On the Optimal Mode of Selling Goods with Uncertain Consumption Quality

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Abstract

We show that choosing a non-centralized distribution channel—that is, a retailer or an intermediary (e.g., sales representative, social media influencer)— instead of a centralized channel for selling goods with uncertain consumption quality can be optimal for a manufacturer as a self-commitment device. By this choice, the manufacturer can save costs from interacting with consumers (e.g., costs for sales activities). We derive conditions under which this self-commitment argument holds. In addition, we show that decentralized selling through a retailer can be even optimal if the manufacturer has to reimburse the retailer for the anticipated costs from consumer interaction, and if the manufacturer and the retailer simultaneously exert sales activities, which eliminates the self-commitment property of a retailer. In a second step, we discuss our self-commitment result under product competition, consumer naivety, product innovation, and product quality improvement.

Keywords: centralized channel, decentralized channel, intermediary, sales activities, self commitment.

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1 Introduction

One of the most fundamental decisions of a manufacturer concerns the optimal design of the channel management including the decision whether to sell via a centralized or a decentralized channel (e.g., Mathewson and Winter, 1984; Moorthy, 1988; Diao et al., 2023; Subramanian and Zhang, 2024). In case of centralized selling, the manufacturer directly sells the products to consumers and manages all interactions with them. In case of decentralized selling, however, the manufacturer sells the products to an independent third party (typically a retailer[1]) who, as the new owner of the products, determines prices and manages consumer interactions. In this paper, we examine the manufacturer's optimal channel choice for products whose consumption quality is uncertain. We show that for these products a manufacturer benefits from non-centralization by using a retailer (i.e., decentralization) or third-party services by intermediaries like sales agents and social media influencers as a self-commitment device not to invest in costly interaction with consumers.

Complex consumer goods like cars, boats, computers, cameras, smartphones, and other electronic gadgets, but also drugs, tourism, financial products, and health services are typically characterized by uncertain consumption quality (e.g., Crawford and Shum, 2005; Inderst and Ottaviani, 2012).[2] This quality uncertainty often comes from a kind of matching problem (Grunewald and Kräkel, 2017, 2022; Drugov and Troya-Martinez, 2019): On the one hand, the manufacturer who offers the consumers the good may have specific information about its features that are not perfectly known by the consumers. On the other hand, individual consumers may have preferences for certain features that are not perfectly known by the manufacturer. As a consequence, neither party has an informational advantage about the good's consumption quality, which can be described by a random variable for both parties. Anecdotal evidence indicates that particularly for such goods with uncertain matching or consumption quality the conjecture that centralized selling dominates decentralized selling because of the double-marginalization problem does not hold. As an example, Table 1 describes the use of centralized channels and non-centralized channels (e.g., retailers and intermediaries like sales agents) by Apple and Samsung to sell products like smartphones, tablets, and laptops. The table shows that a significant fraction of goods is not distributed through a

[1]For the purposes of this paper, the term retailer is used in a broad sense to include both conventional brick-and-mortar outlets and online retailers, sometimes referred to as e-tailers (see, e.g., Abhishek et al., 2016).

[2]Regarding the classification by Nelson (1970, 1974), these goods belong to the class of *experience goods* rather than the class of *search goods*: "A search good is one whose quality can be determined prior to purchase (but perhaps after costly search), whereas the quality of an experience good can be evaluated only after consumption occurs" (Bagwell, 2007, p. 1718). See also Dellarocas (2006) and Aköz et al. (2020).

Table 1: Sales Channel Distribution for Apple and Samsung (2014–2024).

	Apple		Samsung	
Year	Centralized	Non-centralized	Centralized	Non-centralized
2024	38%	62%	50%	41%
2023	37%	63%	46%	49%
2022	38%	62%	51%	46%
2021	36%	64%	51%	45%
2020	34%	66%	47%	48%
2019	31%	69%	46%	48%
2018	29%	71%	50%	44%
2017	28%	72%	46%	47%
2016	25%	75%	41%	54%
2015	26%	74%	39%	57%
2014	28%	72%	35%	60%

Sources: Annual reports of Apple[1] and Samsung[2]. The annual numbers at Samsung do not add up to 100%, as the Samsung category "other" does not allow for a clear assignment to either "Centralized" or "Non-centralized".
[1] https://investor.apple.com/sec-filings/default.aspx
[2] https://www.samsung.com/global/ir/reports-disclosures/business-report/

centralized channel.[3]

Goods with uncertain consumption quality are not only pervasive but, due to their complexity, also more expensive than other goods on average. For these reasons, consumers try to collect as much information as possible to better assess their expected utility from consuming the good. In particular, consumers update their beliefs about product quality based on the information provided by the entities with whom they interact. The entities can influence the flow of information by choosing sales activities like sales talks, lobbying, collecting consumer data, enhancing customer relationships, presenting products, and providing online information. Providing convincing information on the Internet for goods with uncertain consumption quality is quite difficult, so that the entities have to rely more on direct and costly interactions with consumers like sales talks and product presentations (e.g., Peterson et al., 1997; Kiang et al., 2000; Moen et al., 2003). The entities especially benefit from exaggerating the consumers' expected quality to boost sales (e.g., Dellarocas, 2006; Grunewald and Kräkel, 2017, 2022; Aköz et al., 2020). For example, negative experiences of previous consumers with the good can be understated, whereas positive experiences can be overstated during sales talks. Sales activities are also quite helpful for consumers as they

[3]Note that "centralization" is presumably overrepresented in the table as it relates to our usage since it includes B2B sales, whereas our setup focuses on B2C sales. In the annual reports of Samsung, the channel category "Special/direct sales" is identified as centralized selling, but the reports do not further specify what is meant by "Special", and "direct sales" also include B2B (e.g., Apple is listed as a major customer of Samsung), which is not considered in our paper.

reveal important information. Our model comprises both, the transmission of useful information to consumers, and endogenously chosen sales activities that positively bias the consumers' quality beliefs. We model the information flow by an informative signal that the entities send to the consumers via their sales activities. The content of this signal is determined by the true (but uncertain) match quality of the good, the entities' intensity of exaggerating the usefulness of the good, and some random error. The consumers cannot perfectly identify, which part of the information belongs to the true quality of the good, which part is pure exaggeration, and which part is random error, but they can use the informative signal for Bayesian updating of their quality beliefs.

Our analysis highlights a novel argument for the choice of decentralized selling by a manufacturer: In a perfect Bayesian equilibrium, rational consumers correctly anticipate the part of the informative signal that is built on pure exaggeration, so that they cannot be fooled.[4] Nevertheless, entities are forced to costly invest in sales activities to exaggerate the good's usefulness, because otherwise the consumers will downgrade their quality beliefs. In that situation, decentralized selling can be useful for a manufacturer as a self-commitment device not to invest in sales activities. Under decentralization, it is the retailer and not the manufacturer who directly interacts with the consumers and has to choose costly sales activities. This self-commitment device is not free of cost for the manufacturer, who suffers from the double-marginalization problem when selling to a retailer. Our results show that a manufacturer will prefer decentralization to centralized selling if the possible market demand that is induced by quality exaggeration and, thus, the returns from sales activities are large. Decentralization will also be beneficial if the marginal sales costs and the price elasticity are small. The latter leads to a large retail price and large expected sales in equilibrium. In all these situations, the manufacturer has high incentives to invest in sales activities in case of centralized selling and, therefore, clearly benefits from decentralization as a self-commitment device to avoid large sales costs. In our discussion, we point out that the manufacturer can even benefit from decentralization if the retailer requests a reimbursement of the anticipated sales costs from consumer interaction. In addition, we show that the use of an optimal two-part tariff leads to decentralization *strictly* dominating centralization—given that the retailer is not wealth-constrained. However, the crucial assumption of unrestricted wealth is not always satisfied in practice. Furthermore, our discussion reveals that decentralization can even dominate centralization if the manufacturer and

[4]The meta-study by Delvecchio et al. (2006) shows that on average sales promotion does not have an impact on consumers. According to Calfee and Ringold (1994), the majority of 70% of the consumers do not trust the information provided by advertising. In Section 5.2, we show that decentralization can also benefit the manufacturer as a self-commitment device if consumers are naive.

the retailer simultaneously exert sales activities, which eliminates the self-commitment property of a retailer.

In a further step, we discuss several extensions of the basic model to check the robustness of our main result. First, we analyze product market competition among two homogeneous manufacturers. Each of them has to choose between centralized and decentralized selling. The analysis shows that, compared to the basic model, competition makes the choice of decentralization more attractive to a manufacturer than choosing centralization. Intuitively, the manufacturers can use their wholesale prices to influence market behavior, so that competition additionally favors decentralization over centralization irrespective of whether products are substitutes or complements.

As a second extension, we assume consumers to be naive within the meaning of partially ignoring the fact that sales activities are used to systematically exaggerate the usefulness of the good. It turns out that consumer naivety may reduce or increase the relative advantage of using a retailer as a self-commitment device. Because the perceived product quality is higher for partially naive consumers than for fully rational consumers, market demand and, thus, expected sales are higher than in the basic model. Due to the double-marginalization problem, the manufacturer benefits less from this positive demand shift under decentralization than under centralized selling. On the other hand, boosted sales activities of a retailer can lead to considerably higher expected sales under decentralization. Overall, if the sales cost function is sufficiently flat, such that the incentives to choose sales activities are sufficiently high, then using decentralization as a self-commitment device will nevertheless be of primary interest to the manufacturer.

In a third extension, we show why a product innovation can boost the manufacturer's preference for decentralized selling. Here, product innovation means that the consumers' quality uncertainty increases. As a direct consequence, the consumers' desire for new information increases as well, so that the party that is responsible for interacting with the consumers heavily engages in sales activities. To avoid the corresponding high sales costs, the manufacturer prefers to use decentralization as a self-commitment device.

Fourth, we consider the effect of a quality improvement on the manufacturer's channel choice. We focus on the case of a publicly observable quality improvement, which makes the good clearly more attractive to consumers (e.g., a smartphone is equipped with a better camera or a more durable battery). Our results show that a quality improvement will additionally favor the use of decentralization from the manufacturer's perspective if the consumers' brand loyalty towards the good is low. In that case, overall demand for the good is low, and the party that is responsible for

interacting with the consumers has high incentives to increase market demand via sales activities. To prevent the respective high sales costs, the manufacturer better chooses decentralization instead of centralized selling.

