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Strategic information management in a distribution channel

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Abstract

Two-way asymmetric information frequently hampers performances of manufacturer-retailer distribution channel members. Typically, the manufacturer is better informed about the quality of his product than the retailer while the latter knows more about her consumers' preference for product quality than the manufacturer. Bridging these information gaps can enable more profitable channel (wholesale and retail) pricing decisions. Specifically, once the manufacturer knows his product quality, he can at some cost advertise it to the downstream retailer and her consumers. Similarly, the retailer can decide to conduct market research at some cost to more precisely determine her consumers' preference for product quality and share her finding with the manufacturer. In this paper, the authors examine the strategic impacts of two alternative timings of these information gap-filling decisions: In the "Upfront Market Research" (UMR) scenario, the retailer moves first with her market research decision and then the manufacturer makes his product quality advertising decision. Alternatively, in the "Upfront Quality Advertising" (UQA) scenario, the manufacturer first decides about product quality advertising and then the retailer proceeds with her market research decision. This paper analytically investigates and compares the strategic impacts of the UMR and UQA scenarios on the firms' equilibrium information strategies and payoffs in a two-way asymmetric information setting for the first time. The authors find that the retailer is always better off in the UQA than the UMR scenario while the manufacturer can find either UMR or UQA decision sequence more beneficial depending on the relative costs of market research and product quality advertising. The analyses offer new insights and guidelines for more efficient and profitable information acquisition and coordination in bilateral manufacturer-retailer channels.

Keywords: Quality advertising; Market research; Distribution channel; Decision timing; Game theory

Introduction

This is an era of greatly heterogeneous consumer preferences and exploding variety in most retailed product categories. Consequently, to win a targeted customer's business with an appropriate offering, it is imperative for any manufacturer to be well-informed about the consumer's preference for the product's quality as well as break through the product clutter confronting the consumer to inform her/him of its level of product quality. Overcoming these two information-related barriers to realizing a sale – consumer's uncertainty about manufacturer's product quality and manufacturer's uncertainty about consumer's quality preferences – is obviously the core marketing challenge for a manufacturer. As a practical matter, however, manufacturers can negotiate this challenge more effectively by working in coordination with their downstream retailers.

More specifically, while the advertising of product quality (hereafter 'quality advertising') is naturally undertaken by the manufacturer who is informed of the product quality coming out of its production process, the retailer who is in direct contact with the targeted consumers is better positioned to conduct market research providing insights into local consumers' preferences for quality. For example, to mitigate consumer uncertainty, manufacturers can produce informative advertising or offer virtual try-out applications to improve consumer knowledge about their product's quality (Markopoulos and Hosanagar, 2017). Meanwhile, the retailer may conduct market research, e.g., collect consumer data via in- and/or out-of-store surveys and checkout scanner systems, to assess the target consumers' quality preferences (Shin and Tunca, 2010).

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Along with the manufacturer's decision with respect to 'advertising' that reveals the product quality and the retailer's decision with respect to researching and reporting consumers' quality preferences, both parties must also set their respective prices, i.e., the manufacturer (he) must set his optimal wholesale price while the retailer (she) must determine her optimal retail price. Several intriguing questions then arise regarding the process and outcomes of the information exchange about actual and preferred product quality that have not been explored in the related past literature: Do the equilibrium outcomes (profits) for each party and the channel as a whole vary with who moves first in this process – the manufacturer with his quality advertising or the retailer with her market research study and report on consumers' quality preferences? If yes, how do the costs of product quality advertising and conducting market research impact the optimal decision timing for each party and the channel as a whole? This paper investigates these questions analytically to shed new light on the strategic impact of the manufacturer's and retailer's information gap-filling decision timing/sequence on their equilibrium strategies and payoffs. Our findings help to explain the variation in channel arrangements for product quality-related information transmission observed in practice and also offer guidance for the design of efficient information strategies to better coordinate and improve profitability of channel members.

In practice, we can see examples of channels displaying both information gap-filling sequences. That is, in some situations it is apparent that the manufacturer reveals his product quality before the retailer gathers and provides consumer quality preference information; while in other situations, the retailer evidently gathers and shares (or not) information about consumers' quality preferences with manufacturers before the latter reveals (or not) the offered product's quality level. An example of the first approach is observed in the software industry where software developers frequently offer on their websites demonstrations and free trials of limited versions of their software to end-users that can be considered to be 'product quality advertising'. Thus, the free trials serve to reduce or eliminate prospective consumers' uncertainty about product quality and functionality.[1] However the software can only be procured from authorized distributors and resellers in local markets. A specific case of such a software supplier is SigmaX Inc whose official website not only offers free trial downloads to all prospective customers but also provides the names of its authorized distributors in different markets.[2] The latter typically follow up with trial users and learn more about their quality preferences, willingness to pay and overall demand for the software in their markets. Subsequent sharing of this information with the manufacturer will affect the channel members' equilibrium pricing strategy.[3] This can be viewed as a channel in which the software producer first discloses its product quality and then relies on its downstream distributor's market research to appropriately adapt its product quality advertising and wholesale price to the retailer.

However, we also see other software companies that follow a different approach to the provision of free trials to prospective customers, especially when they engage in overseas sales through independent local agents. Specifically, free software trials may be released to end users only after they have interacted with the authorized distributor in their local market. For example, statistical software developers, OriginLab, Eviews, and SHAZAM do not offer free trials downloads to any users surfing on their websites but rather delegate this power to provide free trials to their authorized agents. Specifically, OriginLab publishes a comprehensive list of its worldwide agents in 47 countries on its website but does not provide any access to free trials of its software packages.[4] Instead, the company only facilitates its local agents' release of free trials to targeted end-users, e.g., universities, research institutes and high-tech enterprises in their local markets, only after they have been vetted by the agent. In effect, the software company reveals (or not) its actual product quality only after learning about downstream users' quality preferences from the information gleaned by its downstream agents.

Similar variation in information sharing timing can be observed in other retailing domains. Walmart, for example, owns the world's largest data warehouse which can effectively translate consumers' purchase records into commercial insights (market research) and thus provide useful managerial guidance to its suppliers. However, before obtaining such information, suppliers are required to first clearly reveal their product quality to all, e.g., via ISO 9000 standard labeling on their product packages.[5] In other retailing situations, manufacturers may reveal their quality via direct marketing (samples, free trials) to prospective consumers only after learning from the retailer about their quality preferences, income levels, shopping behaviors or lifestyle habits.

To summarize, as indicated by the above examples, one observes two basic sequences of channel members' information sharing decisions in practice: The first is "Upfront Market Research" (UMR), wherein the retailer first decides on her market research action, i.e., finding out and conveying information about consumers' product quality preferences to the product manufacturer. Subsequently, the latter makes his product quality advertising decision. The second sequence is "Upfront Quality Advertising" (UQA), in which the manufacturer first decides to do product quality advertising to consumers (and the retailer), and then the retailer conducts research to assess consumers' quality preferences. In this paper, we seek to provide insights into

[1] For more information about free trials in the software industry, please refer to "https://successfulsoftware.net/2011/09/19/types-of-free-trial-for-software/."

[2] SigmaXL Inc is a Canadian developer of Excel Add-ins for Lean Six Sigma graphical and statistical tools and Monte Carlo simulation. For more information, please visit its official website: http://sigmaxl.com/SigmaXL Distributors.shtml.

[3] See more information in "https://unbounce.com/email-marketing/convert-free-trial-users-email-marketing/."

[4] OriginLab Corporation is a professional developer with more than 25 years experience at publishing data analysis software. For more information, please refer to its official website: http://www.originlab.com.

[5] See details regarding Walmart's supplier quality requirements at "http://corporate.walmart.com/sourcing-standards-resources" and "https://www.intouch-quality.com/blog/how-comply-walmarts-new-ethical-sourcing-zero-tolerance-policy."

the following questions related to the UQA or UMR information sharing decision patterns: What are the manufacturer's and retailer's equilibrium advertising and market research strategies under UQA or UMR? Which decision sequence leads to a higher expected payoff for the manufacturer, the retailer, and the entire channel? How are the firms' equilibrium decisions and payoffs influenced by the costs of market research and advertising product quality?

To answer these questions, we model and analyze a traditional marketing channel comprised of a manufacturer who wholesales his product to an independent retailer who then resells the product to end consumers. At the outset, neither the manufacturer nor the retailer knows the end consumers' quality preferences, nor are the retailer and end-consumers informed about the manufacturer's product quality. However, the manufacturer and retailer can respectively advertise the product and conduct consumer market research to bridge the information gaps, but incur costs in doing so, specifically, costs of advertising and data collection. Consistent with previous literature, we assume that the decision to undertake or not the action (advertising by the manufacturer; market research by the retailer) by one party is observable by the other and the cost of each action is known to both parties (Guo, 2009b; Guan and Chen, 2015, 2017). Further, we assume that the retailer can precisely determine her consumers' quality preference when she conducts market research, and both she and consumers become fully informed about the product's true product quality if and when the manufacturer decides to advertise it. More specifically, if the manufacturer does not undertake advertising of product quality, the retailer and the consumers strategically update their belief about the product quality accordingly. Finally, in either the UMR or UQA action scenario, the manufacturer first sets the wholesale price to maximize his profits, accounting for the retailer's profit-maximizing retail price-setting rule in response to the wholesale price. That is, the manufacturer is the Stackelberg leader as regards price-setting in the channel.

