Price and Quality Decisions by Self-Serving Managers*

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Abstract

We present a theory of price and quality decisions by managers who are self-serving. In the theory, firms emphasize the price or quality of their products, but not both. Accounting for this, managers exploit any uncertainty about the cause of market outcomes to credit positive results to the dominant, "strategic" factor and blame negative results on the other. The problem with biased explanations, however, is that they prompt biased decisions. The present study reports experimental evidence that support this argument and develops a model to understand the impact of the bias on firm performance. Counter to intuition, we find that firms in a competitive setting actually profit from the self-serving nature of their managers.

Keywords: Causal reasoning, self-serving bias, strategic orientation, managerial decision-making.

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1 Introduction

In many industries, firms anxious of getting "stuck in the middle" approach the market stressing the price or quality of their products, but not both (Porter 2004). For example, in retail Walmart claims "price leadership is core to who we are," while Wholefoods considers quality "the highest form of value."[1] In consumer electronics, Asus bets on "aggressive prices that make technology accessible to all," but Apple creates "the kind of wonder that revolutionizes entire industries." The fashion label H&M works to ensure "the best price for its customers," but DKNY applies "the highest standards of creativity and quality." In industrial equipment, Parker Hannifin warns "you are messing with a company DNA when you touch prices," while to SKF Group "cutting edge quality is our primary differentiator." EasyJet is the airline that wants to make travel "easy and affordable," but Emirates strives to "inspire travelers with excellence in service."

Accounting for the orientation of their firms, managers may be tempted to explain unexpected outcomes in the market in a manner that is self-serving, crediting positive results to the dominant, "strategic" factor and blaming negative results on the other. The problem with biased explanations, however, is that they prompt biased decisions. For example, self-serving attributions encourage overconfidence, which in turn skews perceptions of market entry, acquisitions, and other risky prospects (Billett and Qian 2008; Camerer and Lovallo 1999; Galasso and Simcoe 2011; Malmendier and Tate 2008). They also influence the judgments of onlookers, as evidenced by the link between self-serving disclosures in annual reports and earnings forecasts and valuations by the investing community (Baginski, Hassell, and Hillison 2000; Barton and Mercer 2005; Lewellen, Park, and Ro 1996). Finally, from a statistical perspective a simpler but overlooked argument is that associating an effect with a particular cause increases the attention paid to the same cause in the future (DeGroot and Schervish 2011). This implies that a biased

[1] This comparison may not stand the test of time. Amazon recently acquired Wholefoods, and the former claims "offering low prices to our customers is fundamental to our future success."

appraisal of the contribution of prior price and quality decisions to firm performance is likely to prompt a similar bias in the adjustments that follow.[2]

The objectives of our research are to test this logic empirically and understand the impact of the bias on firm performance. First, we report two experiments. The experiments provide a full picture of the theory in the sense that they elicited not only attributions and adjustments separately for price and quality, but also the underlying beliefs that motivate the pattern of attributions. Specifically, in social psychology attributions are classified along three dimensions: locus (whether an explanation is internal or external), stability (whether it endures over time), and control (whether it is subject to volitional alteration) (Weiner 1985, 1986). A candidate explanation that appears internal, stable, and controllable is typically linked to the self and, therefore, associated with success and dissociated from failure. A candidate explanation that appears external, unstable, and uncontrollable produces the opposite inference. Accordingly, price and quality serve the self-serving tendency of managers to the extent that the orientation of their firms separates the two factors on these criteria.

Second, we develop a model in which the orientation of the firm toward price or quality is determined endogenously and the manager is uncertain about the cause of the market outcome. The presence of uncertainty forces the manager to rely on inference, but this is distorted by the choice of orientation. The starting point of our analysis is the case of a monopolist, and the cost of the bias is simply the difference in profit resulting from the adjustments to price or quality in the self-serving scenario and the adjustments prompted by optimal attributions. Notably, we find that this cost is independent of the orientation of the firm. We then introduce competition, where the unique pure-strategy Nash equilibrium is that firms emphasize price over quality—orientation now matters. Moreover, and counter to intuition, we show that in equilibrium firms actually profit from the self-serving nature of their managers.