Finally, we consider "hybrid selling" as a third possible selling mode, which comprises elements of both centralization and decentralization. Here, the manufacturer delegates interaction with consumers to an intermediary, but keeps the ownership of the products and, thus, control over pricing and sales. Examples of such intermediaries are sales agents, marketing agencies, and social media influencers. We are particularly interested in whether hybrid selling can serve as a better self-commitment device than decentralized selling. On the one hand, an intermediary effectively shields a manufacturer from interacting with consumers. On the other hand, hybrid selling is costly for the manufacturer, who has to pay the contractual costs for the intermediary. If these costs are sufficiently small, the manufacturer will prefer hybrid selling to centralized and decentralized selling. Manufacturer competition further strengthens this preference given that the products are substitutes. Unless the intermediary has a cost advantage when interacting with consumers, hybrid selling will lose its advantage as self-commitment device and is strictly dominated by centralization if consumers are naive. Both a product innovation and a quality improvement favors the use of hybrid selling over decentralization from a manufacturer's perspective. Intuitively, hybrid and decentralized selling both save the manufacturer's sales costs by avoiding direct interaction with consumers. However, the manufacturer benefits more from a demand increase implied by a product innovation and a quality improvement when using hybrid instead of decentralized selling due to the double-marginalization problem in the latter case.

The paper is organized as follows. Section 2 describes the related literature. Section 3 presents our basic model and structure of the game. Our main results of the basic model appear in Section 4. In Section 5, we extend our model in various directions in order to investigate the effects of competition, consumer naivety, product innovation, product quality improvement, and hybrid selling. In Section 6, we conclude our paper with a brief discussion of the predictions, robustness checks, and management recommendations that our results provide.

2 Related Literature

Our paper is related to two strands of the literature. First, there are strong parallels to the ongoing discussion whether a manufacturer should choose centralized or decentralized distribution channels.

As a traditional argument against decentralization, Spengler (1950) already pointed to the problem of double marginalization: Successive markups by the manufacturer and the retailer result in higher prices for the consumers compared to centralization, which leads to lower demand and, ultimately, lower profit for the manufacturer. The subsequent literature on this discussion has emphasized that decentralized selling can nevertheless be optimal if it is supplemented with vertical restraints like a two-part tariff (Mathewson and Winter, 1984; Tirole, 1988; Belleflamme and Peitz, 2015), if there is manufacturer competition (e.g., Zhao et al., 2009; Jerath and Zhang, 2010; Moorthy et al., 2018; Harutyunyan and Jiang, 2019), or if consumers have fairness concerns (Diao et al., 2023). Our paper adds to this discussion by introducing the new argument that a retailer can benefit a manufacturer by serving as a self-commitment device.

Second, our paper contributes to the literature on signal jamming (see Holmström, 1999), and, especially, signal jamming's application in advertising and related sales activities. For instance, Grunewald and Kräkel (2017) consider a model of informative advertising for complex goods where firms can jam consumers' signals on product quality before choosing prices at a second stage. Dellarocas (2006) and Aköz et al. (2020) analyze models in which firms can influence consumers' product quality expectations by strategically biasing the information the consumers collect through, e.g., product reviews.[5] Relatedly, Grunewald and Kräkel (2022) consider, as an application, a market of complex experience goods in which firms may invest in deceptive advertising or online review manipulation in stage one before competing in prices in the second stage. This application is one of several in a general framework that studies the relation between information manipulation incentives on one side, and the competitive environment as well as institutions guarding against information manipulation on the other. However, the previous signal jamming literature does not consider the channel discussion and does not highlight the self-commitment effect addressed in this paper.

3 The Basic Model

Consider a situation where a manufacturing firm produces a good, whose consumer utility is uncertain in advance and only revealed over time during its usage (Nelson, 1970, 1974). In particular, imagine complex consumer goods like cars, boats, drugs, computers, cameras, smartphones, or other electronic gadgets. Such goods often exhibit common quality uncertainty from the manufac-

[5] See also Mayzlin (2006); Chevalier and Mayzlin (2006); Anderson and Simester (2014); Mayzlin et al. (2014) on product review manipulation.

turer's and the consumers' perspective (e.g., Crawford and Shum, 2005; Grunewald and Kräkel, 2017; Drugov and Troya-Martinez, 2019). This quality uncertainty is based on the following matching problem: On the one hand, the manufacturer has better information about the good's specific (technical) features that are not perfectly known by the consumers. On the other hand, consumers may have specific preferences for certain features that are not perfectly known by the manufacturer. As a consequence, the good's consumption quality can be described by a random variable q. It is assumed that the distribution of q is common knowledge of the consumers and the manufacturer (or a retailer as a third party). Let q be normally distributed according to $q \sim N\left(\bar{q}, \sigma^2\right)$ with $\bar{q}$ denoting the good's expected quality and σ^2 its variance. Without loss of generality, the manufacturer has a constant production cost, being normalized to zero.

Because of the good's quality uncertainty, consumers are interested in additional information on the good's features, which can be provided via sales activities (e.g., sales talks, promotional events, informative websites, or advertising in general). These sales activities are offered by the party that directly interacts with the consumers, that is, either by the manufacturer itself (*centralized selling*) or by a retailer (*decentralized selling*). In each case, the consumers receive an informative signal[6]

$$s = q + \theta + a \tag{1}$$

about the unknown quality q with $\theta \sim N\left(0, \sigma_\theta^2\right)$ as exogenously given, random noise and $a \in [0, \bar{a}]$ denoting those endogenously chosen sales activities that are aimed at exaggerating the usefulness of the good with $\bar{a} \geq 0$ being finite. For example, during a sales talk, an overly high satisfaction of previous consumers with the good can be claimed. All in all, the signal s partially comprises true quality information but is also positively biased by the quality exaggeration. Although sales activities serve different purposes in practice, in the following, we focus on the information manipulation role of these activities. Consequently, we generally refer to the exaggerating part a when talking about sales activities. The consumers observe s and update their beliefs about q accordingly, but cannot directly observe the single realizations of the three variables at the right-hand side of (1). In other words, consumers cannot perfectly distinguish between true and distorted quality information, whereas the latter comes from both exogenous random error and endogenous exaggeration.[7]

[6]Such an additive structure of the signal with the following three components is widely used in the literature on information manipulation (see, e.g., Holmström, 1999; Grunewald and Kräkel, 2017, 2022; Aköz et al., 2020).

[7]Technically, sales activities in this context can be labeled as signal jamming, as they aim at influencing the consumers' quality beliefs (see, already, Holmström, 1999). For applications of the signal-jamming approach in advertising and quality exaggeration — in particular concerning goods with uncertain consumption quality — see, for example, Dellarocas (2006); Grunewald and Kräkel (2017, 2022); Aköz et al. (2020).

Sales activities are assumed to be costly, including opportunity costs of time and psychological costs of lying. The corresponding costs are described in monetary terms by the quadratic cost function $c(a) = \frac{\kappa}{2}a^2$ with $\kappa > 0$ being sufficiently large such that an interior equilibrium solution $a \leq \bar{a}$ is guaranteed.

The market, where the selling party (i.e., the manufacturer or a retailer) and the consumers interact, is characterized by the linear demand function

$$D(p) = 1 + d - \beta \cdot p \tag{2}$$

with $p \geq 0$ as the retail price and $\beta > 0$ representing the price elasticity. While a linear demand function is often used in the literature to derive explicit solutions (e.g., Fershtman and Judd, 1987; Sklivas, 1987), the price-independent component d, however, is added to the standard linear setup to capture the part of the market demand that is based on expected product quality. Hence, this component allows for an impact of the informative signal s and the underlying sales activities a on market demand. We assume that $d \in \{d_L, d_H\}$ with $d_H > d_L > 0$ and $1 + d_L$ being sufficiently large to guarantee $D(p) > 0$, and that the probability for the realization of $d = d_H$ is given by

$$P(d = d_H) = P(E[q|s] \geq \hat{q}).$$

$E[q|s]$ denotes the consumers' posterior expected quality of the good given the signal realization s, and $\hat{q}$ represents an exogenously given reference point; thus, $P(d = d_L) = 1 - P(E[q|s] \geq \hat{q})$.[8] In words, the higher the posterior expected quality of the good, the higher will be the probability that market demand $1 + d_L - \beta \cdot p$ increases by $\Delta d := d_H - d_L > 0$. This effect motivates the selling party to exert sales activities a, as these activities boost the consumers' beliefs in a higher product quality, which finally results in a higher market demand. To sum up, expected market demand is given by

$$E[D(p)] = 1 + d_L + \Delta d \cdot P(d = d_H) - \beta \cdot p.$$

Although the reference point $\hat{q}$ is assumed to be exogenous, it is important to discuss, which situations correspond to a low or a high value of $\hat{q}$. Recall that $\hat{q}$ belongs to the price inelastic

[8] It is not possible to directly integrate the posterior expected quality into the demand function, as such modeling can yield a demand of minus or plus infinity, due to the normally distributed random variables. Alternatively, one could assume a non-linear utility function of the consumers, let the posterior expected quality directly enter the consumers' utility function and, subsequently, derive the demand function. However, this would result in a more complex setting without leading to new insights.

part of expected market demand (i.e., $1 + d_L + \Delta d \cdot P(d = d_H)$). A specific value of the reference point may have different reasons. For example, $\hat{q}$ may reflect consumers' brand loyalty towards the considered good. If $\hat{q} < \bar{q}$, market inelastic demand will be high even if the posterior expected quality falls short of prior expected quality, but not below a critical threshold, $\hat{q}$. This feature of the good can be explained by *high brand loyalty* of the consumers.[9] Consequently, the parameter constellation $\hat{q} \geq \bar{q}$ can be interpreted as reflecting *low brand loyalty*, as the price inelastic demand will only be high under (weakly) increased quality expectations. Other reasons for a high value of $\hat{q}$ may include consumers' net income being high due to a current tax reduction. As a consequence, consumers more strongly focus on product quality compared to price, so that the consumers' quality standard $\hat{q}$ rises. Another reason for a high value of $\hat{q}$ may be new insights on the advantages from consuming higher quality, e.g., as in the case of drugs. To abbreviate the discussion of the model results, in the following we will apply the brand loyalty interpretation and speak of high (low) brand loyalty if $\hat{q} < \bar{q}$ ($\hat{q} \geq \bar{q}$).

The further assumptions and the timing of the game depend on whether the manufacturer decides in favor of centralized or decentralized selling. At the first stage of the game, the manufacturer chooses one of the two selling modes. The remaining stages proceed as follows.

(a) Suppose that the manufacturer has chosen centralization. Then, at stage two of the game, the manufacturer chooses sales activities a at cost $c(a)$, and decides on the retail price p. At stage three, the informative signal s is realized and observed by the consumers; the consumers form beliefs about a, and compute their posterior expected quality. Finally, at stage four, consumers' demand realizes according to (2), and the manufacturer and the consumers receive their payoffs.

