2002) and Li and Zhang (2008) consider a supply chain in which a manufacturer provides products to competing retailers with different information. They find that, when the manufacturer’s wholesale price can reflect the shared information, revealing the information to the manufacturer may cause a loss to the retailer. Zhu et al. (2011) examine a supply chain with one manufacturer and one retailer, both the two players can obtain forecasting information of the market demand independently, the retailer can infer the manufacturer’s private forecasting information after observing its wholesale price, and thereby, the retailer has better forecast than the manufacturer under no information sharing. Meanwhile, many studies consider that the information is revealed confidentially, such as Anand and Goyal (2009), Kong et al. (2013), Yan et al. (2017), and Wang et al. (2019). All of them consider a supply chain in which two competing retailers with asymmetric demand information source products from a common supplier, and the retailers’ sourcing quantity reflecting private information may be leaked by the supplier. Anand and Goyal (2009) find that, under a wholesale price contract, the upstream supplier always has an incentive to disclose the retailer’s order information reflecting private demand information. Kong et al. (2013) show that the revenue sharing contract can help the retailer to prevent the upstream supplier from leaking its order information reflecting private information to its competitor. Differing from Anand and Goyal...
(2009) and Kong et al. (2013), Yan et al. (2017) consider a quantity discount contract, and thereby, the order information can be revealed directly between the retailers. Wang et al. (2019) show that whether the supplier leaks information is affected by multiple factors when the downstream retailers are asymmetric.

While many papers investigate information revelation and information sharing, different from Li (2002) and Yan et al. (2017), this paper considers the information is revealed confidentially and indirectly. Further, differing from Zhang (2002), Li and Zhang (2008) and Zhu et al. (2011), we suppose that the demand information is shared by the retailer’s sourcing quantity. Moreover, Anand and Goyal (2009), Kong et al. (2013) and Wang et al. (2019) consider that one of the two retailers can observe accurate information on market demand; differently, this paper considers that the information the retailer observed is inaccurate which will be closer to reality.

### 3 Model framework

We consider a supply chain in which two competing retailers source products from a common manufacturer and then sell all the merchandise to the end-user market. The retailers are asymmetric with demand prediction information, so we distinguish the one with information advantage as the incumbent (she) and the other one as the entrant (he). For the reminder of our paper, we use \( i \), \( e \) and \( m \) to denote the incumbent, the entrant and the manufacturer, respectively. All supply chain members are risk-neutral and try to maximize their own expected profit.

The retailers are engaged in quantity competition so that the market demand is set to follow a linear, downward-sloping function, \( P = A - Q \), where \( P \) is the market clearance price, \( A \) is the market potential and \( Q = q_i + q_e \) is the total quantity which is provided in the market. Given the market potential, the more products are provided in the market, the lower price will incur. Specifically, \( q_i \) and \( q_e \) are the sourcing quantities of the incumbent and the entrant, respectively, which are provided to consumers at the market-clearing price. Additionally, without loss of generality, we suppose that the market potential \( A \) is large enough such that the retail price is always positive. Market competition between the retailers is very general (Zhang et al. 2021), and the inverse demand function is widely used in capturing quantity competition in a game model, such as Anand and Goyal (2009), Kong et al. (2013), Niu et al. (2019), Li et al. (2020) and Jiao et al. (2020), so it is also adopted in our model. Some researchers consider the pricing competition (such as Han et al. 2018; Zhou et al. 2020; Liang and Liang 2021), but we think that the price can be easily altered, while the sourcing quantity will be more stable.

The market demand is always uncertain, and the two retailers have asymmetric information about it. We assume that the market potential \( A \) fluctuates within a binary distribution and there are two possible types for the market potential: either high type (denoted as \( A_H \)) or low type (denoted as \( A_L \)). Suppose \( A_H \) (a booming market) has the value \((1 + \delta)A\) with probability \( \theta \in (0, 1) \) and \( A_L \) (a slack market) has the value \((1 - \delta)A\) with probability \(1 - \theta\), where \( A \) refers to the average market potential and \( \delta \in (0, 1) \) can be considered to be the level of demand uncertainty; as the parameter \( \delta \) increases, the level of demand uncertainty increases. It is noteworthy that the incumbent has better information about the market potential \( A \) than the entrant, but the ex ante distribution of \( A \) is common knowledge to all supply chain members. For example, the firms’ information about the market demand has a positive correlation with their existing time, so that the incumbent knows more about the market demand by analyzing the historical data collected by her, but the entrant just has the prior distribution of the market demand. Similar assumptions have been widely adopted by previous studies such as Jiang et al. (2016), Yan et al. (2017) and Wang et al. (2019).