Upon analysis of the proposed model, we uncover several novel insights into the relative benefits of information sharing for the manufacturer and the retailer in the UQA and UMR scenarios. Specifically, in the UMR scenario, the retailer's market research helps both firms determine higher profit generating wholesale and retail prices. Second, upfront market research induces the manufacturer to spend more or less on advertising his product quality depending on the consumer's specific quality preference. This informed quality advertising strategy, however, does not necessarily improve the manufacturer's payoff. This is because when the observed preference for quality of the consumer is high, the manufacturer has to spend more on advertising his quality to convince the consumer, thereby increasing his expenditure on quality advertising. As regards the retailer, her expected payoff from proceeding with market research is independent of whether the manufacturer discloses product quality information, and she conducts market research if its cost is sufficiently low.

In contrast to the above, in the UQA scenario the manufacturer cannot adjust his quality advertising strategy based on the consumer's revealed preference, as he has to make this decision at the very first stage. In this scenario, the manufacturer's quality advertising strategy could become a way to provide a greater incentive to the retailer to undertake market research. The intuition is that the retailer's incentive for conducting market research hinges on her updated expectation about product quality, which is contingent on the manufacturer's quality advertising action. Specifically, if the manufacturer advertises the product is of high quality, the retailer would be willing to conduct market research given that the expected return can cover the expenditure on market research. However, if the manufacturer does not advertise the quality information, the retailer would infer that the product quality is low and consequently cease market research. In this sense, we show that in contrast to the UMR scenario, the manufacturer is more likely to advertise his product quality in the UQA scenario. This subsequently leads to a higher level of information transparency in the distribution channel as both firms realize benefits from undertaking their respective information enhancing actions.

Comparing the channel members' outcomes in the UQA and UMR scenarios, our analysis shows that the retailer can always achieve a higher ex ante payoff by postponing her decision on market research until observing the manufacturer's quality advertising behavior. However, either decision timing could become the manufacturer's dominant option, which implies that he would voluntarily give up the chance to customize his quality advertising strategy. Although a delayed timing of quality advertising endows the manufacturer with more flexibility in crafting this strategy, it also reduces the retailer's incentive for conducting market research. Instead, if the manufacturer makes the quality advertising decision upfront, he can at least incentivize the retailer to conduct market research by advertising the high quality information. Thus, the balance between these two conflicting effects determines the manufacturer's preference, and we show that both firms prefer upfront quality advertising when the cost of market research is high or it is much lower than the quality advertising cost. Overall, this paper uncovers some novel strategic impacts of decision timing, providing useful managerial insights for firms to better arrange their information tactics to combat information asymmetry and improve profitability.

The rest of the paper is organized as follows. Section 2 reviews the relevant literature. In Section 3, we lay out the model setup. The firms' equilibrium market research, quality advertising and pricing strategies are presented in Section 4. Section 5 discusses the extension. Concluding remarks are provided in Section 6. All the proofs are relegated to the Appendix.

Literature review

Our paper belongs to the rapidly growing stream of literature that studies the impacts of information asymmetry and sharing in the distribution channel. In an excellent review paper, Chen (2003) discusses the impact of information asymmetry, the mechanism of information transmission, and firms' incentives for information sharing in the distribution channel. In particular, there is a large group of papers investigating the value of sharing demand information (e.g., Cachon and Lariviere (2001), Ozer and Wei (2006), Li and Zhang (2008),

Guo and Iyer (2010), Ha and Tong (2008) and Mittendorf et al. (2013)). Some other papers pay attention to upstream information sharing (e.g., production yield and quality), including Guo (2009b), Choi et al. (2008) and Gao et al. (2014). However, the above-referenced papers only consider asymmetric information between the upstream and downstream players with respect to one aspect or 'parameter of the problem'. In contrast, our work allows for the coexistence of asymmetric information with respect to two parameters of the problem: actual product quality and consumer preference for quality. More specifically, the manufacturer is more informed about the actual product quality than the retailer while the latter is more informed consumers' quality preference than the manufacturer. We then investigate, as already discussed, the outcomes under the UMR and UQA sequences of information tactics by the two parties that can alleviate this two-way asymmetric information problem.

Although there are multiple methods (e.g., price signaling and screening) to resolve asymmetric information,[6] this paper focuses on voluntary information revelation mechanisms (Grossman and Hart, 1980; Milgrom, 1981; Jovanovic, 1982; Matthews and Postlewaite, 1985; Shavell, 1994; Guan and Chen, 2015). That is, the manufacturer can voluntarily and truthfully advertise/disclose his private quality information to the unknown consumer. In this stream of literature, Guo (2009b) also investigates the firm's equilibrium quality advertising strategy in a distribution channel, wherein either the manufacturer or the retailer can disclose the quality information to the consumer. Furthermore, this paper's consideration of the retailer's voluntary market research behavior follows the lead of Guo (2009a) who assumes a retailer can conduct costly market research to acquire a binary demand signal and then decides whether or not to share it with the supplier. Other papers also investigate the strategic effect of market research/information acquisition on firms' pricing ability (Chu and Messinger, 1997; Li et al., 1987; Vives, 1988) and competitive strategies (Yang et al., 2017). Unlike these papers, our work combines quality advertising by the manufacturer and consumer market research by the retailer in one model and explores the outcomes in two scenarios, UMR and UQA.

Notably, Guan and Chen (2017) also consider the same two information tactics in a distribution channel, but there are significant differences between their work and ours. First, unlike their setting in which the manufacturer controls and jointly decides both market research and quality advertising tactics, we assume that the two information tactics are controlled separately by the retailer and manufacturer respectively. In this sense, our paper sheds light on the manufacturer-retailer interactions from a channel perspective. Second, Guan and Chen (2017) actually investigate a newsvendor model in which the retailer has to pre-order from the manufacturer and personally carry the inventory risk. Under such circumstances, the manufacturer might cease market research to prevent the retailer's quality updating process, even though market research is costless. In contrast, we assume that the manufacturer and retailer jointly share the demand risk and can respectively undertake quality advertising and market research to improve the channel's information transparency. Therefore, in equilibrium, each firm always has the incentive to utilize the information tactic that it controls if its cost is sufficiently low. Finally, given this separation of quality advertising and market research, we can investigate the novel issue of the strategic impact of decision timing on the firms' information sharing decisions, which is absent in the work of Guan and Chen (2017). To our knowledge, the outcomes of decision timing of manufacturer-advertising and retailer-promotion has been widely investigated in the distribution channel (Sethuraman and Tellis, 2002; Dong et al., 2007; Sigue, 2008), but these papers do not incorporate asymmetric information. Although Gurnani and Erkoc (2010) also compare different contract types by assuming that the retailer has private sales effort information, they do not consider the change in decision timing. Fig. 1 summarizes the distinctive positioning of our article relative to the above-referenced papers within the related prior literature.

Model setting

A manufacturer sells his products to the end consumers through an independent retailer. Both the manufacturer and the retailer are risk neutral and aim to maximize their respective profits. The firms' marginal costs of operations and their respective utilities upon no trade are assumed to be zero. The mass of consumers in the market is normalized to one. Each consumer demands at most one unit of the product from the retailer, whose surplus from purchase is given by $V=\theta q-p$ where q denotes the product quality, and p is the retail price charged by the retailer. Consumer heterogeneity in willingness to pay or preference for quality is captured by the index θ, which is assumed to be uniformly distributed between 0 and 1/2 : $\theta \sim U[0, 1/2]$; or between 1/2 and 1 : $\theta \sim U[1/2, 1]$. This implies that the consumer preference for quality may fall into either a low-preference region: [0, 1/2], or a high-preference region: [1/2, 1] with equal probability.[7] The consumer knows her own precise quality preference (i.e., whether she belongs to the low or high preference region) whereas the manufacturer and the retailer do not know this without conducting market research. Therefore, both firms simply have a prior belief that the consumer's preference is uniformly distributed between zero and one, $\theta \sim U[0, 1]$. See Fig. 2 for graphical illustration.

Next, the product quality level is an unknown random variable for channel members at the outset, only known to be uniformly distributed between zero (lowest quality) and one (highest quality). Upon production, the manufacturer is informed of the true product quality before putting it on the market. The retailer and consumer, however, keep the same prior belief that $q \sim U[0, 1]$. This setting is the same as that assumed by Guo (2009b) and

[6] For a detailed discussion about price signaling or screening, one can refer to the excellent review of Chen (2003).

[7] This setting can be extended to a more complicated case in which there is overlap between the two ranges, i.e., a low region corresponding to [0, 3/4] and a high region corresponding to [1/4, 1] . A detailed analysis of this case is presented in Appendix B.

	Information asymmetry		Information transmission		Decision timing	Manufacturer-retailer interaction
	Upstream	Downstream	Market Research	Quality Advertising		
Guo and Iyer (2010)	*		*			
Mittendorf et al. (2013)	*		*			
Guo (2009b)		*	*			
Gao et al. (2014)	*		*			
Grossman and Hart (1980)		*		*		
Guo (2009)	*		*			
Guan and Chen (2015)		*		*		
Gurnani and Erkoc (2010)		*				*
Sethuraman and Tellis (2002)					*	*
Gurnani ta al. (2007)					*	*
Guan and Chen (2017)	*	*	*	*		
This paper	*	*	*	*	*	*

Fig. 1. Comparison with the related literature.