(b) Suppose that the manufacturer has chosen decentralization. Now, at stage two, the manufacturer sets his wholesale price $w \geq 0$ for the retailer. At stage three, the retailer decides on sales activities a at cost $c(a)$, and chooses the retail price p. At stage four, signal s is realized and observed by the consumers, who form beliefs about a and compute the posterior expected quality of the good according to Bayes' rule. At stage five, consumers' demand realizes, and the manufacturer, the retailer, and the consumers receive their payoffs.

[9] In other words, we can argue that in this situation brand loyalty is considered high, because the consumers' prior expected match quality, $\bar{q}$, is so large that even bad news in terms of $E[q|s] < \bar{q}$ may not prevent a large demand. A stronger brand can also be modeled by a larger price difference in favor of a rival brand that is necessary for switching products (Raju et al., 1990; Agrawal, 1996). However, this concept can only be used when discussing the direct competition between rival products, which is not considered in our basic model.

Like the previous literature on strategic channel choice, we abstract from internal incentive problems at the manufacturer and the retailer. In addition, our analysis abstracts away from additional information asymmetries between the manufacturer and/or the retailer on the one side and consumers on the other side. In particular, in our model, the consumers observe the wholesale price if the manufacturer sells decentralized. The consumers can use this information to update their quality beliefs, so that they are fully informed about the retailer's incentives to exaggerate the good's usefulness.[10] We use pure strategy Perfect Bayesian Equilibria as a solution concept to our game.

4 Solution to the Basic Model

First, we solve for the optimal solutions in the two alternative selling regimes. In a second step, we compare the two outcomes to show, under which conditions decentralized selling dominates centralized selling from the manufacturer's perspective.

4.1 Centralized Selling

The game is solved by backward induction, starting with stage three, at which the consumers update their quality beliefs. Suppose, the consumers have observed the informative signal s. Given their prior expected quality, $\bar{q}$, the consumers' posterior expected quality can be computed as follows (DeGroot, 2005):

$$E[q|s] = \bar{q} + \frac{\sigma^2}{\sigma^2 + \sigma_\theta^2} (s - \bar{q} - \hat{a}) \tag{3}$$

with $\hat{a}$ as the consumers' equilibrium beliefs about the chosen sales activities. The updating formula (3) points out that the higher the uncertainty about the good's quality (i.e., the higher σ^2) and the more precise the signal (i.e., the higher $1/\sigma_\theta^2$), the larger will be the weight that the consumers use for updating. Intuitively, the higher quality uncertainty, the larger the consumers' desire for more information, and the more informative the signal, the more the consumers rely on this signal. The consumers will increase (decrease) their prior quality mean, $\bar{q}$, if the realized signal, s, exceeds (falls short of) the prior expected value of the signal, $E[s] = \bar{q} + \hat{a}$.

[10] The main insights of our model still hold in a more complex setting in which consumers only observe some informative signal on the wholesale price.

At stage two, the manufacturer anticipates that

$$P(d = d_H) = P\left(\bar{q} + \frac{\sigma^2}{\sigma^2 + \sigma_\theta^2}(s - \bar{q} - \hat{a}) \geq \hat{q}\right) \overset{(1)}{=} P\left(q + \theta \geq (\hat{q} - \bar{q})\frac{\sigma^2 + \sigma_\theta^2}{\sigma^2} + \bar{q} + \hat{a} - a\right)$$
$$= 1 - F\left((\hat{q} - \bar{q})\frac{\sigma^2 + \sigma_\theta^2}{\sigma^2} + \bar{q} + \hat{a} - a\right) \tag{4}$$

with F as cumulative distribution function (cdf) of the composed random variable $q + \theta$, and f as corresponding density. As both q and θ are normally distributed, the composed random variable is normally distributed as well with $(q + \theta) \sim N\left(\bar{q}, \sigma^2 + \sigma_\theta^2\right)$. The probability (4) shows that selling activities are beneficial for the manufacturer with respect to market demand, because $P(d = d_H)$ strictly increases in a. Moreover, as $\partial P(d = d_H)/\partial a|_{a=0} > 0$ and $c'(0) = 0$, it is always optimal for the manufacturer to choose strictly positive selling activities in equilibrium. The manufacturer simultaneously chooses a and p to maximize the expected profit

$$\Pi_M(a, p) = E[D(p)] \cdot p - c(a)$$
$$= \left(1 + d_L + \Delta d \cdot \left[1 - F\left((\hat{q} - \bar{q})\frac{\sigma^2 + \sigma_\theta^2}{\sigma^2} + \bar{q} + \hat{a} - a\right)\right] - \beta p\right) \cdot p - \frac{\kappa}{2}a^2. \tag{5}$$

Let the manufacturer's optimal decisions be denoted by a^* and p^*, and define

$$\Psi := (\hat{q} - \bar{q})\frac{\sigma^2 + \sigma_\theta^2}{\sigma^2} + \bar{q}.$$

Then, we obtain the following results:[11]

Lemma 1 *Suppose the following condition holds:*

$$\kappa > \frac{\Delta d}{2\beta}\left[\Delta d f(\Psi)^2 + \left|f'(\Psi)\right|(1 + d_L + \Delta d)\right]. \tag{6}$$

In equilibrium,

$$p^* = \frac{1 + d_L + \Delta d \cdot [1 - F(\Psi)]}{2\beta} \quad \textit{and} \quad a^* = \frac{\Delta d}{\kappa} \cdot f(\Psi) \cdot p^*, \tag{7}$$

and the manufacturer's expected profit is given by

$$\Pi_M(a^*, p^*) = \frac{1}{4\beta}(1 + d_L + \Delta d[1 - F(\Psi)])^2\left[1 - \frac{\Delta d^2}{2\beta\kappa}f(\Psi)^2\right] > 0. \tag{8}$$

[11] All proofs are relegated to the Appendix.

Condition (6) is a pure technical one to guarantee concavity of the manufacturer's objective function. (5) shows that, because of the cdf F, the expression in parentheses is neither a strictly concave nor a strictly convex function of a. To guarantee strict concavity of $\Pi_M(a,p)$, the cost function $c(a)$ has to be sufficiently convex, which is ensured by assuming that the cost parameter κ is sufficiently large.[12]

The intuition for the equilibrium sales activities, a^*, and the equilibrium retail price, p^*, in (7) has to take into account that both variables a and p interact in the objective function. As a consequence, $a^* = \frac{\Delta d}{\kappa} \cdot f(\Psi) \cdot p^*$ in equilibrium. Thus, the lower the marginal costs from sales activities (reflected by the cost parameter κ) and the higher the marginal returns from sales activities, $\Delta d \cdot f(\Psi) \cdot p^*$, the larger will be the optimal value of the manufacturer's sales activities. Here, $f(\Psi)$ measures the marginal impact of a on the probability to increase market demand by Δd in equilibrium. The additional sales from increased market demand are described by $\Delta d \cdot p^*$ in that case, which shows that a and p are complements in this respect.

The optimal value of the retail price, p^*, solves the well-known trade-off: on the one hand, a higher p decreases market demand, on the other hand it also increases the returns for each sold unit of the good. As usual, a higher price elasticity, β, implies a lower retail price in equilibrium. However, the component $\Delta d \cdot [1 - F(\Psi)]$ in the expression for p^* is non-standard. This component stems from the fact that the considered good is a good with uncertain consumption quality. It describes the expected market demand that is due to the consumers' quality beliefs and, hence, price inelastic. As the cdf F is monotonically increasing, the lower Ψ the higher will be $\Delta d \cdot [1 - F(\Psi)]$. The definition of Ψ shows that Ψ will (weakly) decrease with the weighting factor for Bayesian updating, $\frac{\sigma^2}{\sigma^2+\sigma_\theta^2}$, if and only if $\hat{q} \geq \bar{q}$, that is, if and only if the consumers' brand loyalty is low. The technical intuition can be best seen from the first line of the computation of the probability (4). If $\hat{q} - \bar{q} \geq 0$, it will be difficult (i.e., less likely) for the signal s to take a sufficiently high realization such that it exceeds the expected signal value *and* the reference point. However, given that the signal realization exceeds the expected signal value, a higher weight $\frac{\sigma^2}{\sigma^2+\sigma_\theta^2}$ — i.e., higher quality uncertainty and/or higher signal precision — increases the probability that the weighted signal realization $\frac{\sigma^2}{\sigma^2+\sigma_\theta^2} s$ also takes the hurdle that is given by the reference point, $\hat{q}$. In these situations, from an ex-ante perspective, a high weighting factor increases the likelihood that the price inelastic market demand will be high. Then, a larger retail price becomes optimal to benefit

[12] The same kind of technical problem is known from the theory of rank-order tournaments (see, e.g., Lazear and Rosen, 1981), where the contestants' objective functions also depend on a cdf, which captures the contestants' winning probability.

from higher sales for a given market demand. In the knife-edge case $\hat{q} = \bar{q}$, the weighting factor is eliminated in Ψ. Consequently, $1 - F(\Psi) = 1 - F(\bar{q}) = 1/2$ due to the symmetry of the probability distribution for $q + \theta$, so that the effect of quality uncertainty on the equilibrium retail price boils down to $\frac{1}{2}\Delta d$.

The manufacturer's expected equilibrium profits in (8) can be rewritten as follows (see the proof of Proposition 1):

$$\Pi_M(a^*, p^*) = \left(1 + d_L + \Delta d \cdot \left[1 - F\left((\hat{q} - \bar{q})\frac{\sigma^2 + \sigma_\theta^2}{\sigma^2} + \bar{q}\right)\right] - \beta p^*\right) \cdot p^* - c(a^*).$$

This presentation highlights that the retail price reflects the traditional trade-off as mentioned above, but that sales activities only lead to costs for the manufacturer in equilibrium. This observation is due to the fact that, in a Perfect Bayesian Equilibrium, the consumers correctly anticipate the manufacturer's sales activities for influencing the quality beliefs, so that $\hat{a}$ and a^* cancel each other out in equilibrium. For this reason, at first glance, it seems puzzling, why the manufacturer does invest in sales activities at all. The explanation is given by Holmström (1999) in his seminal signal-jamming paper on career concerns:[13] If the signal-jamming player (here: the manufacturer) chooses a lower value than a^*, the market's evaluation of the expected quality will be biased against him. Hence, in equilibrium, the manufacturer is trapped in exerting the sales activities that the market is expected of him. This kind of *equilibrium trap* will also be important for the subsequent results.

4.2 Decentralized Selling

Now, the consumers observe the realization of the informative signal s at stage four of the game, and the signal is based on sales activities of the retailer. The Bayesian updating process is identical to that in Section 4.1 and does not have to be repeated once again. At stage three, for a given wholesale price w, the retailer simultaneously decides on a and p to maximize expected profits

$$\Pi_R(a, p) = E[D(p)] \cdot (p - w) - c(a).$$

Let the optimal values be denoted by a^* and p^*. At stage two, the manufacturer anticipates a^* and p^*, and chooses w to maximize

$$\Pi_M(w) = E[D(p)] \cdot w.$$

[13] See also Dellarocas (2006).