To characterize the incumbent’s information advantage, we assume that only the incumbent can observe a prediction of the market potential which is denoted as \( s \). For the convenience to discuss, we assume that this forecasting of market size also has two possible values: \( s = l \) and \( s = h \). Let the parameter \( \rho \in [0, 1] \) measure the accuracy of the incumbent’s prediction; note that the prediction is imperfect as long as \( 0 < \rho < 1 \). Therefore, \( \rho = 1 \) indicates that the forecast is entirely accurate, whereas \( \rho = 0 \) means that the forecast is totally inaccurate, which means the larger the \( \rho \) is, the more reliable the prediction information is. Furthermore, we suppose that the incumbent’s forecast is unbiased, such that the unconditional probability of a prediction indicating any demand state is equal to the prior probability of that state (i.e., \( \text{Pr}(A_H) = \text{Pr}(h) \) and \( \text{Pr}(A_L) = \text{Pr}(l) \)). Similar assumptions can be found in Iyer et al. (2007) and Jiang et al. (2016). Obviously, one can easily derive the conditional probabilities: \( \text{Pr}(h|A_H) = \frac{\theta}{\theta + (1 - \theta)\rho} \), \( \text{Pr}(l|A_H) = \frac{1 - \theta}{\theta + (1 - \theta)\rho} \), \( \text{Pr}(l|A_L) = \frac{1 - \theta}{\theta + (1 - \theta)\rho} \) and \( \text{Pr}(l|A_L) = (1 - \theta + \theta\rho) \). Thus, for any \( \rho \in (0, 1) \), the imperfect forecasting signal always contributes to improve the demand information of the retailers, which also means that the incumbent has a better information about market size than the entrant.

There are two scenarios for comparison in our paper: no information leakage and information leakage. Figure 1 shows the difference between the two scenarios. Under the
condition of no information leakage, we suppose that the upstream manufacturer makes prior commitment that it does not leak the incumbent’s order information reflecting the private forecasting information to the entrant, for example, the incumbent can sign prior confidentiality agreement with the manufacturer to rule out information leakage. While under the condition of information leakage, we consider that the upstream manufacturer always leaks, for instance, the manufacturer sets up a retailers’ order information sharing platform, the entrant can observe the incumbent’s sourcing quantity under such a condition. To facilitate the discussion, we use the superscript NL and L to refer to the two scenarios.

The sequence of events is as follows: First, the incumbent decides her sourcing quantity \( q_i \) after observing a forecast signal \( s \); second, the upstream manufacturer discloses the incumbent’s order information to the entrant under the scenario of information leakage and does not disclose under the scenario of no information leakage; third, the entrant decides his sourcing quantity \( q_e \); then, “nature” determines the actual market demand state; finally, both the two retailers’ products are provided to the end-users market, and the market-clearing price is realized. Furthermore, when we are deriving the two retailers’ optimal sourcing quantities, to remain our focus, we normalize that \( w \) is equal to zero (Anand and Goyal 2009).

4 Sourcing decisions under no information leakage (NL)

We first consider the scenario of no information leakage; under such a condition, the manufacturer never leaks the incumbent’s order information to the entrant, which can be recognized as a Nash game. Based on the above model setting, given the forecasting signal type \( s \in \{l, h\} \), the incumbent’s expected profit function is as follows:

\[
E \left[ \Pi_i^{NL} (q_i^{NL} | s) \right] = \left( E[A|s] - q_i^{NL} - q_e^{NL} \right) q_e^{NL}, \tag{1}
\]

and the entrant’s expected profit can be written as:

\[
E \left[ \Pi_e^{NL} (q_e^{NL}) \right] = \sum_{s \in \{l, h\}} Pr(s)(E[A|s] - q_i^{NL} - q_e^{NL}) q_e^{NL}, \tag{2}
\]

where \( E[A|s] = A_H Pr(A_H|s) + A_L Pr(A_L|s) \). For convenience, we define \( \tau \equiv 1 + \delta(2\theta - 1)(1 - \rho) \) to indicate the average of expected demand; meanwhile, we use \( \Delta \equiv \delta \rho \) to measure the difference of expected demand between \( h \)- and \( l \)-type, and this means that the expected demand would change more as \( \Delta \) increasing. The equilibrium outcome under this scenario is summarized in Lemma 1, and more calculative details are given in “Appendix.”
Corollary 1 indicates that, for any \( \Delta \in \left( 0, \frac{\tau}{1 + \delta} \right) \), the two retailers’ expected profits are as follows:

\[
E \left[ \Pi_{ih}^{NL} \right] > E \left[ \Pi_{iL}^{NL} \right] > E \left[ \Pi_{il}^{NL} \right],
\]

which illuminates that the incumbent can earn more than the entrant if she forecasts that the market demand will be high; otherwise, the entrant can earn more than the incumbent. We can understand such a result from the two retailers’ sourcing decisions. For the incumbent, if she observes a low-type forecasting signal, she would decrease her order to maintain profitability. For the entrant without any forecast information, he can only place the same sourcing quantity according to the prior probability of the market size. Therefore, when the forecast signal is low type, only the incumbent reduces her orders, which makes her earn less than the entrant. Corollary 1 demonstrates that the incumbent would like to disclose her sourcing quantity to the entrant to moderate competition. Thereby, both the market clearance price and the incumbent’s profit will increase. More details of the incumbent’s voluntarily sharing incentives are discussed in Sect. 6.2.

5 Sourcing decisions under information leakage (L)

In this section, we suppose that the upstream manufacturer always leaks the incumbent’s ordering quantity reflecting her private forecasting information to the entrant. Thereby, the entrant can make his sourcing decision according to the incumbent’s orders the manufacturer leaked. The two retailers’ expected profits are

\[
E \left[ \Pi_{i}^{L}(q_{is}^{L}|s) \right] = \left( E [A|s] - q_{is}^{L} - q_{e}^{L} \right) q_{is}^{L}
\]

(3) and

\[
E \left[ \Pi_{e}^{L}(q_{e}^{L}|s) \right] = \left( \sum_{s \in \{l,h\}} \Pr(s|q_{i})E [A|s] - q_{is}^{L} - q_{e}^{L} \right) q_{e}^{L}
\]

(4) severally. Similarly, we use \( \tau = 1 + \delta(2\theta - 1)(1 - \rho) \) to indicate the average of expected demand and \( \Delta = \delta\rho \) to measure the interval of \( E [A|h] \) and \( E [A|l] \).