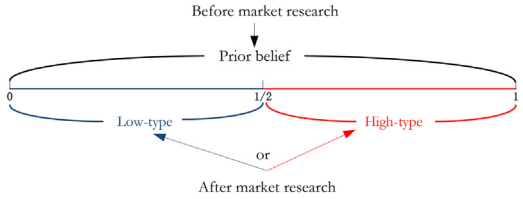

Fig. 2. Firms' belief about consumer preference before/after market research.

Guan and Chen (2017), reflecting the intuitive notion that the manufacturer would get to know the product quality before the retailer and consumer.

The manufacturer can disclose the product quality to the downstream actors via direct advertising, labeling or sample testing but incurs a constant cost c_d in making this disclosure. For example, the manufacturer needs to invest in product quality labeling and advertising (e.g., promotion of ISO 9000 certification of the product). We assume that if the manufacturer does undertake such advertising of quality then the disclosed quality information is truthful and is received as such by the retailer and the consumer. However, if the manufacturer withholds his product quality information then the retailer and the consumer make a rational inference about the product quality. This quality updating process follows the classic theory of voluntary quality disclosure/advertising in the economics and marketing literatures (Grossman and Hart, 1980; Milgrom, 1981; Guo and Zhao, 2009).

Downstream, the retailer may conduct market research to learn the consumer's preference for quality, via, e.g., personal interviews or online questionnaires. Let the corresponding cost of acquiring such information about the consumer be denoted by c_a. We assume that once the retailer conducts such market research, she can perfectly identify the correct region of quality preference in which her consumer falls. Moreover, when the manufacturer knows that the retailer has conducted market research as we assume here, he also can infer the precise information found by the retailer based on the latter's subsequent information disclosure behavior.[8] The rationale for this is as follows: Once the retailer acquires the precise information about the consumer's preference for quality, the retailer can choose to voluntarily share it with the manufacturer or remain silent. (As in Guo (2009b) it is assumed that the disclosed information is truthful and as a result, the retailer's information disclosure decision amounts to either revealing the truth or remaining silent.) However, in this game setting, if the retailer learns that the consumer's preference for quality (or willingness to pay) is low then she would choose to share that information with the manufacturer to induce the latter to decrease his wholesale price. Then, if the retailer learns that the consumer's preference for quality is high, she has an incentive to withhold that information to prevent the manufacturer from increasing his wholesale price. However, the manufacturer can also rationally infer the precise demand information from the retailer's disclosure behavior of the outcome from market research. That is, when receiving no information, the manufacturer immediately infers that the consumer preference for quality must be high; otherwise, the retailer should have already sent him the information that her consumer has a low preference for product quality. Consequently, one can confirm that in equilibrium, the retailer fully discloses to the manufacturer the information she gains about the consumer preference for product quality from her market research.

Incorporating the above reasoning, we now determine the equilibrium actions and results in each of two scenarios of information sharing in the channel: (1) UMR; and (2) UQA. Fig. 3 displays the sequence of actions and price decisions by the manufacturer and retailer in each of these two game scenarios.

To rule out the trivial cases when quality information is never shared by the manufacturer or when the retailer never conducts market research, it is necessary to require throughout the following analysis that the costs of quality advertising and market research are both positive but limited (specifically,

[8] Note that an alternative scenario of market research unobservable to the manufacturer will be discussed in Section 5.

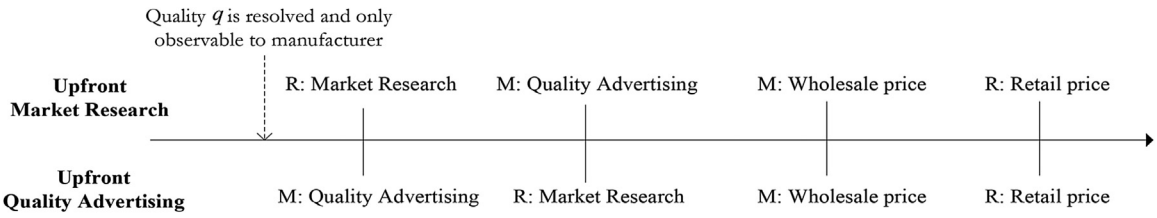

Fig. 3. Timings of the model.

$0 \le c_d \le 1/8$ and $0 \le c_a \le 1/64$, as will be shown later). When these restrictions are violated, no quality/consumer information will be disclosed/acquired in either of the two game scenarios. Moreover, to focus on the strategic impacts of product quality level and consumer preference for quality information sharing between the manufacturer and retailer, we exclude the signaling role of prices in our model. As indicated by many papers, the signaling effect of price would make our analysis almost intractable (Sgroi, 2002; Dellarocas, 2006; Guan and Chen, 2017).

A summary of our model notation is presented in Table 1.

Analysis

In this section, we investigate the manufacturer's and retailer's equilibrium quality advertising/market research and pricing decisions in the two game scenarios. Then, we examine how the change of decision timing in these scenarios can influence the firms' ex-ante payoffs.[9] For ease of exposition, we subsequently use the subscripts "*" and "#" to denote UMR and UQA scenarios, respectively.

Upfront market research (UMR scenario)

We first assume that the retailer's decision on market research, either to do or not to do it, is given and derive the corresponding quality advertising strategy of the manufacturer and both firms' equilibrium pricing strategies. Subsequently, the retailer's equilibrium market research decision is that which is profit-maximizing for herself.

Retailer chooses not to do market research upfront. If the retailer chooses at the outset not to conduct market research, both firms retain the same belief that the consumer's quality preference is uniformly distributed between [0, 1]. The next decision then is the manufacturer's product quality disclosure/advertising decision, i.e., to disclose the product quality or not. Following this decision, let the downstream retailer and consumer' updated belief about the actual product quality be denoted by $\tilde{q} = (q, \overline{q})$. That is, when the manufacturer chooses to advertise, i.e., disclose product quality, $\tilde{q} = q$ the actual level of product quality advertised by the manufacturer; and $\tilde{q} = \overline{q}$ is the updated quality expectation if the manufacturer chooses not to advertise, i.e., withholds the product quality information. Now, in line with previous literature of voluntary advertising/disclosure of quality (Jovanovic, 1982; Matthews and Postlewaite, 1985; Shavell, 1994; Guan and Chen, 2015), it follows that the manufacturer should advertise his quality information only if it is higher than a certain minimum level $q > \hat{q}_n^*$; otherwise, it is better for him to remain silent. That is, $\hat{q}_n^*$ denotes the cutoff level of quality at which the manufacturer is indifferent between advertising or not advertising product quality. Anticipating this, if the manufacturer does not do any advertising of product quality then the retailer and consumer believe the actual product quality must be below $\hat{q}_n^*$ thereby forming the quality expectation $\overline{q} = E[q|q < \hat{q}_n^*] = \hat{q}_n^*/2$.

Further, whichever is the value of the consumer's updated quality belief $\tilde{q}$, the consumer buys the product only if her net utility is positive, i.e., $\theta\tilde{q} - p > 0$, requiring the consumer's quality preference $\theta > p/\tilde{q}$ for a sale. Notably, when the retailer does not do any market research, both firms stay with the belief that the consumer preference for quality is uniformly distributed between zero and one, $\theta \sim U[0, 1]$. Then their expected payoffs are given by $\pi_m = w(1 - p/\tilde{q})$ and $\pi_r = (p - w)(1 - p/\tilde{q})$, where $P_r(\theta > p/\tilde{q}) = 1 - p/\tilde{q}$, representing the expected demand of the consumer. Then, upon deriving the two firms' equilibrium prices and payoffs, depending on whether the manufacturer chooses to advertise product quality or not, we obtain:

$$\begin{gathered}\text{When quality advertising is done :}\\ w = \frac{q}{2},\ p = \frac{3q}{4},\ \pi_m = \frac{q}{8} - c_d \text{ and } \pi_r = \frac{q}{16};\\ \text{When quality advertising is not done}\\ w = \frac{\hat{q}_n^*}{4},\ p = \frac{3\hat{q}_n^*}{8},\ \pi_m = \frac{\hat{q}_n^*}{16} \text{ and } \pi_r = \frac{\hat{q}_n^*}{32}.\end{gathered} \tag{1}$$

Consequently, because the manufacturer is indifferent between advertising the quality or not at $\hat{q}_n^*$, we can characterize the manufacturer's quality advertising strategy in the following lemma.

Lemma 1. *In the UMR scenario, when the retailer chooses not to do market research, the manufacturer advertises his quality information only if* $q > \hat{q}_n^*$, *where* $\hat{q}_n^* = \min(1, 16c_d)$.

Given the manufacturer's equilibrium quality advertising strategy (advertising the quality when $q > \hat{q}_n^*$), the manufacturer's and retailer's expected/ex-ante payoffs when the retailer

[9] Throughout the paper, where no confusion arises, the term ex ante (ex post) is used to represent the scenario before (after) the quality is learned by the manufacturer.

Table 1
Model notation.