Let the equilibrium wholesale price be denoted by w^*. Solving the game with a retailer by backward induction leads to the following results:

Lemma 2 *Suppose the following condition holds:*

$$\kappa > \frac{\Delta d}{4\beta}\left[2\Delta d f\left(\Psi\right)^2 + \left|f'\left(\Psi\right)\right|\left(1 + d_L + \Delta d\right)\right]. \tag{9}$$

In equilibrium,

$$w^* = \frac{1 + d_L + \Delta d\left[1 - F\left(\Psi\right)\right]}{2\beta} \quad , \quad p^* = \frac{3}{2}w^* \quad \textit{and} \quad a^* = \frac{\Delta d}{2\kappa} f\left(\Psi\right) w^*. \tag{10}$$

The retailer's expected profit is given by

$$\Pi_R(a^*, p^*) = \frac{\left(1 + d_L + \Delta d\left[1 - F\left(\Psi\right)\right]\right)^2}{16\beta}\left(1 - \frac{\Delta d^2}{2\beta\kappa} f\left(\Psi\right)^2\right) > 0, \tag{11}$$

and that of the manufacturer by

$$\Pi_M\left(w^*\right) = \frac{\left(1 + d_L + \Delta d\left[1 - F\left(\Psi\right)\right]\right)^2}{8\beta}. \tag{12}$$

Similar to (6) for the case of centralized selling, condition (9) guarantees that the objective function of the party that simultaneously decides on sales activities and the retail price is strictly concave in both dimensions. As in this scenario the retailer is the respective party, the concavity condition slightly differs from the one above. Again, the cost parameter κ has to be large enough such that the cost function $c(a)$ is sufficiently convex.

The presentation of the three equilibrium values in (10) has been chosen for brevity and not because both the retail price and the sales activities only interact with the wholesale price. On the contrary, the retailer's objective function, $\Pi_R(a, p)$, shows that all three variables interact, as the demand function, $D\left(p\right)$, depends on the sales activities. Hence, the marginal returns from investing in a are now determined by the difference between the retail and the wholesale price, so that the whole marginal returns are given by $\Delta d f\left(\Psi\right)\left(p^* - w^*\right)$ in equilibrium. On the other hand, again, incentives for sales activities are dampened by large values of the cost parameter κ.

In the situation considered in this section, there are two independent parties on the supply side — the manufacturer and the retailer. Consequently, we have to differentiate between two expected profits in equilibrium, being described by (11) and (12). The comparison of the two

expressions shows that the manufacturer's expected profits exceed those of the retailer, because $\Pi_R(a^*, p^*) = \frac{1}{2}(1 - \frac{\Delta d^2}{2\beta\kappa} f(\Psi)^2) \cdot \Pi_M(w^*)$.

4.3 Comparison of Centralized and Decentralized Selling

In this section, we compare the retail prices, the sales activities, and the manufacturer's expected profits in equilibrium for the two scenarios considered above. In particular the last comparison is essential for the manufacturer's choice of the selling mode at stage one of the game. For notational clarity, we use the subscripts *Cen* and *Dec* to denote the values of variables under centralized and decentralized selling, respectively, when necessary. The findings of Lemmas 1 and 2 yield:

Proposition 1 *In equilibrium,* $p^*_{Cen} < p^*_{Dec}$ *and* $a^*_{Cen} > a^*_{Dec}$. *The manufacturer will prefer decentralized selling to centralized selling if and only if*

$$\frac{\Delta d^2}{\beta\kappa} f(\Psi)^2 > 1. \tag{13}$$

Under centralized selling, the manufacturer faces the trade-off that a higher retail price decreases demand but increases the returns for each sold unit of the good. In case of decentralization, however, the retailer sets the price for the consumers. This retail price is larger than p^*_{Cen} because the retailer has to pay the wholesale price w^* to the manufacturer and, thus, requests a retail markup in order to still realize positive expected profits. In other words, consumers suffer from the well-known consequences of double marginalization under retailing. At the end of this section, we will discuss how vertical restraints by the manufacturer can be used to avoid the double-marginalization problem.

Sales activities are higher under centralized selling. From the discussion above, we know that the magnitude of the retail price determines the marginal returns from the chosen sales activities. As $p^*_{Cen} < p^*_{Dec}$, at first glance it seems puzzling that sales activities are higher under centralized selling than under decentralization. However, as the retailer has to pay w^* for each unit of the good to the manufacturer, the retailer's marginal returns from choosing a are determined by $p^*_{Dec} - w^* < p^*_{Cen}$, which explains why a^*_{Cen} exceeds a^*_{Dec}.

Proposition 1 shows that the manufacturer will prefer to sell decentralized if condition (13) is satisfied.[14] In that case, the manufacturer benefits from a kind of self-commitment by delegating

[14] Although the conditions (6) and (9) are only sufficient and may be much too strong, they can still hold together with condition (13).

sales activities to a third party — the manufacturer commits himself not to invest in a, which leads to a saving of $c(a^*_{Cen})$. Hence, condition (13) will be satisfied if a^*_{Cen} is sufficiently large. The magnitude of a^*_{Cen} is determined by the manufacturer's incentives to invest in sales activities in case of centralization. The larger the returns from successful sales activities as measured by Δd, the larger will be the incentives to invest in a and, thus, the larger $c(a)$. The smaller the price elasticity β, the larger will be the optimal retail price and, thus, realized sales, which increases the incentives to invest in a. A flatter cost function (i.e., a lower κ) also increases incentives for sales activities. The magnitude of the composed signal-jamming parameter Ψ, however, plays an ambiguous role, as the density f is not a monotonic function.

To sum up, by decentralization, the manufacturer saves costs $c(a^*_{Cen})$ by letting the retailer interact with the consumers, so that the former gets rid of the equilibrium trap described above. However, the disadvantage for the manufacturer is given by the fact that decentralization is accompanied by the problem of double marginalization, which leads to lower expected sales for the manufacturer in comparison to centralized selling. Thus, if the manufacturer's disadvantage from double marginalization is sufficiently small relative to $c(a^*_{Cen})$, he will prefer decentralization to centralization.

Under decentralized selling, the manufacturer transfers his products to the retailer for a specified wholesale price w per unit. So far, we have assumed that this transfer of property rights also gives full responsibility for selling to consumers to the retailer, who — as the new owner of the products — specifies the retail price p. Following this reasoning, decentralization perfectly works as a self-commitment device as shown above. However, in practice, manufacturers sometimes still invest in sales activities, although they do not directly interact with consumers. In that case, the self-commitment argument of Proposition 1 is eliminated. The following corollary points out that, nevertheless, decentralization can be helpful to the manufacturer when producing a good with uncertain consumption quality:

Corollary 1 *Suppose that the manufacturer and the retailer simultaneously choose sales activities at stage three in case of decentralized selling, and that both have the same cost function $c(a)$. Let $\hat{q} < \bar{q}$ and*

$$\kappa > \sqrt{\frac{\Delta d^3 f(\Psi)^2}{2\beta^2} \max\left\{\Delta d f(\Psi)^2 - f'(\Psi)\left(1 + d_L + \Delta d\left[1 - F(\Psi)\right]\right), 0\right\}} \tag{14}$$

be satisfied. The manufacturer will prefer decentralization to centralized selling if and only if

$$\frac{\Delta d^2}{\beta\kappa} f\left(\Psi\right)^2 > \frac{1+\sqrt{5}}{2}. \tag{15}$$

To simplify matters, Corollary 1 focuses on the case of $\hat{q} < \bar{q}$, as for this case the sufficient condition (14) guarantees that all second-order conditions for the manufacturer's and the retailer's optimization problems are satisfied.

Although inequality (15) is stricter than inequality (13) in Proposition 1, it can still be satisfied if $c(a^*_{Cen})$ is sufficiently large. In other words, selling via a retailer can be even beneficial to a manufacturer without the self-commitment effect and despite the double-marginalization problem. On the contrary, the double-marginalization problem now leads to an advantage for the manufacturer. As, due to double marginalization, the manufacturer receives lower sales under decentralization than under centralization, his incentives to invest in sales activities under Corollary 1 are clearly lower than his corresponding incentives under Proposition 1. Hence, via decentralization the manufacturer now saves sales costs exactly *because of* the double-marginalization problem. If this saving is larger than the sales reduction due to double marginalization, decentralization will be optimal even without self-commitment.

As alternative scenario, imagine that the manufacturer chooses decentralization as a self-commitment device like in the basic model but, up-front, offers the retailer a reimbursement of the anticipated sales costs, $c(a^*_{Dec})$ (e.g., because the retailer has some bargaining power in this respect, or the manufacturer wants to invest in a long-term, more complex relationship with the retailer). Such reimbursement reduces the manufacturer's advantage from self commitment, but the choice of decentralization can still be beneficial to the manufacturer, because $a^*_{Dec} < a^*_{Cen}$, implying $c(a^*_{Dec}) < c(a^*_{Cen})$:[15]

Corollary 2 *If the manufacturer up-front compensates the retailer for $c(a^*_{Dec})$ in case of decentralized selling, the former will prefer decentralization to centralized selling if and only if $\frac{\Delta d^2}{\beta\kappa} f\left(\Psi\right)^2 > \frac{4}{3}$.*

The intuition for this result stems from the fact that, different to Corollary 1, now the retailer has lower incentives to invest in sales activities compared to the manufacturer under Proposition 1. Thus, again, the general disadvantage of double marginalization turns into an advantage concerning sales costs, $c(a^*_{Dec})$. As a consequence, compensating the retailer for his sales costs under decentral-

[15]The inequality $\Pi_{M,Dec}\left(w^*\right) - \frac{\kappa}{2}(a^*_{Dec})^2 > \Pi_{M,Cen}\left(a^*_{Cen}, p^*_{Cen}\right)$ can be computed by using the previous results (8), (12), and (10).

ization is less expensive for the manufacturer than directly investing in a under centralized selling. The comparison of the two corollaries shows that the condition of Corollary 2 is less restrictive than the condition of Corollary 1. Intuitively, the retailer under Corollary 2 faces a lower profit margin and, thus, lower returns from sales effort than the manufacturer under Corollary 1. Corollary 2 highlights that decentralization may not only have a positive effect on the manufacturer's expected profit, but may also enhance overall efficiency by the welfare gain $c(a^*_{Cen}) - c(a^*_{Dec})$.