Once the incumbent realizes that the manufacturer will leak her order quantity, she will strategically readjust her order to maximize her expected profit. Because the entrant can deduce the demand forecast type indirectly, the incumbent will think over the entrant’s action before she places her sourcing quantity. Therefore, a signaling game emerges, as common knowledge in such a game, two types of pure strategy perfect Bayesian equilibria arise: the separating equilibrium and the pooling equilibrium. We discuss these two kinds of equilibria in Sects. 5.1 and 5.2 separately. The superscripts S and P are used to indicate the two equilibria, respectively. For example, LS represents the separating situation under orders’ information leakage and LP represents the pooling situation under information leakage.

5.1 The separating equilibrium

The separating equilibrium supposes that the incumbent possessing private prediction information makes different sourcing decisions for each forecasting signal type. Thereby, the entrant can infer the forecasting signal type the incumbent
observed after obtaining the incumbent’s sourcing quantity. In such an equilibrium, for the incumbent, if the forecasting signal is \( l \)-type, her sourcing quantity is \( q_i = q_i^LS \); if the signal is \( h \)-type, her sourcing quantity is \( q_i = q_i^{LS} \). For the entrant, according to the incumbent’s sourcing quantity, he can infer the forecasting signal type and update his belief in terms of the market size later. It is reasonable for the entrant to deduce that the incumbent will purchase more when she observed a high-type signal, such that the entrant’s belief system with a threshold quantity can be given by:

\[
\Pr(s = h) = \begin{cases} 
1, & \text{if } q_i > q_i^{LS} \\
0, & \text{if } q_i \leq q_i^{LS}, 
\end{cases}
\]

which indicates that the entrant believes that the forecasting signal is high-type if the incumbent retailer’s sourcing quantity \( q_i > q_i^{LS} \) and low otherwise.

Next, we discuss the incentive compatibility constraints of the separating equilibrium to ensure that both the \( h \)-type and \( l \)-type incumbents are willing to separate from each other. The constraints can be demonstrated as follows:

\[
\begin{align*}
\max_i E \left[ \Pi_i(q_i > q_i^{LS} | h) \right] &\geq \max_i E \left[ \Pi_i(q_i \leq q_i^{LS} | h) \right], \\
\max_i E \left[ \Pi_i(q_i \leq q_i^{LS} | l) \right] &\geq \max_i E \left[ \Pi_i(q_i > q_i^{LS} | l) \right], \\
q_i^{LS} &\geq 0.
\end{align*}
\]

The incumbent’s expected profits under the equilibrium are represented by the left-hand side of those inequation constraints, and the incumbent’s expected profits under off-equilibrium profits are represented by the right-hand side. The separating equilibrium can be realized if and only if the left-hand side is greater than the right-hand side. The constraint of \( q_i^{LS} \geq 0 \) is to ensure that the incumbent’s expected profit is non-negative. Then, we can find the incumbent’s possible motivation by analyzing her expected profits under different forecasting signal types, which are presented in Lemma 2.

**Lemma 2** Given \( \delta, \rho \) and \( \theta \), the high-type incumbent may have an incentive to mimic a low-type one, while the low-type incumbent has an incentive to disclose her type.

Lemma 2 indicates that the first constraint does not always hold, which means that the high-type incumbent has an incentive to mimic a low-type one for the higher profit. But the second constraint above does not bind, which shows that the incumbent will never have an incentive to pretend to be a high-type one when her prediction of the market size is low type. We can further understand the incumbent’s incentive by analyzing the inverse demand function, \( P = A - Q \), which illuminates that the market demand clearing price will increase if the total sourcing quantities of the two retailers decrease. Therefore, the incumbent who observed a high-type forecasting signal in advance may mimic a low-type one to induce the entrant to purchase less to realize a higher market-clearing price, while the incumbent who observed a high-type forecasting signal in advance will disclose her sourcing quantity to make the entrant reduce his orders to ease the market competition. Lemma 3 summarizes the separating equilibrium outcome. Here again, more calculative details are given in “Appendix.”

**Lemma 3** For any \( \Delta \equiv \delta \rho > 0 \), under the scenario of information leakage, the separating equilibrium exists:

1. The optimal sourcing quantities of the incumbent are:

\[
q_i^{LS} = \begin{cases} 
\frac{(\tau + \Delta)\bar{A}}{4(1 - D)} & \text{if } \Pr(s = h) = 1, \\
\frac{(\tau - \Delta)\bar{A}}{4(1 + D)} & \text{if } \Pr(s = h) = 0 \text{ and } 0 < \Delta < \frac{\tau}{2}, \\
\frac{(\tau - \Delta)\bar{A}}{4} & \text{if } \Pr(s = h) = 0 \text{ and } \frac{\tau}{2} \leq \Delta < 1.
\end{cases}
\]