Notation	Explanation	Notation	Explanation
q	Product quality.	$\overline{q}$	Expected quality conditional on no quality advertising.
θ_i	Consumer preference,$i \in (h, l)$.	$\hat{q}$	Quality advertising cutoff point.
p	Retail price.	Π_i	Ex-ante payoff, $i \in (r, m)$.
w	Wholesale price.	c_a	Cost of market research.
π_i	Ex-post payoff, $i \in (r, m)$.	c_d	Cost of quality advertising.
*, #	Subscripts to denote UMR and UQA scenarios.		
n, h, l	Subscripts to denote cutoff points under non-market research, high preference and low preference.		
a/na	Subscripts to denote market research (acquisition) and no market research(no acquisition).		
d/nd	Subscripts to denote quality advertising (disclosure) and no quality advertising (no disclosure).		

does not conduct market research in the first stage are given by

$$\Pi_m^{na*} = \underbrace{\int_0^{\hat{q}_n^*} \frac{\hat{q}_n^*}{16} dq}_{\textit{No quality advertising}} + \underbrace{\int_{\hat{q}_n^*}^1 (\frac{q}{8} - c_d) dq}_{\textit{Quality advertising}} \textit{ and } \Pi_r^{na*}$$

$$= \underbrace{\int_0^{\hat{q}_n^*} \frac{\hat{q}_n^*}{32} dq}_{\textit{No quality advertising}} + \underbrace{\int_{\hat{q}_n^*}^1 \frac{q}{16} dq}_{\textit{Quality advertising}} . \quad (2)$$

Retailer chooses to do market research upfront. Next, we investigate the channel members' equilibrium decisions when the retailer conducts market research initially. In this case, both firms can confirm the consumer type before making the product quality advertising and pricing decisions. Accordingly, we assign $\hat{q}_l^*$ ($\hat{q}_h^*$) to denote the cutoff point of actual product quality that makes the manufacturer indifferent between advertising it or not when the consumer preference for quality is low (high). Because the derivations of these cut-off levels is routine (similar to what we described in the previous sub-game), we relegate them to Appendix A and directly move to the firms' equilibrium strategies as expressed in the following lemma:

Lemma 2. *In the UMR scenario, if the retailer conducts market research:*

(1) *when the consumer preference is low, the manufacturer advertises his quality information only if* $q > \hat{q}_l^*$, *where* $\hat{q}_l^* = \min(1, 32c_d)$;
(2) *when the consumer preference is high, the manufacturer advertises his quality information only if* $q > \hat{q}_h^*$, *where* $\hat{q}_h^* = \min(8c_d, 1)$.

Lemma 2 shows that the manufacturer changes his quality advertising strategy after confirming the consumer's preference for quality. Specifically, noting that $\hat{q}_h^* < \hat{q}_l^*$, the manufacturer does quality advertising at a lower (higher) level of actual product quality when the consumer preference for quality is high (low). The intuition is that the manufacturer chooses to disclose product quality only if it can cover its disclosure cost. When the consumer preference for quality is high, the manufacturer can obtain a higher payoff with disclosure than when the consumer has a low preference for quality and hence the product quality cutoff for disclosure also becomes lower. Thus, the retailer's market research allows the manufacturer to strategically adjust its quality disclosure (advertising) strategy based on the identified consumer's preference type.

Building upon the firms' equilibrium strategies, we then derive the manufacturer's and retailer's ex-ante payoffs when the retailer conducts consumer market research:

$$\Pi_m^{a*} = \underbrace{\frac{1}{2}(\int_0^{\hat{q}_l^*} \frac{\hat{q}_l^*}{32} dq + \int_{\hat{q}_l^*}^1 (\frac{q}{16} - c_d) dq}_{\text{Facing the low-type consumer}}$$

$$+ \underbrace{\int_0^{\hat{q}_h^*} \frac{\hat{q}_h^*}{8} dq + \int_{\hat{q}_h^*}^1 (\frac{q}{4} - c_d) dq)}_{\text{Facing the high-type consumer}}; \quad (3)$$

$$\Pi_r^{a*} = \frac{1}{2}(\underbrace{\int_0^{\hat{q}_l^*} \frac{\hat{q}_l^*}{64} dq + \int_{\hat{q}_l^*}^1 \frac{q}{32} dq}_{\text{Facing the low-type consumer}}$$

$$+ \underbrace{\int_0^{\hat{q}_h^*} \frac{\hat{q}_h^*}{16} dq + \int_{\hat{q}_h^*}^1 \frac{q}{8} dq)}_{\text{Facing the high-type consumer}} - c_a.$$

Proposition 1. *In the UMR scenario, in equilibrium,*

(1) *if* $c_a < 1/128$, *the retailer conducts market research; otherwise, she does not conduct market research.*
(2) *When the retailer conducts market research, the manufacturer advertises the quality to the high-type consumer when* $q > \hat{q}_h^*$ *and advertises quality to the low-type consumer when* $q > \hat{q}_l^*$.
(3) *When the retailer does not conduct market research, the manufacturer advertises quality information to the consumer when* $q > \hat{q}_n^*$.

Proposition 1 derives the firms' equilibrium strategies in the UMR scenario, which are also illustrated in Fig. 4. It shows that

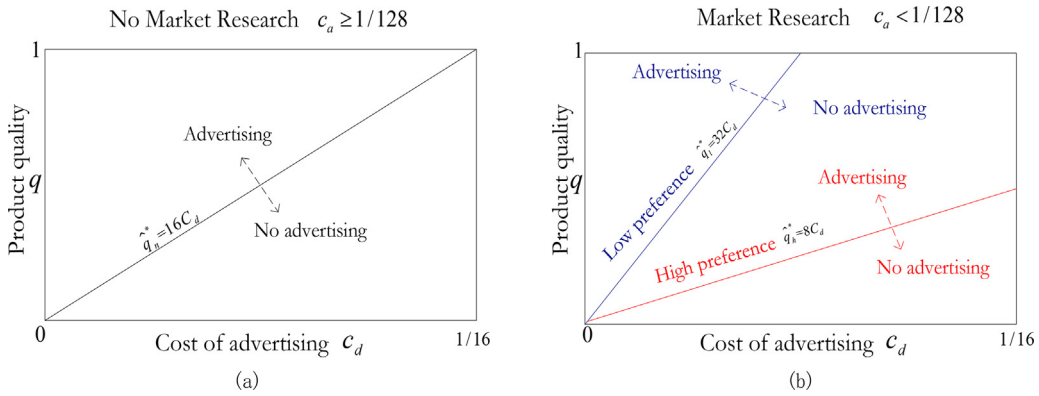

Fig. 4. The firms' equilibrium strategies in UMR scenario.

the retailer's equilibrium market research strategy exhibits a cut-off structure wherein she conducts market research only if its cost is lower than a certain level, $c_a < 1/128$. Note that under this scenario, the retailer makes the decision of market research at the very first stage so that the optimal market research strategy is driven by the comparison of her ex-ante/expected payoffs under two market research options. In contrast, as shown in Fig. 4, the manufacturer's optimal quality advertising strategy changes with the retailer's market research decision, i.e., whether she conducts market research or not. Moreover, if the retailer has conducted market research, the manufacturer's quality advertising strategy further adjusts to the identified quality preference of the consumer, which is shown in the subfigure in Fig. 4(b). In this sense, our analysis establishes the direct influence of the retailer's decision to do market research or not on the manufacturer's quality advertising strategy in the UMR scenario. We next investigate the firms' equilibrium strategies in the 'Upfront Quality Advertising' (UQA) scenario to see how they differ from those in the UMR scenario.

Upfront quality advertising (UQA scenario)

In this scenario, the manufacturer first makes his product quality revealing/advertising decision accounting for the retailer's and consumer's possible responses. Again, we assume that the retailer's and consumer's expectation of the product quality, based on the manufacturer's quality advertising decision, is expressed by $\tilde{q} = (q, \overline{q})$. However, it is worth mentioning that now, the updated quality expectation is no longer related to the consumer's preference for quality, since the manufacturer's quality advertising decision is made before learning the consumer's quality preference information. Following the similar approach as that in Section 4.1, we will derive the channel members' equilibrium decisions and outcomes when the manufacturer first chooses to advertise or not his product quality.

Manufacturer elects to do product quality revealing/advertising. If the manufacturer advertises the product quality in the first stage and the retailer conducts/reports consumer market research, then all the information is publicly shared in the distribution channel. When the retailer discovers consumer's preference to fall into the high region, $\theta \sim U[1/2, 1]$, the consumer buys the product when $\theta > p/q$. Thus, the manufacturer's and retailer's payoffs are $\pi_m = 2w(1 - p/q)$ and $\pi_r = 2(p - w)(1 - p/q)$. Thus, the equilibrium prices and payoffs are $w_h = q/2$, $p_h = 3q/4$, $\pi_m = q/4$ and $\pi_r = q/8$. However, if the retailer finds that the consumer preference is low, $\theta \sim U[0, 1/2]$, the firms' payoffs are given by $\pi_m = 2w(1/2 - p/q)$ and $\pi_r = 2(p - w)(1/2 - p/q)$, and their equilibrium prices and payoffs are $w_l = q/4$, $p_l = 3q/8$, $\pi_m = q/16$ and $\pi_r = q/32$. Combining the two possible payoffs based on the consumer type, we derive the firms' expected payoffs when the retailer conducts market research after the manufacturer advertises product quality.

$$\pi_m^{d-a\#} = \frac{1}{2}\left(\frac{q}{4} + \frac{q}{16}\right) - c_d \quad \text{and} \quad \pi_r^{d-a\#} = \frac{1}{2}\left(\frac{q}{8} + \frac{q}{32}\right) - c_a.$$

On the other hand, if the retailer does not conduct market research, both firms keep a prior belief that the consumer preference is uniformly distributed between zero and one: $\theta \sim U[0, 1]$. Therefore, the firms' expected payoffs are $\pi_m = w(1 - p/q) - c_d$ and $\pi_r = (p - w)(1 - p/q)$. This subsequently leads to the equilibrium payoffs

$$\pi_m^{d-na\#} = q/8 - c_d \quad \text{and} \quad \pi_r^{d-na\#} = q/16.$$

Therefore, if the manufacturer advertises the product quality upfront at q, the retailer will conduct market research only if $\pi_r^{d-a\#} > \pi_r^{d-na\#}$, in which the advertised quality must be sufficiently high to cover the market research cost, $q/64 > c_a$. This differs from that in the UMR scenario, because now the retailer's incentive of market research hinges on the quality level advertised by the manufacturer.