Finally, the literature on decentralized selling has shown that the use of vertical restraints by a manufacturer (e.g., a two-part tariff) can be helpful to mitigate or even eliminate the inefficiencies of decentralized selling (Mathewson and Winter, 1984; Tirole, 1988; Belleflamme and Peitz, 2015). Allowing for a two-part tariff that consists of an optimal wholesale price, w^*, and an optimal lump-sum payment, L^*, yields the following result:

Corollary 3 *If the retailer is not wealth-constrained, the manufacturer will strictly prefer decentralized selling to centralization. The manufacturer offers the retailer a two-part tariff* $(w^* > 0, L^*)$ *with* L^* *amounting to the anticipated retailer's expected gross profit from selling to the consumers minus his costs from exerting sales activities.*

It is a standard result that the manufacturer can eliminate the double-marginalization problem from decentralization via a two-part tariff — given that the retailer is not wealth-constrained. In that case, the manufacturer specifies a wholesale price to the amount of marginal production cost (which is zero in our setting) and a lump-sum payment that fully extracts the anticipated retailer profit from selling to consumers. As $w = 0$, the retailer chooses the same retail price as the manufacturer under centralized selling, and the corresponding market profits accrue to the manufacturer via the lump-sum payment. However, the findings of Corollary 3 show that, in our setting, the manufacturer prefers a wholesale price that is strictly larger than marginal production cost. The intuition for this result is the following. A two-part tariff with $w = 0$ would imply that the retailer's incentives to exert sales activities are the same as the manufacturer's under centralization. As a consequence, the retailer would end up with the same high sales costs $c(a^*_{Cen})$, and the lump-sum payment equals the manufacturer's expected net profit under centralization, $\Pi_{M,Cen}\left(a^*_{Cen}, p^*_{Cen}\right)$. In other words, decentralization would no longer work as a self-commitment device, and the manufacturer would be indifferent between centralized and decentralized selling. Corollary 3 shows that the manufacturer is better off by a wholesale price strictly above marginal cost. $w^* > 0$ balances the cost of double marginalization and the aforementioned equilibrium trap.

It optimally fine-tunes the retailer's incentives for exerting sales activities to maximize the overall net surplus from selling to the consumers.

As emphasized above, such kind of solution — which is called "selling the vertical structure" by Tirole (1988, p. 176) — will only be feasible if the retailer is not wealth-constrained and, hence, able to pay the respective lump-sum payment up-front. This important prerequisite is in strict analogy to the one in principal-agent hidden-action models, in which implementing the first-best solution under a risk-neutral agent via a selling-the-firm contract requires that the agent is not wealth constrained (see, e.g., Laffont and Martimort, 2002, pp. 154–155). However, such crucial assumption of unrestricted wealth is not always satisfied in practice. Thus, for the remainder of the paper, we abstract away from two-part tariffs to focus on our self-commitment argument.

5 Extensions

In this section, we extend the basic model in several directions and investigate the effect of these on the results of Proposition 1. That is, for each of the extensions presented in this section, we show how these affect the manufacturer's preferred mode of selling. First, we analyze product market competition, where products are either substitutes or complements. Second, we divert from the assumption of fully rational consumers, who are able to perfectly anticipate sales activities in equilibrium. In particular, we analyze a setting in which consumers are naive in the sense that they underestimate the amount of quality exaggeration. Third, we investigate the impact of product innovation. Fourth, we analyze the impact of a product quality improvement. Finally, we introduce hybrid selling as a third mode of selling. Here, the manufacturer contracts with an intermediary to interact with the consumers.

5.1 Competing Manufacturers

In this section, we analyze how product market competition affects a manufacturer's preferred kind of selling. Consider the case in which a manufacturer i faces competition from another manufacturer j who offers a good that is similar to manufacturer i's good. The goods' retail prices are denoted by p_i and p_j, respectively. To make the results of this section comparable to those of the basic model, we assume that the two products' uncertain qualities, q_i and q_j, follow the same normal distribution $N\left(\bar{q}, \sigma^2\right)$. Following McGuire and Staelin (1983), Moorthy (1988, p. 338) and Choi (1991, p. 275), we model product market competition by adding the term $\alpha\beta p_j$ to the expected demand for the

good of manufacturer i and vice versa for manufacturer j. The parameter $\alpha \in [-1,1]\backslash\{0\}$ measures the degree of substitutability between the two goods.[16] We call the products complements if $\alpha < 0$ and substitutes if $\alpha > 0$. Hence, the expected demand for product i is given by

$$E[D_i(p_i, p_j)] = 1 + d_L + \Delta d\left[1 - F\left(\Psi + \hat{a}_i - a_i\right)\right] - \beta p_i + \alpha\beta p_j, \tag{16}$$

with a_i denoting the selling entity i's sales activities and $\hat{a}_i$ as the consumers' equilibrium beliefs about a_i. From equation (16), we can see that the expected demand for product i is directly influenced by the retail price of product j. If the two products are substitutes (i.e., $\alpha > 0$), the expected demand of product i is increasing in the retail price of product j. If the two products are complements (i.e., $\alpha < 0$), the expected demand of product i is decreasing in the retail price of product j.

At the beginning of the game, both manufacturers simultaneously decide between centralized and decentralized selling. The subsequent stages are identical to those of the basic model, assuming that the players have common knowledge about the previous decisions and again decide simultaneously. We obtain the following results:

Proposition 2 *Suppose the following condition holds:*

$$\kappa > \frac{\Delta d}{\beta}\left[\frac{\Delta d}{2} f\left(\Psi\right)^2 + \left|f'\left(\Psi\right)\right|(1 + d_L + \Delta d)\right]. \tag{17}$$

There only exist symmetric equilibria. Both manufacturers choose centralized selling if and only if

$$\frac{4 - 3\alpha^2}{4 - 2\alpha^2} \geq \frac{\Delta d^2}{\beta\kappa} f\left(\Psi\right)^2, \tag{18}$$

and both choose decentralized selling if and only if

$$\frac{\Delta d^2}{\beta\kappa} f\left(\Psi\right)^2 \geq 2 - \frac{8(2-\alpha)(2+\alpha)(2-\alpha^2)^3}{(4-\alpha-2\alpha^2)^2(4+\alpha-2\alpha^2)^2}. \tag{19}$$

Compared to the basic model, competition additionally favors decentralized selling over centralized selling.

Similar to the previous analysis, the technical restriction (17) is only a sufficient condition that

[16] We exclude $\alpha = 0$, as in that case both products are again independent of each other and the results of the basic model apply.

guarantees concavity of a manufacturer's objective function.

Technically, the final conclusion of the proposition follows from the fact that the left-hand side of (18) and the right-hand side of (19) are both smaller than one. Thus, the first equilibrium condition is satisfied for a smaller parameter space and the second equilibrium condition for a larger parameter space than condition (13) of Proposition 1, which guarantees dominance of decentralization over centralization.

The economic intuition for this finding can be explained as follows. Suppose that the two products are substitutes (i.e., $\alpha > 0$), so that the retail price of each product has a positive impact on the expected demand for the other product. In that case, optimal expected sales are larger under centralization compared to the basic model. This effect boosts optimal sales effort and, hence, sales costs under centralization in combination with manufacturer competition. Consequently, decentralized selling becomes more attractive as self-commitment device to avoid sales costs. By the same kind of argument, decentralization seems to be less attractive under manufacturer competition if products are complements (i.e., $\alpha < 0$). However, there is a countervailing effect. The retail price under decentralized selling increases more in α than the wholesale price set by the manufacturer, which has a hampering effect on expected demand. Hence, keeping everything else constant, this provides a direct cost of decentralization in case of product substitutability and a benefit of decentralization in case of product complementarity. The reason that the benefit of decentralization outweighs the costs regardless of whether the products are complements or substitutes is that competition allows the manufacturer to set a higher wholesale price under decentralized selling. If the products were independent (i.e., $\alpha = 0$), as we have shown in Section 4, this wholesale price would be identical to the retail price set by the manufacturer under centralized selling. However, with competition, the manufacturer can set a higher wholesale price under decentralized selling. If the products are substitutes (i.e., $\alpha > 0$), the manufacturer anticipates that the retail price of the competing product depends positively on the retail price of his own product, which itself is increasing in the wholesale price of his product. In turn, this allows him to set a wholesale price that is higher than would be the retail price of his product under centralization. If the products are complements (i.e., $\alpha < 0$), the manufacturer anticipates that the retail price of the competing product depends negatively on the retail price of his own product. Hence, the manufacturer indirectly decreases the retail price of the competing product by setting a wholesale price of his own product higher than would be the retail price under centralization, and thereby decreases the negative effect of the competing product on the demand of his product. In turn, this subdues the negative effect on expected

demand under decentralized selling. Hence, the manufacturer will additionally favor decentralized selling over centralized selling regardless of whether the products are complements or substitutes. The finding that the manufacturer will additionally prefer decentralized selling to centralized selling if the products are substitutes is in line with the results of McGuire and Staelin (1983), who analyze how product substitutability affects the market structure and find that manufacturers will prefer decentralized selling when the products are highly substitutable.[17]

5.2 Consumer Naivety

In this section, we consider the case of consumer naivety. Until now, we have assumed that the consumers correctly anticipate the equilibrium sales activities, so that $\hat{a}$ and a^* coincide. Hence, an equilibrium trap arises, which results in the manufacturer or the retailer exactly exercising the sales activities that are expected by the market. We now consider the possibility that the consumers are naive in the sense that they underestimate the degree of signal jamming, i.e., the consumers form beliefs $\hat{a}$ satisfying $\hat{a} < a^*$.[18] For the comparison between centralization and decentralization, we analyze the effect of naivety by considering a marginal decrease of $\hat{a}$ at $\hat{a} = a^*$. However, the proof shows that the manufacturer's equilibrium profits will be monotonic in naivety, so that our comparative-static analysis does not address a negligible effect. Moreover, the findings of this section show that decentralized selling can benefit the manufacturer as a self-commitment device even under full naivety of consumers. In particular, the proof of the following proposition shows that, in case of centralization, the manufacturer's sales activities under (partially and fully) naive consumers are larger compared to rational consumers, as sales activities have an impact in equilibrium given consumer naivety. Hence, the manufacturer now saves even more costs via decentralized selling.

Proposition 3 *Suppose that, under decentralization, the manufacturer's optimal wholesale price, w^*, is described by the respective first-order condition. Then, the introduction of slight naivety in terms of $\hat{a} < a^*$ will additionally favor the use of centralization over decentralization if and only if*

$$\frac{1 + d_L + \Delta d \cdot [1 - F(\Psi)]}{2\beta} > \frac{1}{2}\left[1 - \frac{\partial a^*_{Dec}}{\partial \hat{a}}\right] \cdot w^* \tag{20}$$

[17] The authors do not consider the case of complements.