2. The optimal sourcing quantities of the entrant are:

\[
q_e^{LS} = \begin{cases} 
\frac{(\tau + \Delta)\bar{A}}{4} & \text{if } \Pr(s = h) = 1, \\
\frac{(\tau - \Delta)\bar{A}}{4} & \text{if } \Pr(s = h) = 0 \text{ and } 0 < \Delta < \frac{\tau}{2}, \\
\frac{(\tau - \Delta)\bar{A}}{4} & \text{if } \Pr(s = h) = 0 \text{ and } \frac{\tau}{2} \leq \Delta < 1.
\end{cases}
\]

3. The maximal expected profits of the incumbent are:

\[
E \left[ \Pi_i^{LS} \right] = \begin{cases} 
\frac{(\tau + \Delta)^2\bar{A}^2}{16(1 - D)} & \text{if } \Pr(s = h) = 1, \\
\frac{(\tau - \Delta)^2\bar{A}^2}{16} & \text{if } \Pr(s = h) = 0 \text{ and } 0 < \Delta < \frac{\tau}{2}, \\
\frac{(\tau - \Delta)^2\bar{A}^2}{16} & \text{if } \Pr(s = h) = 0 \text{ and } \frac{\tau}{2} \leq \Delta < 1.
\end{cases}
\]

4. The maximal expected profits of the entrant are:

\[
E \left[ \Pi_e^{LS} \right] = \begin{cases} 
\frac{(\tau + \Delta)^2\bar{A}^2}{16} & \text{if } \Pr(s = h) = 1, \\
\frac{(\tau - \Delta)^2\bar{A}^2}{16} & \text{if } \Pr(s = h) = 0 \text{ and } 0 < \Delta < \frac{\tau}{2}, \\
\frac{(\tau - \Delta)^2\bar{A}^2}{16} & \text{if } \Pr(s = h) = 0 \text{ and } \frac{\tau}{2} \leq \Delta < 1.
\end{cases}
\]

Here, \( D \equiv \frac{2\sqrt{\tau + \Delta \Delta - 2\Delta}}{\tau - \Delta} \in (0, 1) \) represents the forecasting information distorting degree by signaling, where \( 0 < \Delta < \frac{\tau}{2} \).

In the separating equilibrium, the entrant can infer the forecasting signal type by analyzing the incumbent’s sourcing quantity which is disclosed by the common manufacturer. Thus, both the two retailers have the forecasting information; the difference is that the incumbent’s forecasting signal is first hand, while the entrant’s forecasting information is obtained by conjecturing. This means that the incumbent will make...
sourcing decision strategically in order to take advantage of her prediction information, and she can impact the entrant’s sourcing decision by adjusting her sourcing quantity under the condition of manufacturer information leakage.

Since the upstream manufacturer always discloses the incumbent’s sourcing quantity reflecting private information to the entrant, it makes the incumbent needs to take into account the entrant’s response before making her own decision. If \( 0 < \Delta < \frac{x}{2} \), which means the difference between \( E[A_H | h] \) and \( E[A_L | l] \) is small, the \( l \)-type incumbent who wants to reveal the real type needs to sacrifice part of her profit and decrease her sourcing quantity, even lower than her first-best sourcing quantity. Only in this way, can she separate from the \( h \)-type incumbent and signal the correct information to the entrant. However, when \( \frac{x}{2} \leq \Delta < 1 \), that is, the difference of expected market size between the high-type and the low-type is large, the cost of information distorting increases; for these reasons, the \( h \)-type incumbent will have no incentive to mimic under such a condition, which means that the \( l \)-type incumbent could spontaneously separate from the \( h \)-type one.

For the entrant, he can deduce the forecasting signal type by analyzing the incumbent’s orders the upstream manufacturer disclosed, which makes he can utilize the forecasting information he inferred to make his sourcing decision to maximize his expected profit. When \( q_i > q_{i[H]}^L \), the entrant will believe that the incumbent’s forecasting signal must be high-type, and he will implement a high-type sourcing strategy. When \( 0 < \Delta < \frac{x}{2} \) and the interval between \( E[A_H | h] \) and \( E[A_L | l] \) is small, the \( h \)-type incumbent’s mimicking cost is low. In order to avoid the \( h \)-type incumbent’s imitation, the entrant will slightly increase his sourcing quantity even though he infers that the forecasting signal is low type. When \( \frac{x}{2} \leq \Delta < 1 \), \( E[A_H | h] \) and \( E[A_L | l] \) are far apart, the incumbent’s information distorting cost becomes large and the \( h \)-type incumbent will not mimic any more. Under such a condition, the entrant will not worry about the incumbent deceiving him, and he could obtain the right forecasting signal effortlessly no matter what the signal type is.