Manufacturer elects not to do product quality revealing/advertising. Alternatively, if the manufacturer chooses not to reveal his product quality information upfront, the retailer/consumer form a quality expectation $\overline{q}$ (whose value will be characterized later). Given this quality expectation, we can directly derive the firms' expected payoffs when the retailer subsequently chooses to do or not do market research. These results are shown below.

$$\begin{aligned} &\text{Market research is done :} && \pi_m^{nd-a\#} = \frac{5}{32}\overline{q} \quad \text{and} \quad \pi_r^{nd-a\#} = \frac{5}{64}\overline{q} - c_a. \\ &\text{Market research is not done :} && \pi_m^{nd-na\#} = \frac{1}{8}\overline{q} \quad \text{and} \quad \pi_r^{nd-na\#} = \frac{1}{16}\overline{q}. \end{aligned} \tag{4}$$

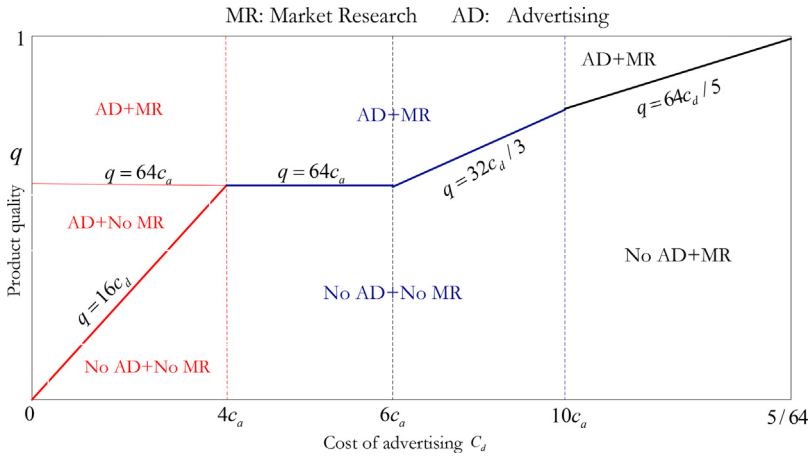

Fig. 5. The firms' equilibrium strategies in the UQA scenario.

Based on equation (3), the retailer conducts market research only if $c_a < \overline{q}/64$, which still depends on her expected quality of the product based on the manufacturer's decision to not do any product quality revealing advertising.

Finally, we move back to the first stage to derive the manufacturer's optimal quality advertising strategy. Note that the manufacturer's quality advertising strategy in equilibrium would also be conditional on the product quality, i.e., the manufacturer advertises quality only if the product quality is higher than a cutoff point $\hat{q}^{\#}$. Therefore, the consumer's and retailer's quality expectation when the manufacturer chooses not to do quality advertising meets the condition that $q = \hat{q}^{\#}/2$. The manufacturer's equilibrium quality advertising strategy is summarized in the following proposition.

Proposition 2. *In the UQA scenario, in equilibrium:*

(1) *If $c_d < 4c_a$, the manufacturer advertises the product quality information when $q > \hat{q}_3^{\#} = 16c_d$, and the retailer conducts market research only if the manufacturer advertises the quality information and the advertised quality $q > 64c_a$.*
(2) *If $4c_a < c_d < 10c_a$, the manufacturer advertises the product quality information when $q > \hat{q}_2^{\#} = \max(\frac{32c_d}{3}, 64c_a)$, and the retailer conducts market research only if the manufacturer advertises the quality information.*
(3) *If $c_d > 10c_a$, the manufacturer advertises the product quality information when $q > \hat{q}_2^{\#} = 64c_d/5$, and the retailer always conducts market research regardless of the manufacturer's quality advertising decision.*

Thus, comparing with Proposition 1, one sees an entirely new pattern of the two firms' equilibrium information strategies in the UQA scenario, which is also shown in Fig. 5. Specifically, the most significant difference is that now both the manufacturer's quality advertising and the retailer's market research decisions are determined by the balance between the costs of quality advertising (c_d) and market research (c_a). Recall the firms' equilibrium strategies in the UMR scenario: the retailer conducts market research only if its cost is above a fixed value at 1/128 and the manufacturer's quality advertising decision is only determined by the cost of quality advertising. Neither of these results, however, arises in the UQA scenario, which again highlights the pivotal role of decision timing on the firms' information strategies.

In particular, when the retailer's market research decision is made after observing the manufacturer's quality advertising behavior, she can better assess the product quality and thus make a more appropriate market research decision. In this case, the retailer conducts market research only if the updated quality belief, q or $\overline{q}$, is sufficiently high to cover her cost spent on market research. That is, the retailer conducts market research if $q > 64c_a$ when the manufacturer advertises the product quality or $\overline{q} > 64c_a$ when the manufacturer does not advertise it. Thus, if the cost of quality advertising is very low ($c_d < 4c_a$), the manufacturer would advertise the quality when it is above a low threshold $q > 16c_d$. In such circumstances, the retailer would do market research only if the disclosed quality $q > 64c_a$ but not do market research when the disclosed quality information is between ($16c_d$, $64c_a$). On the other hand, if the cost of quality advertising is very high ($c_d > 10c_a$), the manufacturer would be reluctant to advertise the product quality unless its level is sufficiently high. This means that even if the manufacturer chooses not to advertise his product quality, the retailer and consumer would form a high quality expectation inducing the retailer to proceed with market research despite the manufacturer withholding his quality information upfront.

The last subcase is when the cost of quality advertising falls into an intermediate range such that $4c_a < c_d < 10c_a$. One can see that now the retailer's market research decision matches the manufacturer's quality advertising decision. That is, if the manufacturer advertises (withholds) quality information, the retailer infers that the product quality is high (low) and conducts (ceases) market research. Moreover, we show that when $c_d \in (4c_a, 6c_6)$, the manufacturer advertises the quality when $q > 64c_a$, which implies that the cutoff point for quality advertising is no longer associated with the manufacturer's related cost but instead is determined only by the retailer's cost of market research. This is an unexpected result that has never been identified in prior liter-

ature. Note that at this quality cutoff point, the retailer's payoff remains unchanged regardless of which market research option she takes. Thus, it follows that the manufacturer has to advertise the product quality in order to provide the retailer sufficient incentive to undertake market research.

Payoff implication

In this subsection, we further examine which decision timing sequence, UMR or UQA, results in a higher ex-ante payoff for the manufacturer and the retailer. The following proposition indicates the respective outcomes under the two decision timing scenarios (see Appendix A for proof and tabulated summary of the ex-ante payoffs.)

Proposition 3. *The retailer's ex-ante payoff is always higher in the UQA scenario. The manufacturer's ex-ante payoff is higher in the UQA scenario when* $c_a > 1/128$ *or* $c_a < c_d/10$ *and* $5/88 < c_d < 1/16$*; otherwise, the manufacturer's ex-ante payoff is higher in the UMR scenario.*

Proposition 3 implies that the doing market research after the manufacturer makes his quality advertising decision is always beneficial to the retailer considering that the retailer's ex-ante payoff is always higher in the UQA scenario than in the UMR scenario. The intuition is that the retailer needs to weigh the value versus cost of conducting market research given the manufacturer's product quality. If the retailer is able to make this decision after observing the manufacturer's quality advertising behavior, she can make a more precise assessment of actual product quality and thereby a more informed market research decision than she would be able to in the UMR scenario, thereby achieving a higher ex-ante payoff.

However, whether the manufacturer's ex-ante payoff is higher in the UMR scenario or the UQA decision timing scenarios depends on the relative magnitudes of the costs of the respective information sharing actions. More specifically, the manufacturer's ex-ante payoff is always higher if the retailer conducts and shares her market research information before the manufacturer makes his wholesale price decision. However, in the UMR scenario, the retailer will not conduct market research if the cost of market research is higher than 1/128, because then her quality expectation of the product quality is only $q = 1/2$ which will not provide her sufficient expected return to cover her cost of market research. In contrast, in the UQA scenario, the retailer would still conduct market research as long as the manufacturer advertises that the product quality is above 1/2. In this case, the UQA scenario gives the manufacturer a chance to induce the retailer to conduct market research by providing information about his relatively high quality. The manufacturer can then make a more informed wholesale price decision that generates a higher expected return. In short, the manufacturer is better off under the UQA scenario when $c_a > 1/128$.