[18] As a consequence, naive consumers have too optimistic quality expectations in equilibrium. Consumer naivety is also modeled via incorrect quality perceptions elsewhere in the literature (e.g., Glaeser and Ujhelyi, 2010; Hattori and Higashida, 2012; Gamp and Krähmer, 2022). Similar to our setting, Daughety and Reinganum (2008); Baumann and Rasch (2020), and Gupta (2023) assume that naive consumers do not (correctly) update quality beliefs.

with $w^* < p^*_{Cen}$ *and* $\partial a^*_{Dec}/\partial \hat{a} < 1$.

The proof of Proposition 3 points out that the expected demand for the good increases under each selling mode when introducing consumer naivety. First, the expected demand is boosted by the effect that consumers underestimate the amount of signal jamming in equilibrium, such that their quality expectations are too optimistic. Second, there is an indirect effect that reinforces the first effect. Anticipating that consumer behavior is now influenced by signal jamming in equilibrium may additionally motivate the retailer to invest in sales activities under decentralization, which then further boosts consumer demand because of higher quality expectations.

According to Proposition 3, introducing consumer naivety can lead to a comparative advantage of centralization over decentralization. First, the double-marginalization problem of decentralization prevents that the manufacturer fully captures the advantage of increased demand induced by consumer naivety. Second, contrary to the basic model, the optimal wholesale price falls short of the manufacturer's optimal retail price under centralization in case of consumer naivety (i.e., $w^* < p^*_{Cen}$).[19] This effect additionally reduces the manufacturer's demand-enhancing advantage of consumer naivety when choosing decentralization. Technically, the left-hand side of (20) denotes p^*_{Cen} according to (7). The right-hand side of (20) will be smaller than the optimal wholesale price w^* if the indirect effect on the retailer described in the previous paragraph is negligible (i.e., $\partial a^*_{Dec}/\partial \hat{a} \to 0$). As the proof of the proposition shows, this will be the case if κ is sufficiently large. Intuitively, in this situation the retailer has generally very low incentives to exert sales effort. If, however, the indirect effect on the retailer is sufficiently large — i.e., $\partial a^*_{Dec}/\partial \hat{a}$ is negative and has a sufficiently large absolute value — this reinforcing indirect demand effect will heavily boost the retailer's incentives to invest in sales activities and, hence, in expected sales, so that naivety will favor the use of decentralization by the manufacturer.

Overall, it is important to emphasize that the possible advantage of centralization only refers to a relative advantage of centralization over decentralization under consumer naivety. Considering absolute profits, it will still be beneficial to the manufacturer to use decentralization instead of centralization to avoid high sales costs if κ is sufficiently small.

[19] The proof shows that, under decentralization, the manufacturer prefers a rather small wholesale price to induce higher incentives to the retailer for choosing sales activities.

5.3 Product Innovation

This section considers the possibility that the manufacturer introduces a product innovation. Typically, ex ante, there is uncertainty about whether the consumers are comfortable with the innovation or not. Recall that we consider a good, whose quality, q, is uncertain and distributed according to $q \sim N\left(\bar{q}, \sigma^2\right)$. Introduction of a product innovation in our context means that quality uncertainty becomes larger from the consumers' perspective.[20] Hence, we can model the introduction of an innovation by a comparative-static analysis with respect to σ^2. As we are primarily interested in the effect of product innovation on the manufacturer's preferred kind of selling and the innovation does not depend on the kind of selling, we neglect possible innovation costs for the manufacturer in the following. The manufacturer's main motivation for introducing a product innovation is a positive impact on expected sales. The following result shows, under which conditions a product innovation boosts expected sales for both kinds of selling:

Lemma 3 *The introduction of a product innovation (i.e., an increase in σ^2) will weakly increase the manufacturer's expected sales for both kinds of selling if and only if the consumers' brand loyalty is low ($\hat{q} \geq \bar{q}$).*

Intuitively, in case of high brand loyalty, expected market demand for the good is already high, so that the introduction of a product innovation cannot really improve the market situation. Only if the consumers' brand loyalty is low, positive quality information can increase market demand and, thus, expected sales. A more technical intuition for the result of Lemma 3 is highlighted by the first line of expression (4), which becomes

$$P\left(d = d_H\right) = 1 - F\left(\Psi\right) = P\left(\frac{\sigma^2}{\sigma^2 + \sigma_\theta^2}\left(q + \theta - \bar{q}\right) \geq \hat{q} - \bar{q}\right) \tag{21}$$

in equilibrium. From this expression and the proof of the lemma, we know that expected sales will increase with σ^2 if and only if $F\left(\Psi\right)$ decreases with σ^2. Hence, the probability described by (21) increases. If σ^2 and thus quality uncertainty increases, consumers will more heavily rely on newly arriving information and use a higher weighting factor for Bayesian updating, $\frac{\sigma^2}{\sigma^2+\sigma_\theta^2}$. If the hurdle $\hat{q}-\bar{q}$ is negative, a higher weight $\frac{\sigma^2}{\sigma^2+\sigma_\theta^2}$ has either no impact on the probability (21) (if $q+\theta \geq \bar{q}$) or a negative impact (if $q+\theta < \bar{q}$). Only if the hurdle $\hat{q}-\bar{q}$ is positive, a higher weight $\frac{\sigma^2}{\sigma^2+\sigma_\theta^2}$ can have a positive impact on the probability (21) — namely, in case the realized signal value is favorable in the

[20] See, similarly, Aron and Lazear (1990). Our notion of product innovation also follows the extensive literature on risk taking in innovation races (e.g., Klette and de Meza, 1986; Cabral, 2003).

sense that it exceeds the expected signal in equilibrium: $s > \bar{q} + \hat{a} \Leftrightarrow q + \theta + a > \bar{q} + \hat{a} \Leftrightarrow q + \theta > \bar{q}$. In words, the latter condition means that the quality information from the informative signal s implies that the posterior expected product quality exceeds the prior one (see (3)). If this is the case, a higher weight on Bayesian updating yields a positive effect on expected sales.

In the next step, we will analyze, which kind of selling benefits most from a product innovation (i.e., from an increase in σ^2) — given that the innovation leads to increased expected sales, as it would not be part of a rational firm strategy otherwise. We obtain the following result:

Proposition 4 *Suppose brand loyalty is low ($\hat{q} \geq \bar{q}$). A product innovation will additionally favor the use of decentralization over centralization if and only if*

$$(\hat{q} - \bar{q})^2 > \frac{\sigma^6}{\left(2\sigma_\theta^2 + \sigma^2\right)\left(\sigma_\theta^2 + \sigma^2\right)}. \tag{22}$$

Although the manufacturer's expected sales increase by a product innovation under both kinds of selling in case of low brand loyalty, the innovation nevertheless works differently under centralization and decentralization. Under centralization, the manufacturer directly sells to consumers and realizes sales costs $c(a^*_{Cen})$, which are influenced by the product innovation. Under decentralization, the manufacturer does not sell to consumers but to a retailer and saves the sales costs $c(a^*_{Cen})$. These differences and the fact that expected sales differ between the two kinds of selling explain, why the introduction of a product innovation has an impact on the manufacturer's preference for decentralization versus centralization.

Proposition 4 shows that a product innovation will additionally favor decentralized selling over centralization if $\hat{q} - \bar{q}$ is sufficiently large and $\frac{\sigma^2}{\sigma^2 + \sigma_\theta^2}$ sufficiently small, which can be seen from condition (22). The technical intuition is the following. Under the described parameter values, Ψ is quite large, such that the normal density $f(\Psi)$ is evaluated at the right-hand tail and, thus, takes a very small value. Consequently, in the initial situation, the manufacturer's sales costs $c(a^*_{Cen}) = c(\frac{\Delta d}{\kappa} f(\Psi) p^*_{Cen})$ are quite small. Hence, the manufacturer's advantage from self-commitment via decentralization — i.e., saving costs $c(a^*_{Cen})$ — is quite small as well. If, in this initial situation, the manufacturer introduces a product innovation, the increase in σ^2 will boost both $f(\Psi)$ and $1 - F(\Psi)$, which considerably increases $c(a^*_{Cen})$.[21] Thus, in the given situation, the product innovation amplifies the manufacturer's self-commitment effect of avoiding costly interaction with consumers, which explains the finding of Proposition 4.

[21] Recall that p^*_{Cen} increases with $1 - F(\Psi)$.

Less technically, if initially there exists a very low brand loyalty — i.e., the reference point $\hat{q}$ is considerably larger than the prior expected quality $\bar{q}$ —, the chance to achieve a high demand via investing in sales effort a is quite low. Hence, the motivation to exert a is low as well. If now the manufacturer introduces a product innovation (i.e., σ^2 increases), the consumers' quality uncertainty and, thus, their desire for new information will increase.[22] As a consequence, the party that is responsible for selling to customers will strongly engage in sales effort. To avoid the corresponding high sales costs, the manufacturer better decides to delegate interacting with consumers to a retailer.

5.4 Quality Improvement

We now consider the case that the quality of the product rises, that is, $\bar{q}$ increases, but the uncertainty, as measured by σ^2, remains the same. Such an effect may be the result of improving the manufactured good in a manner that is well-known to the consumers. For instance, suppose that the manufacturer is selling smartphones and can improve the battery life by implementing a new and more efficient processor, which is produced by a third party. Such an improvement increases the expected quality of the good, which is reflected in a higher $\bar{q}$. Analogously to the previous section, we analyze the impact of a quality improvement on the manufacturer's preferred kind of selling. Hence, we neglect possible costs for the manufacturer in the following. In general, the manufacturer appreciates a higher product quality because of its positive impact on the consumers' demand. As a preliminary result, the following lemma shows that a quality improvement boosts expected sales for centralized and decentralized selling:

Lemma 4 *The introduction of a quality improvement (i.e., an increase in $\bar{q}$) weakly increases the manufacturer's expected sales for each kind of selling.*

The intuition for this result is straightforward. A higher expected quality of the good implies an increase in the consumers' posterior expected quality, $E[q|s]$, which, in turn, increases the probability of high demand, d_H. Consequently, the manufacturer's expected sales increase.

We obtain the following impact of a quality improvement on the manufacturer's preferred kind of selling:

Proposition 5 *A quality improvement will additionally favor the use of decentralized selling over centralized selling if and only if $\hat{q} > \bar{q}$.*

[22] In other words, the weight for Bayesian updating becomes larger.

Proposition 5 shows that a quality improvement will additionally favor decentralized selling over centralization if brand loyalty is low. The manufacturer faces the following trade-off. On the one hand, if the threshold $\hat{q}$ is larger than the prior expected quality, $\bar{q}$, the current quality expectation will not be high enough to trigger a high market demand. In that situation, an increase of $\bar{q}$ considerably boosts the manufacturer's incentives to exert sales effort, which would lead to high costs $c(a^*_{Cen})$. Keeping all other factors constant, this effect reinforces the manufacturer's benefit from avoiding costly interaction with consumers by choosing decentralization. On the other hand, an increase in $\bar{q}$ increases expected sales under each selling mode (Lemma 4). However, due to the double-marginalization problem, this effect is less strong for selling under decentralization than for centralized selling.