### 5.2 The pooling equilibrium

In a pooling equilibrium, the incumbent would like to source the same quantity no matter what the signal type she observed is. Thus, the entrant cannot infer the incumbent’s forecasting type even though the upstream manufacturer leaks the incumbent’s sourcing quantity to him. In detail, for the incumbent, she would order the same quantity under both signal types, because she does not want the entrant to infer out any information under the condition of information leakage. The entrant’s belief system with a threshold can be given as follows:

\[
Pr(s = h) = \begin{cases} 
1, & \text{if } q_i > q_{i[H]}^L \\
\theta, & \text{if } q_i \leq q_{i[H]}^L.
\end{cases}
\]  

(7)

The entrant’s sourcing decision depends on his deduction; once the incumbent orders the same quantity, the entrant cannot correctly deduce which types the forecasting signal is, and he would source the same quantity according to his updated belief. Similar to the separating situation we have discussed, the incumbent would like to pool if and only if the following constraints exist:

\[
\begin{align*}
P &= c_1^H - c_2^H, \\
&\text{max } E[\pi_i^L | h] = E[\pi_i^H | h], \\
&\text{max } E[\pi_i^L | l] = E[\pi_i^H | l], \\
&\text{max } E[\pi_i^L | h] \geq \text{max } E[\pi_i^H | h], \\
&\text{max } E[\pi_i^L | l] \geq \text{max } E[\pi_i^H | l], \\
q_i^L \geq 0.
\end{align*}
\]  

(8)

The following proposition shows the pooling equilibrium outcomes. More details are given in “Appendix” too.

**Lemma 4** When \( \frac{(1-\theta)\tau}{2-3\theta - \theta^2} < \Delta < \frac{\tau}{2+\theta} \), a pooling equilibrium exists and we show it in the following:

1. **The incumbent orders:**

\[
q_i^L = \frac{(\tau - \Delta - 2\theta \Delta) \tilde{A}}{2}.
\]

2. **The entrant orders:**

\[
q_i^L = \frac{(\tau - \Delta + 6\theta \Delta) \tilde{A}}{4}.
\]

3. **The expected profits of the incumbent under different forecasting signal types are:**

\[
E[\pi_i^L] = \begin{cases} 
(\tau - \Delta - 2\theta \Delta)^2 + 8\Delta(\tau - \Delta - 2\theta \Delta) \tilde{A}^2 \frac{8}{8} & \text{if } s = h, \\
(\tau - \Delta - 2\theta \Delta)^2 \tilde{A}^2 & \text{if } s = l.
\end{cases}
\]

4. **The expected profit of the entrant is:**

\[
E[\pi_e^L] = \frac{(\tau - \Delta + 6\theta \Delta)^2 \tilde{A}^2}{16}.
\]
market-clearing price, which motives her to choose the pooling equilibrium even though her market share is reduced. By the same token, the \(l\)-type incumbent will have a similar motivation to choose the pooling equilibrium. For such a reason, both types of incumbents source the same quantity, the entrant cannot infer out the types of forecasting signal by analyzing the incumbent’s order, but only update his belief. Note that, differing from the condition of the upstream manufacturer never leaks, under pooling, the entrant can update his belief according to the incumbent’s sourcing quantity the manufacturer disclosed, but the updated belief is the same as the prior belief. Compared to the profit of the entrant under no information leakage, the entrant’s income reduced, due to the influence of the incumbent’s sourcing decision under information leakage. Therefore, in some cases, without any forecasting information may be constructive for the entrant, which will be discussed in Section 6.3 in detail.

5.3 Equilibrium outcome

Based on the results we solved above, for the incumbent, we find that there are multiple equilibria in our model setting when \(\frac{1-\theta^r}{2-3\theta^r} < \Delta < \frac{r}{2+\theta} \), and this indicates that we need to find the unique equilibrium outcome, so that we use LMSE (lexicographically maximum sequential equilibrium) concept to find such an outcome (see Mailath et al. Mailath et al. 1993), the LMSE concept has been widely used as one of the multiple equilibria selection criteria (such as Guo et al. 2017; Jiang et al. 2016, 2020), and thus, it is also adapted in our setting. The unique and optimal equilibrium result is summarized in Proposition 1, and the relevant proof is given in “Appendix.”

Proposition 1 Under information leakage, the pooling equilibrium is dominated by the separating equilibrium.

As Proposition 1 illuminates, there indeed exists the unique choice of equilibrium by using the LMSE concept we refined. We compare the \(l\)-type incumbent’s two kinds of pure-strategy expected profits and find that \(E[\Pi_{h}^S] > E[\Pi_{l}^P] \) always holds when \(\frac{1-\theta^r}{2-3\theta^r} < \Delta < \frac{r}{2+\theta} \). That is, for the \(l\)-type incumbent, who has the incentive to reveal her type, she always has sufficient incentive to separate from the \(h\)-type incumbent for the larger profit she can realize. This means that the \(h\)-type incumbent cannot pool with the \(l\)-type incumbent successfully, because of the \(l\)-type incumbent’s revealing intention. We call the result summarized in Proposition 1 that the separating equilibrium \(l\)-dominates the pooling equilibrium when \(\frac{1-\theta^r}{2-3\theta^r} < \Delta < \frac{r}{2+\theta} \). Under information leakage, the separating equilibrium is the unique outcome and the pooling equilibrium is ruled out by the concept of Lexicographically Maximum Sequential Equilibrium.

6 Analysis

In this section, we compare the expected profits of the three game players to find the effect of the downstream retailer’s inaccurate prediction on each party’s preference for information revelation. We discuss the manufacturer’s preference in Sect. 6.1 and the two retailers’ preferences in Sect. 6.2 and Sect. 6.2 separately. The superscripts L and NL are used to denote the two scenarios severally.