[2]The argument is also a psychological one: a basic tenet of attribution theory as it applies to motivation is that a person's own explanations for an event dictate the effort spent again on these activities (Weiner 1986).

Overall, our paper makes several contributions to the management literature on the self-serving bias (Bettman and Weitz 1983; Clapham and Schwenk 1991; Curren, Folkes, and Steckel 1992; Salancik and Meindl 1984). First, while the standard approach is to distinguish between causes that are internal or external to the organization itself, we consider a setting where managers attribute unexpected firm performance—be it surprisingly positive or negative—only to factors at their discretion. Indeed, to the best of our knowledge we are the first to show that perceptions, not reality, determine whether a given explanation is internal, stable, and controllable or otherwise. Second, the managerial decisions that interest us are concrete, routine, and consequential—decisions about the price and quality of a product are among the most common and significant in a firm. Again, this is a deviation from the norm of attributing events generally to intent and competence across conditions of success, and to states of nature and bad fortune across conditions of failure.

Third, we care not only about the presence of the bias, but also about its impact on profits. While conventional wisdom suggests that any prejudice hinders performance, we demonstrate that the opposite is true in a competitive setting. The intuition for this result is that the adjustments prompted by self-serving attributions create upward pressure on equilibrium prices—a positive externality. Fourth, we are the first to offer a formal model of self-serving behavior. While there is considerable research that maps the bounded rationality of individuals, most of this work construes the individual as a consumer rather than a professional. We are interested in bridging the gap. In addition, the managers in our theory stray from optimal Bayesian updating and fail to introspect. To address these and other limitations, Goldfarb et al. (2011) recommend specifying alternative utility functions or adopting non-equilibrium concepts. However, in our model managers chase the standard profit-maximizing objective function in a standard equilibrium structure. It is the way these managers interpret information that creates the problem. Fifth, a classic advice in strategy is that firms should focus, and that competitive advantage comes from leadership in price or quality (Porter 2004). Our research points to one possible pitfall of this imperative: managers internalize the orientation chosen by their firms and are unable or unwilling to interpret events in an objective manner.

The remainder of the paper is structured as follows. Section 2 reports the experiments. Section 3 analyzes the profit impact of self-serving attributions and the optimal choice of orientation in a monopoly setting. Section 4 extends this analysis to include competition. Section 5 concludes, highlighting limitations of the research and offering directions for future work.

2 Empirical Evidence

This section reports experiments that test three predictions. First, we wanted to show that the orientation of a firm toward price or quality determines how the manager uses these factors to explain unexpected success and failure in the market. Specifically, we anticipated that participants credit a positive result primarily to the dominant factor and blame a negative result primarily on the other. Second, we wanted to show that this effect is mediated by a shift in the way participants perceived price and quality on the causal dimensions identified by Weiner (1985, 1986). That is, we argue that the choice of orientation makes the dominant factor appear more internal, stable, and controllable than the other factor, and this in turn interacts with the valence of the market outcome to determine attributions—an instance of moderated mediation (Muller, Judd, and Yzerbyt 2005). The third prediction is a positive relationship between attributions and adjustments.

2.1 Experiment 1

Participants and Method. The sample in the first experiment comprised 306 undergraduate and graduate business students (42% female, 63% graduate, on average 21.6 years old). Participants read a scenario that describes the launch of a new product at a firm in a competitive market. The firm is "large with a significant presence in several geographies across Europe" and "diverse in the sense that it sells a variety of products and services in different categories." The manager in the firm learns from initial testing and extensive research that the most profitable scenario in the first year is a price of €25, resulting in sales of 10,000 units.