5.5 Hybrid Selling

Instead of centralization and decentralization, the manufacturer may prefer to delegate interaction with consumers to an external party (i.e., an intermediary), but retain ownership of the products and, hence, control over pricing and sales. We call this alternative mode of selling "hybrid selling", as it comprises elements of both centralization and decentralization. Typical examples of intermediaries in hybrid selling include commissioned sales agents (e.g., insurance brokers, pharmaceutical representatives), marketing agencies (e.g., external sales agents, field marketing firms), and social media influencers. We assume that the intermediary is risk-neutral and has the reservation value $\bar{u} \geq 0$.[23] In analogy to the assumption of publicly observable wholesale prices under decentralization, we assume that the consumers observe the intermediary's compensation in case of hybrid selling.[24]

In this section, the manufacturer can freely choose between centralization, decentralization, and hybrid selling at stage one. In case of hybrid selling, at stage two, the manufacturer decides on the retail price p and offers an incentive contract (S, r) to the intermediary. This contract comprises a fixed payment S,[25] and a commission rate $r \in [0, 1]$ as a fraction of realized sales, $p \cdot D(p)$.[26] At

[23]The assumption of risk-neutrality can be justified by the empirical findings of Ackerberg and Botticini (2002), Hilt (2008), and Bellemare and Shearer (2010), who document that, typically, less risk averse and risk neutral individuals sort themselves into more risky jobs, e.g., as sales reps. The proofs will show that our main results exactly hold for a risk-averse intermediary. Hence, this assumption only serves to simplify the presentation.

[24]If, for example, the intermediary is a social media influencer, this assumption can be justified by disclosure rules for advertising via social media posts (see, e.g., Mitchell, 2021; Janssen and Williams, 2024; Ershov and Mitchell, 2025).

[25]We will see that our main results will hold irrespective of whether the intermediary is unlimitedly or limitedly liable, i.e., whether the fixed payment S can be freely chosen or has to satisfy $S \geq 0$.

[26]The contract describes the typical pay scheme for a sales rep. It also captures the situation of a social media influ-

stage three, the intermediary decides whether to accept or reject the manufacturer's contract offer. In case of rejection, the game ends for the intermediary, who receives his reservation value $\bar{u}$. In case of acceptance, at stage four, the intermediary chooses the sales activity a as a hidden action at cost $c(a)$. Thus, the manufacturer faces a typical moral-hazard problem. At stage five, signal s is realized and observed by the consumers, who form beliefs about a and compute the posterior expected quality of the good according to Bayes' rule. At stage six, consumers' demand realizes, and the manufacturer, the intermediary, and the consumers receive their payoffs.

Suppose that the manufacturer has chosen hybrid selling at stage one. In that case, for a given retail price and a given incentive contract (S, r) that satisfies the intermediary's participation constraint, the intermediary chooses sales activities at stage four to maximize expected utility

$$EU(a) = S + r \cdot E\left[D\left(p\right)\right] \cdot p - c\left(a\right).$$

The manufacturer anticipates the optimal sales activities, a^*, and simultaneously decides on the retail price and the incentive contract to maximize expected profits

$$\Pi_M\left(p, S, r\right) = \left(1 - r\right) E\left[D\left(p\right)\right] \cdot p - S.$$

Let the manufacturer's optimal decisions be denoted by p^* and (S^*, r^*). Then, we obtain the following results for hybrid selling:

Lemma 5 *In equilibrium, the manufacturer offers the incentive contract* $(S^*, r^*) = (\bar{u}, 0)$ *to the intermediary, and sets the retail price*

$$p^*_{Hyb} = \frac{1 + d_L + \Delta d \cdot \left[1 - F\left(\Psi\right)\right]}{2\beta},$$

while the intermediary chooses sales activities $a^* = 0$. *The manufacturer's expected profits in equilibrium are*

$$\Pi_M\left(p^*_{Hyb}, S^*, r^*\right) = \frac{\left(1 + d_L + \Delta d \cdot \left[1 - F\left(\Psi\right)\right]\right)^2}{4\beta} - \bar{u},$$

and the intermediary's expected utility is given by $EU(a^*) = \bar{u}$.

encer, who often receives fixed pay that is independent of sales (pay-per-post, gifts, compensation for user-generated content), but also pay for performance (see, e.g., Stubb et al. (2019); Janssen and Williams (2024), as well as https://tipalti.com/resources/learn/influencer-payments/ and https://stackinfluence.com/influencer-compensation-models/).

The lemma shows that the manufacturer chooses zero incentives for the intermediary in equilibrium. This outcome seems too extreme at first sight. However, our finding can be explained by the fact that we consider a stylized model that only focuses on the sales activities in the interaction with the consumers. In the real world, an optimal incentive contract typically specifies some minimum incentives. Thus, our optimal incentive contract should be interpreted as a contract with very low-powered incentives in the real world. The intuition is the following. The manufacturer anticipates the above-mentioned equilibrium trap at stage four of the game. Here, the intermediary chooses the amount of sales activities that is induced by the commission rate r^*, although he cannot fool the consumers and boost demand in equilibrium. As the manufacturer anticipates this outcome for stage four, he optimally chooses $r^* = 0$ to minimize his contractual costs. Thus, he only has to compensate the intermediary for his outside option $\bar{u}$, which makes the latter's participation constraint bind. Finally, the manufacturer chooses the same optimal retail price as under centralization.

Lemma 5 has a clear implication. As is known from the strategic-delegation literature (e.g., Vickers, 1985; Fershtman and Judd, 1987; Sklivas, 1987), delegation to an agent can be beneficial to a principal as a self-commitment device in order to make the agent behave either more or less aggressively in the market than a profit-maximizing principal. Lemma 5 emphasizes a new self-commitment motive for strategic delegation in markets: Here, the manufacturer delegates sales activities to an intermediary in order to get rid of the negative consequences of the equilibrium trap, i.e., unnecessary costs that do not yield any positive returns. This trap still exists, as we have to solve for Perfect Bayesian Equilibria, but delegation in combination with low-powered incentives undermines the equilibrium trap and eliminates the manufacturer's costs from centralized selling.

In the following proposition, we compare hybrid selling to centralization and decentralization under the assumptions of the basic model:

Proposition 6 *(a) The manufacturer will prefer hybrid selling to centralized selling if and only if*

$$\frac{\left(1 + d_L + \Delta d\left[1 - F\left(\Psi\right)\right]\right)^2}{8\beta} \frac{\Delta d^2}{\beta\kappa} f\left(\Psi\right)^2 > \bar{u}. \tag{23}$$

(b) The manufacturer will prefer decentralized selling to hybrid selling if and only if

$$\bar{u} > \frac{\left(1 + d_L + \Delta d\left[1 - F\left(\Psi\right)\right]\right)^2}{8\beta}. \tag{24}$$

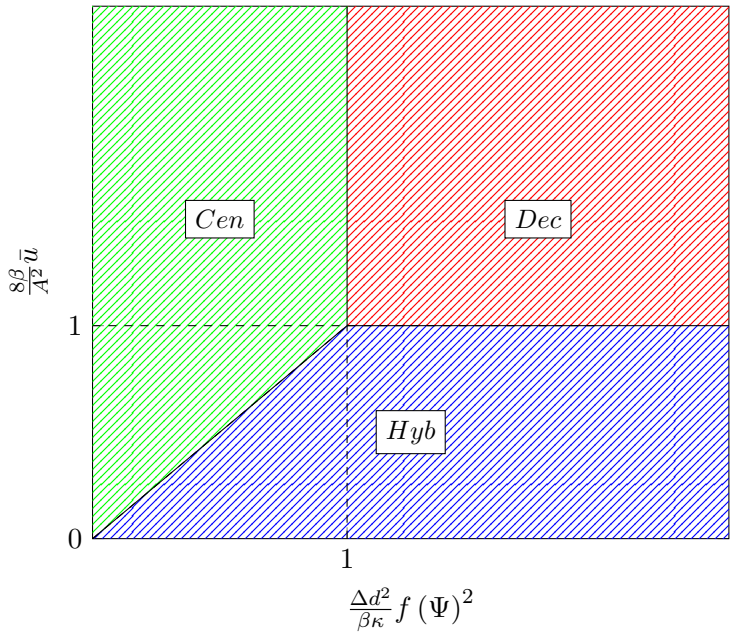
The discussion of Lemma 5 has already shown that delegation of sales services to an intermediary is beneficial as a self-commitment device, because, similar to decentralization, the manufacturer saves costs $c(a^*_{Cen})$. However, he has to pay the intermediary for his services. Nevertheless, if the outside option of the intermediary is sufficiently unattractive (i.e., $\bar{u}$ is sufficiently low), hybrid selling will be better to the manufacturer than centralized selling. As the intermediary is only needed for the self-commitment effect, he does not have to be very qualified. Hence, if the manufacturer can choose from a heterogeneous pool of intermediaries, he can pick the least qualified one with a very low market value $\bar{u}$, so that condition (23) is satisfied. The comparison of (13) and (23) shows that in (23) an additional determinant kicks in, which does not appear in condition (13), namely $1 + d_L + \Delta d\,[1 - F\,(\Psi)]$. This term describes the price inelastic expected demand in equilibrium.[27] If this term is large, the manufacturer's optimal retail price under centralization will be large as well, leading to high sales activities, a^*_{Cen}. Thus, this effect makes the use of an intermediary as a self-commitment device more profitable.

Result (b) of Proposition 6 shows that the manufacturer will prefer decentralized selling to hybrid selling if the intermediary's outside option is sufficiently high. In this case, the manufacturer can save high contractual costs for employing the intermediary by letting the retailer interact with the consumers. As mentioned above, decentralization gives rise to the problem of double marginalization. Condition (24) shows that the manufacturer will prefer decentralization if the intermediary's outside option, $\bar{u}$, exceeds the loss in revenue that the manufacturer incurs from the double-marginalization problem. This loss is based on the higher retail price in case of decentralization, $p^*_{Dec} > p^*_{Hyb}$, which in turn depends on both the price elasticity β and the price inelastic expected market demand, $1 + d_L + \Delta d[1 - F(\Psi)]$.