6.1 The manufacturer’s performance comparison

In this section, we compare the manufacturer’s profits under two different scenarios to find its preference for information leakage. Given \(w\), the manufacturer’s profit is \(wQ\), which is directly proportional to the total orders of the two retailers. For tractability, we can compare the \(Q\) under different scenarios to find the manufacturer’s preference, which does not affect the major results. Meanwhile, we suppose that the retailers’ sourcing quantities are non-negative to make sure that the manufacturer’s revenue is always positive. Because the manufacturer is a profit maximizer, he would prefer the most beneficial information management strategy, and we show such a result in the following proposition.

Proposition 2 By analyzing the totally retailers’ sourcing quantities, we have:

1. If \(s = h\), \(Q^L > Q^{NL}\);
2. If \(s = l\), the results are impacted by \(\theta\) and \(\rho\), specifically:
   - Under the condition of \(0 < \delta \leq 0.5\), \(Q^L > Q^{NL}\) for any \(\theta \in \left[\frac{11-6\sqrt2}{4}, 1\right]\), or \(0 < \rho < \rho_1\) where \(\rho_1 = (0, (\frac{\sqrt2}{8} - 3)^2)\), or \(\rho_2 < \rho < 1\) where \(\theta \in (0, 0.16565)\); otherwise, \(Q^{NL} > Q^L\).
   - Under the condition of \(0.5 < \delta \leq 1\), \(Q^L > Q^{NL}\) for \(0 < \rho < \frac{1-\delta+2\theta}{2\theta+\sqrt3}\) where \(\theta \in \left[\frac{11-6\sqrt2}{4}, 1\right]\), or \(0 < \rho < \rho_1\) where \(\rho_1 = (0, (\frac{\sqrt2}{8} - 3)^2)\), or \(\rho_2 < \rho < \frac{1-\delta+2\theta}{2\theta+\sqrt3}\) where \(\theta \in (0, 0.16565)\), or \(\frac{1-\delta+2\theta}{2\theta+\sqrt3} < \rho < \frac{1-\delta+2\theta}{\theta+\sqrt3}\) where \(0 < \theta < 0.25\); otherwise, \(Q^{NL} > Q^L\).

Here, \(\rho_1 \equiv \frac{(1-\delta+2\theta)(7+6\delta-24\sqrt3\theta)}{6(4\delta^2-13\delta+4\sqrt3\theta-80\sqrt3\theta+7)}<\rho_2 \equiv \frac{(1-\delta+2\theta)(7+6\delta-24\sqrt3\theta)}{6(4\delta^2-13\delta-4\sqrt3\theta+80\sqrt3\theta+7)}\).

Comparing the total quantities under different scenarios, we find that the downstream retailer’s forecasting signal type and accuracy, the prior probability of high-type market size and the market uncertainty will impact the manufacturer’s preference for information management strategy. As Proposition 2 shows, the manufacturer always prefers the information disclosure strategy when the incumbent’s forecasting signal type is high. This result no longer holds when the forecasting signal is low-type.
From Proposition 2, we can find that the manufacturer’s preferences are variable if the incumbent’s forecasting signal type is low. More specifically, if the forecasting signal is \(l\)-type and the market uncertainty is low, the manufacturer prefers an information disclosure strategy when the prior probability of \(H\)-type market size is sufficiently large (larger than \(\frac{11 - 6\sqrt{2}}{4} \approx 0.628\)), or when the forecasting accuracy is low and the prior probability of high-type market size is sufficiently low (lower than \((\frac{\sqrt{2}}{2} - 3)^2 \approx 0.0945\), or the forecasting signal is sufficiently accurate and the prior probability of \(H\)-type market size is low (lower than 0.16565).

However, if the forecasting signal type is low but the market uncertainty is high, the manufacturer prefers a disclosure strategy when the forecasting accuracy is not high and the prior probability of \(H\)-type market size is large enough (i.e., \(\theta > \frac{11 - 6\sqrt{2}}{4} \approx 0.628\)), or both the forecasting accuracy and the prior probability of \(H\)-type market size are sufficiently low (i.e., \(\theta < \frac{\sqrt{2}}{2} - 3 \approx 0.0945\)), or the forecasting accuracy is moderate to inferior and the prior probability of \(H\)-type market size is low (i.e., \(\theta < 0.16565\)), or the forecasting accuracy is on the upper-middle level and the prior probability of \(H\)-type market size is low (i.e., \(\theta < 0.25\)). Otherwise, the manufacturer will prefer no information disclosure strategy for the higher sales and profits.

We illustrate this proposition in Fig. 3. As shown in Fig. 3a, it is better-off for the manufacturer to choose an information leakage strategy under the condition of the incumbent’s forecasting signal is \(h\)-type. Once the forecasting signal is \(l\)-type, the manufacturer’s preference is not unimodal. From Fig. 3b and c, in most cases, it is plain to find that the manufacturer prefers no information leakage when the incumbent’s forecasting signal is \(l\)-type; only under certain conditions, the manufacturer would prefer information leakage.

### 6.2 The incumbent’s performance comparison

In this part, we compare the profits of the incumbent under alien scenarios to find her preference for information management strategy. Note that we normalize that the wholesale price \(w\) is equal to zero, and this does not affect the major results and allows us to focus on the incumbent’s preference. Furthermore, when \(s = l\), we assume \(\Delta < \frac{1}{\sqrt{2}}\) (i.e., \(\rho < \frac{1 + 4 + 2\delta}{2\sqrt{2}}\)) to ensure that the incumbent’s sourcing quantity is non-negative. The outcome is summarized in Proposition 3.