On the other hand, when the cost of market research is lower than 1/128, the retailer would always conduct market research upfront in the UMR scenario. This allows the manufacturer to design more precise wholesale price and quality advertising strategy according to the consumer type. Thereby, the manufacturer can achieve a higher ex-ante payoff in the UMR scenario than that in the UQA scenario, except when $c_a < c_d/10$ and $5/88 < c_d < 1/16$. Note that when c_a and c_d fall into this region, as shown in Proposition 2, the retailer would always adopt market research in even UQA scenario given the relatively low cost of market research. Then, the only difference between UQA and UMR is that the latter scenario endows the manufacturer with more flexibility in crafting his quality advertising strategy after observing the consumer's preference for quality. However, similar to the result of Guan and Chen (2017), we also show that more leeway regarding quality advertising can sometimes be detrimental to the manufacturer's payoff.[10] This is because if the consumer's quality preference is discovered to be high, the manufacturer has to advertise much more quality information which can significantly increase his quality advertising expenditure in this UMR scenario than in the corresponding UQA scenario,.

The above discussion uncovers some inherent differences between the UMR and UQA scenarios. Recalling our motivating example from the software industry, the reason why some companies post downloadable free software on their websites is to signal their relatively high quality to both the retailer and the consumers and thereby induce their authorized retailers to invest more in market research. In contrast, companies who delegate releases of free trials to retailers intend to use the consumer information thereby acquired by the retailer to make more efficient and targeted quality advertising and wholesale price decisions. Interestingly and importantly, our results reveal that there are conditions when the manufacturer and retailer can both prefer the same sequence of information sharing decisions. Our model analyses, therefore, provide theoretical justification for the diversity of decision timing arrangements observed in practice and offer guidance for channel members' information acquisition and sharing arrangements that can lead to improved information transparency, better outcomes for channel members, and greater channel coordination.

Model extension

A critical assumption in our paper is that the manufacturer can always make the rational inference about the consumer preference after observing the retailer's market research behavior. Specifically, if the manufacturer observes that the retailer has conducted market research but does not share what she discovers about the consumer preference for product quality with him, the manufacturer immediately infers that the consumer preference must be high. However, if the retailer privately undertakes market research that is unobservable to the manufacturer then the latter is unable to perfectly infer the consumer preference for product quality in the retail market. This situation is in fact quite prevalent in practice and in this section we investigate how

[10] Note that in Guan and Chen (2017), the authors show that a manufacturer's costless acquisition behavior would undermine his ex-ante payoff given that it may require the manufacturer to disclose more quality information to the consumers and increase the cost of disclosure to the manufacturer.

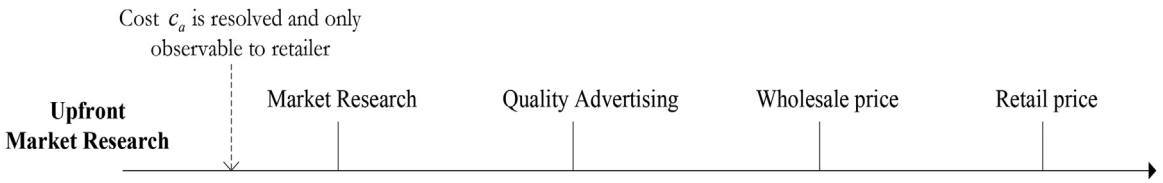

Fig. 6. Timings of unobservable market research under the UMR scenario.

the firms' equilibrium strategies may vary when the retailer's market research strategy is unobservable to the manufacturer.

To evaluate the impact of lack of observability of market research, we assume a similar setting as Guo (2009a) in which the cost of market research c_a can exhibit two possible values $c_a \in (c_a^l, c_a^h)$, a low cost c_a^l with probability λ and a prohibitively high cost c_a^h with probability $1-\lambda$, where $0 \le \lambda \le 1$. The retailer would not conduct market research if c_a^h is realized, e.g., because of the costs of data collection, analyses, and producing useful consumer insights. Thus, the retailer remains uninformed about the consumer preference for product quality in this case. On the other hand, if c_a^l is realized, the retailer may choose to become fully informed about the consumer preference via market research. As in our basic model, in making her market research decision, the retailer now needs to trade off the return from and cost of market research. Again, the values of c_a^l, c_a^h and λ are known to both the manufacturer and the retailer. However, only the retailer knows the actual cost of market research in her situation (either c_a^l or c_a^h). Conditional on her realization of c_a, the retailer decides whether or not to conduct market research but this decision is unobservable to the manufacturer. Given this modification of the basic model, it follows that if $\lambda = 1$ or $\lambda = 0$, the manufacturer is able to perfectly infer the retailer's market research strategy (conducting it when c_a^l is lower than a threshold or not conducting it when c_a^h is realized), and the model reduces to our basic model. Considering the more general case of a value of λ between 0 and 1, below we focus on the UMR scenario to investigate how unobservability of market research could influence the firms' equilibrium strategies and payoffs.[11] The UMR decision sequence in this model is shown Fig. 6.

It can be inferred that in equilibrium, the retailer would conduct market research only if c_a^l is realized and it is lower than some threshold c_a^{l*}. Otherwise, if $c_a^l > c_a^{l*}$, the retailer would not conduct market research. In anticipating this, the manufacturer would advertise the quality information when $q > 16c_d$ by assuming that the consumer quality preference is between zero and one, i.e., $\theta \sim U[0, 1]$.

Let us now assume that $c_a^l < c_a^{l*}$, the retailer conducts market research once a low cost is realized. Consequently, if the observed consumer preference is low, the retailer would voluntarily share this information with the manufacturer to reduce the wholesale price; whereas if the observed consumer preference is high, the retailer would remain silent. Anticipating this, if the manufacturer does not receive any information shared by the retailer, he cannot distinguish between the following two conditions. First, the retailer has no chance to conduct market research due to a high market research cost c_a^h, which happens with probability $1-\lambda$. Second, the retailer has conducted market research but found that the consumer preference is high, which happens with probability $\lambda/2$. Combining them together, the manufacturer can deduce the conditional probability for each condition after observing no information from the retailer and accordingly update his belief about consumer quality preference, where

(1) if retailer does not conduct market research

$$\theta \sim U[0, 1] \text{ with probability } \frac{1-\lambda}{(1-\lambda)+\lambda/2};$$

(2) if retailer conducts market research but consumer preference is high:

$$\theta \sim U[\frac{1}{2}, 1] \text{ with probability } \frac{\lambda/2}{(1-\lambda)+\lambda/2}. \quad (5)$$

The above discussion concludes how the observability of market research influences the manufacturer's speculation of consumer preference. Building upon this, we then derive the firms' equilibrium market research and quality advertising strategies in the following proposition.

Proposition 4. *In the UMR scenario and market research is unobservable to the manufacturer, in equilibrium,*

(1) *if* $c_a^l < c_a^{l*} = 1/128$, *the retailer conducts market research when low market research cost is realized. The manufacturer advertises the quality information when* $q > 32c_d$ *if the retailer shares the low consumer preference with him. Otherwise, the manufacturer advertises the quality information when* $q > 8c_d(2-\lambda)$ *if he does not receive any information from the retailer.*
(2) *If* $c_a^l > c_a^{l*} = 1/128$, *the retailer does not conduct market research, and the manufacturer advertises the quality information when* $q > 16c_d$.

In comparison with Proposition 1, one can verify that the retailer still prefers to conduct market research once its resolved cost is low, i.e., $c_a^l < c_a^{l*} = 1/128$. The intuition is similar to that in Proposition 1, i.e., the retailer needs to trade-off the value of conducting market research and its cost by keeping the quality expectation at 1/2. However, under such a circumstance the manufacturer can no longer craft quality advertising

[11] As will be shown later, the observability of market research mainly influences the manufacturer's quality advertising strategy instead of his wholesale price decision. Thus, in the UQA scenario in which quality advertising is performed first, the strategic effect of an unobservable market research vanishes.

strategies precisely due to the unobservability of retailer's market research behavior. Recalling Proposition 1, the manufacturer can always confirm the retailer's market research decision and thus design the appropriate quality advertising strategy according to the updated consumer preference (i.e., $\hat{q}_n^*$, $\hat{q}_l^*$ and $\hat{q}_h^*$). However, if market research is unobservable, the manufacturer can only confirm the low consumer preference once the retailer shares it with him after conducting market research. Otherwise, the manufacturer cannot confirm the consumer quality preference and thus advertises the quality information when $q > 8c_d(2-\lambda)$. This cutoff point $8c_d(2-\lambda)$ is just between $\hat{q}_h^*$ and $\hat{q}_n^*$: $\hat{q}_h^* < 8c_d(2-\lambda) < \hat{q}_n^*$, which implies that the manufacturer cannot confirm whether the retailer has observed a high consumer preference via conducting market research or has not conducted market research due to a high cost c_a^h. In either case, the manufacturer adopts less-targeted quality advertising strategy given that his inference regarding the retailer's market research decision (and also consumer preference) is less accurate. This also undermines the manufacturer's expected payoff in comparison to the UMR scenario.