Figure 1 uses the findings of Propositions 1 and 6 to summarize the three different equilibrium outcomes. Intuitively, if $\Delta d^2 f(\Psi)^2/\kappa$ takes large values, the manufacturer will exert high sales effort in case of centralization because of high marginal returns and low marginal costs of choosing a. Consequently, the manufacturer prefers a kind of non-centralized selling in equilibrium in order to avoid $c(a^*_{Cen})$. If, in this situation, contractual costs for an intermediary, $\bar{u}$, are sufficiently low, the manufacturer will choose hybrid selling as equilibrium outcome; otherwise, the manufacturer prefers retailing to benefit from decentralized selling. On the other hand, if the effort-cost problem is unimportant (i.e., $\Delta d^2 f(\Psi)^2/\kappa$ is small), contracting with an intermediary is too expensive (i.e.,

[27] The term canceled out in condition (13) of Proposition 1, because the same term also exacerbates the double-marginalization problem of decentralization.

Figure 1: Optimal Selling Mode



(Cen: centralized selling; Dec: decentralized selling; Hyb: hybrid selling; $A := 1 + d_L + \Delta d[1 - F(\Psi)]$)

$\bar{u}$ is large), and the double-marginalization problem is sufficiently important (i.e., β is large), the manufacturer will prefer centralization in equilibrium.

The following proposition compares hybrid selling to centralization and decentralization under the extensions of the basic model:

Proposition 7 *(a) Under manufacturer competition, hybrid selling by both manufacturers will be an equilibrium outcome for a larger (smaller) set of parameter constellations than hybrid selling in the single-manufacturer setting if and only if* $\alpha > (<)0$.

(b) Under consumer naivety, the manufacturer strictly prefers centralized selling to hybrid selling, irrespective of whether the latter is protected by limited liability or not.

(c) Let $\hat{q} \geq \bar{q}$. *A product innovation additionally favors the use of hybrid selling over decentralization. It will additionally favor the use of hybrid selling over centralization if and only if*

$$\Delta d\left(\hat{q} - \bar{q}\right) f\left(\Psi\right) \sigma^2 + \left(1 + d_L + \Delta d\left[1 - F\left(\Psi\right)\right]\right) \left[\left(\hat{q} - \bar{q}\right)^2 - \frac{\sigma^6}{\left(2\sigma_\theta^2 + \sigma^2\right)\left(\sigma^2 + \sigma_\theta^2\right)}\right] > 0. \quad (25)$$

(d) A quality improvement additionally favors the use of hybrid selling over decentralization. It

will additionally favor the use of hybrid selling over centralization if and only if

$$\hat{q} - \bar{q} > -\frac{\sigma^2 \Delta d f(\Psi)}{1 + d_L + \Delta d[1 - F(\Psi)]}. \tag{26}$$

To explain result (a), recall that expected demand will increase under manufacturer competition compared to the single-manufacturer setting if the two products are substitutes (i.e., $\alpha > 0$), and it will decrease if the products are complements (i.e., $\alpha < 0$). As the manufacturer's expected sales are identical for hybrid selling and centralized selling, only the competition effect on the manufacturer's costs from sales activities remains decisive for the comparison of the two selling modes. Under centralization, the manufacturer suffers from direct costs $c(a^*_{Dec})$, which increase with expected demand. Under hybrid selling, the manufacturer only indirectly suffers via the intermediary's contractual costs, $\bar{u}$, which are unaffected by expected demand. Consequently, under manufacturer competition, hybrid selling becomes more (less) attractive compared to centralization if products are substitutes (complements).

Regarding the comparison between hybrid selling and decentralization, under both kinds of non-centralized selling the manufacturer saves sales costs $c(a^*_{Dec})$, so that the competition effect highlighted in the previous paragraph does not play a role. However, the competition effect on the manufacturer's expected profits via his expected sales matters. Under hybrid selling, the manufacturer directly sells to consumers, so that the positive (negative) impact of competition on expected sales in case of substitutes (complements) directly benefits (harms) the manufacturer. In case of decentralized selling, however, this effect is attenuated, as the manufacturer only indirectly sells to the consumers via a retailer.

Result (b) shows that hybrid selling is a dominated selling mode under consumer naivety and, thus, never chosen by the manufacturer in equilibrium. In particular, centralized selling is always better for a manufacturer than delegation of sales activities to an intermediary, because delegation would not yield a strategic advantage any longer — i.e., escaping the equilibrium trap under fully rational consumers — and would lead to additional contractual costs. Concerning the latter effect, the manufacturer has to compensate the intermediary at least for his foregone reservation value. If the intermediary's participation constraint is slack, delegation will be even more costly for the manufacturer, who has to leave a positive limited-liability rent to the intermediary. Under centralization, however, the manufacturer does not have to pay contractual costs. It is important to emphasize that the dominance of centralization over hybrid selling also hinges on our assumption

that each party that interacts with the consumers has the same cost function. If, however, the intermediary is specialized in interacting with consumers (e.g., if the intermediary is a social media influencer), the cost function of the specialized intermediary can be much flatter than the one of the non-specialized manufacturer, so that delegation to an intermediary may be still profitable despite consumer naivety.

The clear-cut parts of results (c) and (d) point out that both a product innovation and a product quality improvement make hybrid selling more attractive to the manufacturer than decentralized selling. Consider first the case of a product innovation. Under either kind of non-centralization, the manufacturer gets rid of the sales costs $c(a^*_{Cen})$. As, in addition, his contractual costs for employing an intermediary do not depend on σ^2, the only influence of the product innovation on the manufacturer's preferences for the two alternative kinds of non-centralized selling arises from his different expected sales. As the manufacturer's expected sales under hybrid selling are twice his expected sales under decentralization and because both expected sales increase with the product innovation, the amplifying effect of an innovation is higher for the manufacturer under hybrid selling. Consequently, the introduction of a product innovation makes hybrid selling more attractive to the manufacturer than decentralization. The same kind of argument also holds for the case of a product quality improvement: The contractual costs for an intermediary are independent of $\bar{q}$, and the amplifying effect of an increase in expected quality $\bar{q}$ on the manufacturer's expected sales is higher under hybrid selling than under decentralization.

The intuition for the impact of a product innovation on hybrid selling versus centralization is similar to the one on decentralized selling versus centralization as explained subsequent to Proposition 4. Under condition (25), the manufacturer's incentives to invest in sales activities are quite low. If in this situation σ^2 rises, the incentives increase, resulting into high sales costs $c(a^*_{Cen})$. Therefore, the manufacturer additionally benefits from choosing hybrid selling to get rid of consumer interaction under centralization, which explains the second part of result (c).

The second part of result (d) can be explained as follows. Condition (26) marks the threshold for when optimal sales effort a^*_{Cen} and, thus, the corresponding costs $c(a^*_{Cen})$ either increase or decrease with the expected quality $\bar{q}$. If brand loyalty is sufficiently high, optimal sales effort will decrease with $\bar{q}$. This happens because the probability of high demand is already sufficiently high, so that the benefits of exerting high sales effort are outweighed by its costs. Hence, in that case, the manufacturer's optimal sales effort is decreasing in the expected product quality and since the intermediary is unaffected by this effect, the manufacturer will additionally favor centralization.

On the other hand, if brand loyalty is low, or not too high, sales effort will be increasing in $\bar{q}$, such that the manufacturer additionally favors hybrid selling over centralization to save $c(a^*_{Cen})$. As expected sales under centralization and hybrid selling are affected identically by an increase in $\bar{q}$, this effect does not play a role for the comparison of both selling modes.

6 Conclusion

This paper studies the role of sales activities on the fundamental decision of a manufacturer of goods with uncertain consumption quality to sell centralized, decentralized via a retailer, or to use an intermediary. In particular, regarding experience or trust goods, often both the manufacturer and the consumers face uncertainty about the good's quality, as each party has private information that is not known by the other one. In such a setting, a manufacturer may engage in selling activities, such as sales talks and product presentations, to exaggerate the quality of the good.

On the one hand, in a perfect Bayesian equilibrium, consumers cannot be fooled because they correctly anticipate the quality exaggeration. Hence, this renders the effect of sales activities on the consumers' expectation of the quality null. However, on the other hand, sales activities cannot be omitted, since, otherwise, the consumers would lower their expectation about the quality of the product. In that situation, shifting the interaction with consumers to a third party can serve as a self-commitment device not to invest in costly sales activities and, hence, benefit the manufacturer. This will be optimal if the benefits of not being required to invest in the sales activities outweigh the contractual costs in case of selling via an intermediary, or the costs associated with double-marginalization in case of selling via a retailer. These benefits will tend to outweigh the costs if either the returns from sales activities are large or if marginal sales costs and the price elasticity are small. In these situations, manufacturers should prefer a retailer or an intermediary to centralized selling.

In addition to the setting described above, we extend our model in several directions. The results of the extensions provide a mixture of predictions, robustness checks, and management recommendations, which we briefly address below.

First, we consider the case of manufacturer competition. Our results show that if, for example, an incumbent centralized selling monopolist faces competition from a new manufacturer, then it may be optimal for the incumbent to switch to decentralized selling, even if centralized selling was an optimal selling mode as a monopolist. In general, our findings point out that if we observe a market

of goods with uncertain consumption quality changing from a monopoly to a competitive market, decentralized selling via a retailer should be more prevalent than centralized selling. Furthermore, manufacturer competition will also foster the use of intermediaries like social media influencers if products are substitutes.

Our second extension deals with consumer naivety. In such situations, exaggerating the quality of the product through sales activities now has an effect on the consumers' expected quality, so that overall expected sales increase. We show that, even if consumers are naive, a manufacturer can still prefer decentralization to centralized selling as a kind of self-commitment device. In particular, a retailer who anticipates consumer naivety may be additionally motivated to invest in sales activities, which, in turn, further boosts demand. Moreover, if marginal sales costs are sufficiently low, leading to high incentives for investing in sales activities, using a retailer as a self-commitment device will be strictly better than selling via a centralized channel.

Our third and fourth extensions show that decentralized selling may become a more favorable selling mode for a manufacturer following a product innovation or product quality improvement if the consumers' loyalty toward the brand is low (i.e., $\hat{q} \geq \bar{q}$). In particular, if brand loyalty is sufficiently low, the manufacturer has little motivation to invest in sales activities. If now the manufacturer engages in product innovation, the consumers' uncertainty about the quality increases. This leads to an increase in the motivation to invest in sales activities and, therefore, an increase in the benefits of shifting the interaction with consumers to a retailer. By the same token, given low brand loyalty, the introduction of a quality improvement leads to a considerable increase in the motivation to invest in sales activities, which, once again, increases the benefits of using a retailer. All in all, firms selling via a retailer or an intermediary (like social media influencers) are better off from reacting to low brand loyalty by a product-innovation or a quality-improvement strategy than firms selling via a centralized channel.

One potential limitation of our framework that could be addressed in future research is its static nature. In particular, it would be interesting to use a dynamic setting in order to endogenize our notion of brand loyalty by letting it be a function of prior realizations. Such a framework would allow for a further robustness check of decentralization and intermediaries serving as optimal self-commitment devices to shield manufacturers from costly interaction with consumers.

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