**Proposition 3** The outcome of the incumbent’s performance comparison is as follows:

1. **When \(s = h\), her preference is impacted by her forecasting accuracy and the prior probability of \(H\)-type market size:**

   - If \(\theta \geq \frac{4\sqrt{\frac{2}{3} - 3}}{2\sqrt{2}}\), \(E[\Pi_i^L] > E[\Pi_i^{NL}]\) always holds;
   - If \(\theta < \frac{4\sqrt{\frac{2}{3} - 3}}{2\sqrt{2}}\), \(E[\Pi_i^L] > E[\Pi_i^{NL}]\) when \(\rho < \frac{(3 - 2\sqrt{2})(1 - \delta + 2\delta)}{6(\sqrt{2} - 1)(1 - \theta)^3}\), and vice versa;

2. **When \(s = l\), \(E[\Pi_i^L] > E[\Pi_i^{NL}]\) always holds.**

Proposition 3 shows that, interestingly, when the incumbent observes a \(h\)-type forecasting signal, she may also have an incentive to voluntarily share her order information reflecting private information if the prior probability of \(H\)-type market size is large (larger than \(\frac{4\sqrt{\frac{2}{3} - 3}}{2\sqrt{2}} \approx 0.93934\)); besides, the incumbent will prefer order information leakage only when her forecasting signal is not sufficiently accurate. Otherwise, the incumbent would like the no information leakage strategy. When the prior probability of \(H\)-type market size is larger than \(\frac{4\sqrt{\frac{2}{3} - 3}}{2\sqrt{2}} \approx 0.93934\), i.e., the market size is mainly stable in the \(H\)-type, it is easy for the entrant to infer the market size according to common knowledge, and there is no need for the \(h\)-incumbent to conceal her information. But once the prior probability of \(H\)-type market size is lower than \(\frac{4\sqrt{\frac{2}{3} - 3}}{2\sqrt{2}} \approx 0.93934\), the \(h\)-incumbent will prefer information leakage under the condition of a low forecasting accuracy, such that she can share the risk of miscalculation with the entrant. As we know from Proposition 2, information leakage increases the manufacturer’s payoff when the forecasting signal is \(h\)-type. Therefore, the manufacturer and the incumbent can achieve a win–win condition under information leakage when \(\theta \geq \frac{4\sqrt{\frac{2}{3} - 3}}{2\sqrt{2}}\) or \(\rho < \frac{(3 - 2\sqrt{2})(1 - \delta + 2\delta)}{6(\sqrt{2} - 1)(1 - \theta)^3}\), where \(\theta \leq \frac{4\sqrt{\frac{2}{3} - 3}}{2\sqrt{2}}\).

Recall from Lemma 2 that for any forecasting accuracy, prior probability and market size uncertainty, the \(l\)-incumbent always prefers to reveal her forecasting signal type. Proposition 3 also shows that the incumbent will prefer information leakage strategy when she observes a \(l\)-type forecasting signal. The intuition for this result is as follows. When the incumbent forecasts that the market size will be small, she would like to disclose her \(l\)-type sourcing quantity to the entrant to make him decrease his sourcing quantity and hence ease the market competition.

In summary, Proposition 3 demonstrates that the incumbent has an incentive to reveal her order information reflecting her private forecasting information, and the win–win situation may occur between the incumbent and the manufacturer under certain conditions.

As the examples of Proposition 3, Fig. 4(a) shows, for different \(\delta\) values and \(h\)-type forecasting signal, information leakage (L) is benefit to the incumbent if and only if \(\theta\) is sufficiently large and \(\rho\) is low; otherwise, no information leakage will benefit the incumbent. As shown in Fig. 4(b), when \(s = l\), given any \(\delta \leq 0.5\), \(0 < \Delta < \frac{1}{\sqrt{2}}\) always holds; under such a condition, information leakage (L) always benefits the
incumbent. Figure 4(c) shows, when \( s = l \), for the lower part of the dotted line (i.e., the condition of \( 0 < \Delta < \frac{\delta}{2} \)), information leakage always benefits the incumbent; for the upper part of the dotted line (i.e., the condition of \( \frac{\delta}{2} \leq \Delta < 1 \)), information leakage is better than no information leakage for the incumbent too.

6.3 The entrant’s performance comparison

We analyze the influence of the incumbent’s forecasting accuracy on the entrant by comparing his expected profits under different scenarios in this part. As a competitor of the incumbent, the entrant must be impacted by the incumbent’s ordering decision and forecasting information, but how to influence him is not clear. We list the comparison results in Proposition 4.

Proposition 4 The result of the entrant’s performance comparison is as follows:

1. When \( s = h \), the result is impacted by the incumbent’s forecasting accuracy and the prior probability of \( H \)-type market size:
   - If \( \theta \geq \frac{7}{8} \), \( E[\Pi^1_se] > E[\Pi^1_e] \);
   - If \( \theta < \frac{7}{8} \), \( E[\Pi^1_se] > E[\Pi^{NL}_e] \) when \( \rho > \frac{1-\delta+2\delta^2}{6(1-\theta)^2} \), and vice versa.