Conclusion

This paper considers a manufacturer-retailer-consumer distribution channel and attempts to explain different approaches to information sharing and price coordination amongst channel members observed in practice. In our basic model, the manufacturer has private information about the product's quality that would be useful for the retailer and her consumer to know, while the retailer can research and learn the consumer's preference for product quality that the manufacturer would like to know. Note that both the manufacturer and retailer-consumer need to close their respective gaps in information in order for the manufacturer (retailer) to set his (her) profit-maximizing wholesale (retail) price. More specifically, the manufacture can, at a cost, advertise his private information about product quality while the retailer can do market research to learn the consumer's quality preference at some cost. Considering this setting, this paper investigates the outcomes under two information exchange timing scenarios: Upfront Market Research (UMR) scenario when the retailer decides on market research to discover the consumer preference for quality and then the manufacturer decides on the advertising of his product quality; and Upfront Quality Advertising (UQA) scenario when the manufacturer first makes his quality advertising decision and then the retailer decides her market research action. Although both decision sequences are apparent in practice, their implications for channel members' ultimate outcomes have not been systematically probed and presented in previous literature. Our analytical results in this paper are the first to shed light on the dramatic differences in outcomes that can be realized depending on which party moves first to bridge the information gaps in the channel.

More specifically, this paper uncovers strategic impacts of the decision timing on the firms' equilibrium information strategies and payoffs. We show that when the retailer conducts consumer market research first, it not only allows the manufacturer (retailer) to set more profitable wholesale (retail) price but also helps the manufacturer to adapt his quality advertising strategy to the consumer's preference for quality revealed by the retailer's market research behavior. In contrast, there are two effects if the manufacturer advertises his product's quality level first: specifically, the retailer and consumer form a higher expectation of the product's quality and the retailer's incentive to conduct market research is enhanced. The retailer is always better off by postponing her market research decision until she sees the manufacturer's decision on quality advertising as this allows her to make a more precise assessment of the product quality. However, from the manufacturer's perspective, either UMR or UQA decision timing could become his preferred scenario, depending on the relative magnitudes of the costs of quality advertising and market research. In particular, if the cost of market research is so high that the retailer would not do it upfront then the manufacturer can find it beneficial to move first with his advertising decision if his product quality is sufficiently high because, by doing so under this condition, the manufacturer is able to induce the retailer to conduct market research.

Our findings carry several implications for channel members' management of information strategies during the new product promotion process. First, they suggest that when the retailer's market research decision is made upfront, a manufacturer should carefully monitor the retailer's behavior and accordingly adjust his quality advertising strategy. In particular, a manufacturer should invest more (less) on quality advertising to enhance the consumer's quality expectation once the consumer quality preference is high (low). Second, when the manufacturer makes the quality advertising decision upfront, it allows the retailer to better infer the product quality and thus to make more precise market research decision. For example, a retailer can infer that the product quality is low when the manufacturer does not launch any quality advertising campaign, and consequently cease market research.

Third, the timing of the manufacturer's (retailer's) decision with respect to product quality advertising (market research), i.e., whether the decision sequence scenario is UQA or UMR, is evidently crucial to either firm's profitability. From the retailer's perspective, it is always better for her to make the market research decision after seeing the manufacturer's quality advertising decision. For the manufacturer, there are conditions related to the retailer's cost of market research when the UQA scenario in which he first makes the quality advertising decision results in better outcomes for him. Thus, we show that both the manufacturer and the retailer can be better off under the same UQA decision timing scenario under certain conditions. However, when the firms prefer different decision timings, some mechanisms to coordinate their informational moves are needed. For example, the manufacturer can offer to partially defray the retailer's cost of conducting market research or use a revenue sharing contract to balance their profits in the channel. Overall, our findings can provide guidelines for the firms to better arrange their corresponding information strategies to improve the level of information transparency and achieve higher payoffs in the distribution channel.

Like all model-based analyses, our work is subject to certain limitations. First, we have assumed that either the retailer or the manufacturer has to truthfully share her/his private information with the other firm. This truthful information revelation assumption is also made in previous papers by Guo (2009b) and Guan and Chen (2017). However, other papers allow for different mechanisms to resolve the asymmetric information problem. For example, the manufacturer can offer a menu of contracts to induce the retailer to reveal her private demand information – i.e., a screening game - or the manufacturer can signal his private quality information to the retailer via setting the wholesale price, - i.e., a signaling game. We have included a detailed discussion of a screening game-based analysis of our research problem in Appendix B. The signaling game is even more complicated, as the signaling effect of price may arise from both the manufacturer' wholesale price (to the retailer) and the retailer's retail price (to the consumer). Solving this challenging issue requires a fundamentally new investigation that we reserve for future research. Another limitation of our analysis is that we assume that both firms hold the same prior beliefs about the consumer preference towards the product. A more complex representation of information asymmetry about the demand side would be an interesting extension of our framework. Finally, this paper does not consider horizontal competition in either the downstream (between retailers) or upstream (between manufacturers). An investigation of a more complicated channel structure may lead to new and fruitful results.

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Appendix A. Proofs

Proof of Lemma 1. At $\hat{q}_n^*$, the manufacturer is indifferent between quality advertising and no quality advertising, thereby leading to the equilibrium function $\hat{q}_n^*/8 - c_d = \overline{q}_n/8 = \left(\hat{q}_n^*/2\right)/8$. Thus, the quality cutoff point of advertising $\hat{q}_n^* = \min(1, 16c_d)$.

Proof of Lemma 2. We start from the firms' pricing strategies when the consumer's quality preference is in the low region: $\theta \sim U[0, 1/2]$. The firms' expected payoffs can be given by: $\pi_m = w(1 - 2p/\tilde{q})$ and $\pi_r = (p - w)(1 - 2p/\tilde{q})$, in which $\tilde{q}$ could still exhibit two possible values: $(q, \overline{q})$, depending on whether the manufacturer advertises the quality information. Facing the low-type consumer, in equilibrium the wholesale price $w_l = \tilde{q}/4$ and the retail price $p_l = 3\tilde{q}/8$. This leads to the manufacturer's and retailer's expected payoffs: $\pi_m = \tilde{q}/16$ and $\pi_r = \tilde{q}/32$. Therefore, if the manufacturer advertises his quality to the low-type consumer, he can obtain a payoff $\pi_m = q/16 - c_d$. Otherwise, his payoff with no quality advertising is $\pi_m = \overline{q}/16$. Following the similar principle as that in the above case, we can derive the manufacturer's quality threshold for advertising $\hat{q}_l^* = \min(32c_d, 1)$, at which level the manufacturer is indifferent between two advertising options. This leads to the equilibrium function of $\hat{q}_l^*$, in which $\hat{q}_l^*/16 - c_d = (\hat{q}_l^*/2)/16$ and $\hat{q}_l^* = \min(1, 32c_d)$.

We then briefly introduce the firms' equilibrium quality advertising and pricing decisions when the consumer's quality preference falls into the high region: $\theta \sim U[1/2, 1]$. The analysis is routine so that we provide the manufacturer's wholesale price w_h and the retailer's retail price p_h directly: $w_h = \tilde{q}/2$ and $p_h = 3\tilde{q}/4$, which are the same as that in the no market research case. However, given a high consumer preference, the firms' expected payoffs become higher: $\pi_m = \tilde{q}/4$ and $\pi_r = \tilde{q}/8$. Thus, we can derive the manufacturer's quality advertising strategy when the consumer's quality preference is high. That is, the manufacturer advertises quality when $q > \hat{q}_h^*$, where $\hat{q}_h^* = \min(8c_d, 1)$; otherwise, he would withhold the quality information when $q \le \hat{q}_h^*$.

Proof of Proposition 1. We first identify the retailer's payoffs when she conducts market research or not, respectively. Thus, we have $\Pi_r^{a*} = 5/128 - c_a$ and $\Pi_r^{na*} = 1/32$. It is straightforward to see that the retailer's payoff is independent with the manufacturer's reaction, and she does not conduct market research when $c_a > 1/128$. Under this circumstance, the manufacturer chooses quality advertising when $q > \hat{q} = \min(16c_d, 1)$. Otherwise, if the retailer conducts market research, then the manufacturer's quality advertising cutoff point is $\hat{q}_h = \min(8c_d, 1)$ to the high-preference consumer or $\hat{q}_l = \min(32c_d, 1)$ to the low-preference consumer.

Proof of Proposition 2. The key step to derive the firms' equilibrium quality advertising and market research decisions is to identify the quality advertising cutoff point $\hat{q}^{\#}$, at which point the manufacturer would switch from no quality advertising to quality advertising. Thus, the proof is conducted over two steps. We first provide all the candidates of equilibrium quality advertising and market research strategies that could arise at the cutoff point. After that, we derive the essential conditions for each sustainable candidate.

At $\hat{q}^{\#}$, there are four possible information strategies for the manufacturer and the retailer. (1) The manufacturer does not advertise quality and retailer conducts market research when $q < \hat{q}^{\#}$ and the manufacturer chooses quality advertising and the retailer conducts market research when $q = \hat{q}^{\#}$, denoted by $nd - a \to d - a$. (2) The manufacturer does not advertise quality and the retailer does not conduct market research when $q < \hat{q}^{\#}$ and the manufacturer chooses quality advertising and the retailer conducts market research when $q = \hat{q}^{\#}$, denoted by $nd - na \to d - a$. (3) The manufacturer does not advertise quality and the retailer does not conduct market research when $q < \hat{q}^{\#}$ and the manufacturer chooses quality advertising and the retailer does not conduct market research when $q = \hat{q}^{\#}$, denoted by $nd - na \to d - na$. (4) The manufacturer does not advertise

Table A.1
The firms' ex-ante payoffs under the UQA scenario.