2. When \( s = l \), \( E[\Pi^{NL}_e] > E[\Pi^1_e] \).
According to Proposition 4, under the condition of $h$-type forecasting signal, both the incumbent’s forecasting accuracy and the prior probability of $H$-type market size will impact the entrant’s preference. Information leakage will hurt the entrant’s profit when the prior probability of $H$-type market size is large (larger than $\frac{7}{8} = 0.875$). This means that the incumbent’s order information leakage is meaningless to the entrant and even damages his profit under the condition of the market size being mainly stable in $H$-type. However, when the prior probability of $H$-type market size is not sufficiently large, information leakage is better-off for the entrant if the incumbent’s forecasting signal is sufficiently accurate; otherwise, information leakage is worse-off. This is because the entrant does not want to share the risk of the incumbent’s misprediction. Recalling Proposition 3, interestingly, we find that no information leakage is a win–win information management strategy for the incumbent and the entrant when $\rho > \frac{(3-2\sqrt{2})(1-\delta+2\theta)}{6(\sqrt{2}-1)(1-\theta)^3}$, or $\frac{(3-2\sqrt{2})(1-\delta+2\theta)}{6(\sqrt{2}-1)(1-\theta)^3} < \rho < \frac{1-\delta+2\theta}{6(1-\theta)^3}$ when $\theta < \frac{7}{8}$. However, the win–win condition will never occur between the three supply chain members.

From Proposition 4, it is obvious that no order information leakage is better-off for the entrant under the condition of the incumbent forecasting signal is $l$-type. Under such a condition, the presence of forecasting accuracy does not impact the entrant’s preference. From Propositions 2 and 3, it is plain to find that the win–win condition will never occur in this...
supply chain under the condition of the \( l \)-type forecasting signal.

In summary, Proposition 4 shows, knowing the incumbent’s order information reflecting private forecasting information may hurt the entrant’s profits. What is more, recall from Propositions 2 and 3 that, in the presence of forecasting accuracy, the many-win condition will never occur in this supply chain.

Figure 5a shows, for different \( \delta \) values, the entrant prefers on information leakage (NL) when \( \delta \) is sufficiently large or the incumbent’s forecasting signal is not sufficiently accurate. From Fig. 5b and c, it is obvious that the entrant does not have the incumbent’s order information reflecting private information is better-off for any \( 0 < \rho < 1 \) and \( 0 < \theta < 1 \) when \( s = l \).

### 7 Conclusions

The competing relationship and asymmetric forecasting information between Circuit City and Best Buy motivated them to source strategically and manage information carefully. The forecasting information of uncertain demand is often viewed as an important basis of firms’ decisions (e.g., Zara and Mimoco), and it is asymmetric between retailers (e.g., Circuit City and Best Buy). To investigate retailers’ sourcing decisions under different information management strategies and supply chain members’ preferences to those strategies, we developed a framework consisting of an upstream manufacturer and two competing retailers in which only the incumbent can observe the forecasting signal priorly. By solving the question of the two retailers’ optimal sourcing
quantities under different scenarios, we find some interesting results.

Our results are concluded as follows. First, under the scenario of no information leakage, we find that the retailer possessing the private forecasting information may have a worse-off profit than the retailer who does not have private forecasting information, and the retailer with private information may have a lower market share when she forecasts that the market will be slack. Second, under the scenario of information leakage, we find that, in order to control the market competition, the retailer with private information indeed has an incentive to distort her sourcing quantity and hence to impact the other retailer’s sourcing decisions. Finally, the forecasting signal accuracy and the prior probability of a booming market have a vital impact on the supply chain members’ preferences for different information management strategies. (1) For the manufacturer, one may intuit that the manufacturer will prefer information leakage when the incumbent forecasts that the market will be booming, and no information leakage when the market will be slack. Thereby, it can realize a higher selling quantity. But the presence of forecasting accuracy may alter the manufacturer’s preference when the incumbent forecasts that the market will be slack. The manufacturer still has an incentive to leakage the incumbent’s order information under certain conditions (for example, the forecasting accuracy is sufficiently low or the prior probability of a booming market is low), even though the incumbent forecasts that the market will be slack. (2) For the incumbent, in order to ease the market competition, the intuition for her preference is that she will prefer no information leakage when she forecasts that the market is booming, and information leakage when the market is slack. However, once the incumbent’s forecasting signal is incompletely accurate, when she forecasts that the market will be booming, interestingly, we find that information leakage is better-off for the incumbent under certain conditions (for instance, her forecasting signal is not sufficiently accurate or the prior probability of a booming market is high enough). (3) For the entrant, intuitively, inferring more information about future market size according to the retailer with forecasting information advantage always benefits her sourcing decisions. Nevertheless, in order to avoid the incumbent’s influence and hence to capture a bigger market share, no information leakage is better for him when the incumbent forecasts that the market will be slack, or when the incumbent forecasts that the market will be booming but the forecasting accuracy is low or the prior probability of a booming market is high. Furthermore, we show that the many-win condition will never occur in such a supply chain, and the preferences of all three supply chain members will never become concert, that is, there is no many-win information management strategy in the current model.

There are some limitations of the game model we have considered in this study, and some promising questions require further research. We adopt the Cournot game to capture the competition between the two retailers. It would be interesting to explore price competition, which can be modeled, for instance, as Bertrand competition. Additionally, we have compared the supply chain members’ performances to find their preferences in response to inaccurate forecasting information in our paper, but the specific coordination contract between the manufacturer and the incumbent retailer in response to the forecasting information is still unclear. These problems are deserving of future study.

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Declarations

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