Condition	Cutoff point $\hat{q}^{\#}$	Manufacturer $\Pi_m^{\#}$	Retailer $\Pi_r^{\#}$
$c_a < c_d/10$	$64c_d/5$	$\frac{5}{64} - c_d(1 - \frac{64c_d}{5})$	$\frac{5}{128} - c_a$
$c_d/10 < c_a < c_d/6$	$32c_d/3$	$\frac{5}{64} - c_d(1 - \frac{32c_d}{3}) - \frac{16{c_d}^2}{9}$	$\frac{5}{128} - c_a(1 - \frac{32c_d}{3}) - \frac{8{c_d}^2}{9}$
$c_d/6 < c_a < c_d/4$	$64c_a$	$\frac{5}{64} - 64{c_a}^2 - c_d(1 - 64c_a)$	$\frac{5}{128} - c_a + 32c_a^2$
$c_d/4 < c_a < 1/64$	$16c_d$	$\frac{5}{64} - 64{c_a}^2 - c_d(1 - 16c_d)$	$\frac{5}{128} - c_a + 32c_a^2$

quality and the retailer conducts market research when $q < \hat{q}^{\#}$ and the manufacturer chooses quality advertising and the retailer does not conduct market research when $q = \hat{q}^{\#}$, denoted by $nd-a \to d-na$. Thus, it can be inferred that the condition (4) $nd-a \to d-na$ can never arise in equilibrium, in which the retailer's market research incentive should monotonically increases in her quality expectation.

We then derive the essential conditions for each possible equilibrium. (1) Under the condition of $nd-a \to d-a$, at $\hat{q}^{\#}$ because the manufacturer is indifferent between quality advertising and no quality advertising, we have $\pi_m^{d-a\#} = \pi_m^{nd-a\#}$ and $\pi_r^{d-a\#}|_{q=\hat{q}^{\#}} \geq \pi_r^{d-na\#}|_{q=\hat{q}^{\#}}$. The second inequality implies that the retailer must have enough incentive to conduct market research regardless of whether the manufacturer advertises quality or not. This subsequently leads to the condition that $\hat{q}^{\#} = 64c_d/5$ and $c_a \leq c_d/10$.

(2) Under the condition of $nd-na \to d-a$, there might be two equilibrium conditions at $\hat{q}^{\#}$. First, the manufacturer is indifferent between quality advertising and no quality advertising, and the retailer's payoff is higher with conducting market research when the manufacturer disclosed quality. Thus, $\pi_m^{nd-na\#} = \pi_m^{d-a\#}$ and $= \pi_r^{d-a\#}|_{q=\hat{q}^{\#}} \geq \pi_r^{d-na\#}|_{q=\hat{q}^{\#}}$, which leads to the condition that $\hat{q}^{\#} = 32c_d/3$ and $c_d/10 < c_a \leq c_d/6$. Second, the retailer is indifferent between conducting market research and no market research and the manufacturer's payoff is higher when the retailer conducts market research. This implies that the manufacturer must disclose a sufficiently high quality information to induce the retailer to conduct market research. Thus, $\pi_m^{nd-na\#} \leq \pi_m^{d-a\#}$ and $\pi_r^{d-a\#}|_{q=\hat{q}^{\#}} = \pi_r^{d-na\#}|_{q=\hat{q}^{\#}}$, which leads to the condition that $\hat{q}^{\#} = 64c_a$ and $c_d/6 < c_a \leq c_d/4$.

(3) The last condition is $nd-a \to d-na$. Under this circumstance, the manufacturer is indifferent between quality advertising and no advertising and the retailer would not conduct market research. This leads to the equilibrium conditions that $\pi_m^{nd-na\#} = \pi_m^{d-na\#}$ and $\pi_r^{d-a\#}|_{q=\hat{q}^{\#}} < \pi_r^{d-na\#}|_{q=\hat{q}^{\#}}$, in which $\hat{q}^{\#} = 16c_d$ and $c_d/4 < c_a \leq 1/64$. Combining all these possible conditions, we present the firms' equilibrium quality advertising and market research strategies in Proposition 2.

Proof of Proposition 3. Before comparing the firms' payoffs under two timing scenarios, let us first derive the firms' ex-ante payoffs under UQA scenario from Proposition 2. When $c_a < c_d/10$, the manufacturer's and retailer's ex-ante payoffs are given by

$$\Pi_m^{\#} = \underbrace{\int_0^{\hat{q}^{\#}} \frac{5}{32}\frac{\hat{q}^{\#}}{2} dq}_{\text{No-quality advertising + Market research}} + \underbrace{\int_{\hat{q}^{\#}}^1 \left(\frac{5q}{32} - c_d\right) dq}_{\text{Quality advertising + Market research}};$$

$$\Pi_r^{\#} = \underbrace{\int_0^{\hat{q}^{\#}} \left(\frac{5}{64}\frac{\hat{q}^{\#}}{2} - c_a\right) dq}_{\text{No-quality advertising + Market research}} + \underbrace{\int_{\hat{q}^{\#}}^1 \left(\frac{5q}{64} - c_a\right) dq}_{\text{Quality advertising + Market research}}.$$

Similarly, we can derive the firms' ex-ante payoffs under all conditions discussed above, and conclude them in the following table.

Given firms' ex-ante payoffs under the UQA scenario in Table A.1, we then compare them to the firms' ex-ante payoffs under the UMR scenario (shown in equations (2) and (3)). Because the comparion is routine and standard, we omit the details and present the result in Proposition 3.

Proof of Proposition 4. We first derive the manufacturer's equilibrium quality advertising strategy by given the retailer's equilibrium market research strategy. Notably, the retailer's market research strategy should exhibit a cutoff structure, in which she conducts it only if (1) c_a^l is realized and (2) c_a^l is lower than a threshold c_a^{l*}. Otherwise, if $c_a^l > c_a^{l*}$, in equilibrium the retailer would never conduct market research even though a low market research cost is realized. The manufacturer can also infer such a market research strategy from the retailer, so that he would choose quality advertising when $q > 16c_d$.

Now we assume that $c_a^l < c_a^{l*}$, two consequences would emerge. First, if the retailer shares the low consumer preference with the manufacturer, the firms' equilibrium pricing and quality advertising strategies remain the same as that in Section 4.1, wherein the manufacturer advertises the quality information only if $q > 32c_d$. Second, if the retailer remains silent, the firms' payoffs are given by

$$\pi_m = \frac{1-\lambda}{1-\lambda+\lambda/2} w\left(1 - \frac{p}{\tilde{q}}\right) + w\left(2 - \frac{2p}{\tilde{q}}\right)\frac{\lambda/2}{1-\lambda+\lambda/2},$$

and

$$\pi_r = \begin{cases} (p-w)(1-\frac{p}{\tilde{q}}), & \text{if } \theta \sim U[0,1]; \\ w(2-\frac{2p}{\tilde{q}}), & \text{if } \theta \sim U[\frac{1}{2},1]. \end{cases}$$

Building upon this, we can derive the firms' equilibrium prices and payoffs that $w = 1/2$, $p = 3/4$, $\pi_r = \frac{q}{8(2-\lambda)}$ and $\pi_m = \frac{q}{4(2-\lambda)}$. Thus, the manufacturer would advertise quality when $q \geq 8(2-\lambda)c_d$, in which his payoff remains indifferent between two quality advertising options at $q = 8(2-\lambda)c_d$.

We then derive the retailer's market research strategy by identifying c_a^{l*}. Note that there is no difference between market research and no market research at c_a^{l*}. If the retailer conducts market research at c_a^{l*} and finds that the consumer preference is low, he would share such information to the manufacturer. While if the observed consumer preference is high, the retailer remains silent. However, under such a circumstance, the manufacturer does not know whether the silent is driven by the high consumer preference or the high market research cost. Therefore, he would charge a price at $w = q/2$.

Building upon this, we can derive the retailer's ex-ante payoff with market research (when c_a^l is realized)

$$\Pi_r^a = \underbrace{\frac{1}{2}\left(\int_0^{32c_d} \frac{32c_d}{64}dq + \int_{32c_d}^1 \frac{q}{32}dq\right)}_{\textit{Low quality preference}}$$

$$+\underbrace{\frac{1}{2}\left(\int_0^{8c_d(2-\lambda)} \frac{8c_d(2-\lambda)}{16}dq + \int_{8c_d(2-\lambda)}^1 \frac{q}{8}dq\right)}_{\textit{High quality preference}} - c_a$$

$$= \frac{5}{128} - c_a,$$

and her payoff with no market research

$$\Pi_r^{na} = \frac{1}{2}\left(\int_0^{8c(2-\lambda)} \frac{8c(2-\lambda)}{16}dq + \int_{8c(2-\lambda)}^1 \frac{q}{8})dq\right) = \frac{1}{32}.$$

Thus, we can see that if $c_a^{l*} = 1/128$, there is no difference between conducting market research and no market research to the retailer. This completes the proof of Proposition 4.

Appendix B. Supplementary Data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jretai.2019.01.001.

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