We manipulated Orientation (price or quality) and Market Outcome (positive or negative) in a between-subjects design. We varied Orientation with the following text: "Despite its complexity, the company is clear that it competes in each market based on price (quality). For example, on the company website this statement is immediately visible: 'When it comes to our customers, our priority and obsession is price (quality). Everything that we do is guided by the goal of providing excellent prices (quality), while remaining competitive on quality (price). This goal defines who we are and how we act.' " We varied Market Outcome by telling participants that the firm eventually sold 12,500 units (25% above the estimate) or 7,500 units (25% below the estimate) for the year.[3]

The stimulus included three main measures. First, participants evaluated price and quality separately as the cause of the market outcome (-3 = "The price (quality) of the product is a lot lower than that of competitors" to 3 = "The price (quality) of the product is a lot higher than that of competitors"). Second, they expressed their response in the coming year (-3 = "Significantly decrease price (quality)" to 3 = "Significantly increase price (quality)"). Third, participants rated the two factors on locus ("Price (Quality) is a defining element of a product's value proposition;" 1 = "Strongly disagree" to 7 = "Strongly agree"), stability ("Price (Quality) is easy to change;" 1 = "Very easy to change" to 7 = "Very hard to change"), and control ("Market forces such as strong competitors and demanding customers play a role in determining the prices (qualities) of the products that firms sell;" 1 = "A very small role" to 7 = "A very large role"). As a background check, participants also judged the gap in sales experienced by the firm (-3 = "A really bad result" to 3 = "A really good result"). These data show only a main effect of Market Outcome, with the mean score in the positive condition ($M = 5.65$, $SE = .08$) significantly

[3]In Section 3, we demonstrate that the market outcome is qualitatively equivalent irrespective of whether firm performance is measured by profit or demand.

higher than the one in the negative condition ($M = 2.73$, $SE = .09$; $F(1,302) = 611.15$, $p < .001$, $\eta_p^2 = .67$), and both values significantly different from the midpoint of the scale ($t(152) = 21.16$, $p < .001$ and $t(152) = -14.33$, $p < .001$, respectively).

Attributions. A two-way analysis of variance on Net Attributions, which is the difference between the participants' valuations of price and quality as the cause of the market outcome (each expressed in absolute terms), shows a main effect of Orientation ($F(1,302) = 21.98$, $p < .001$, $\eta_p^2 = .07$) and, importantly, the expected interaction between Orientation and Market Outcome ($F(1,302) = 85.15$, $p < .001$, $\eta_p^2 = .22$; see Figure 1). Consistent with the first prediction, participants in the price orientation condition reported stronger net attributions (i.e., attributions slanted more toward price) in response to the positive outcome ($M = 1.32$, $SE = .16$) than to the negative one ($M = -.22$, $SE = .16$; $F(1,302) = 47.15$, $p < .001$, $\eta_p^2 = .14$). While the first of these means is positive and significantly greater than zero (the point where the two factors are considered equally responsible for the market outcome; $t(75) = 8.21$, $p < .001$), the second is negative but only directionally consistent ($p = .233$). Likewise, participants in the quality orientation condition reported weaker net attributions (i.e., attributions slanted more toward quality) in response to the positive outcome ($M = -.88$, $SE = .16$) than to the negative one ($M = .49$, $SE = .16$; $F(1,302) = 38.20$, $p < .001$, $\eta_p^2 = .11$). In this case, both means are in the predicted direction and statistically different from zero ($t(76) = -5.67$, $p < .001$ and $t(76) = 3.95$, $p < .001$, respectively).

Mediation. Our theory predicts that the effect of orientation on attributions is mediated by the participants' beliefs about price and quality on locus, stability, and control. The second step of this causal chain, the relationship between beliefs and attributions, is itself contingent on the valence of the market outcome. Accordingly, we conducted two tests of moderated mediation using model 14 of the PROCESS macro (Hayes 2013).[4] In the model, Orientation and Market Outcome are contrast coded, and Net Beliefs is the

[4]The number of bootstrap samples for the percentile confidence intervals is 10,000.

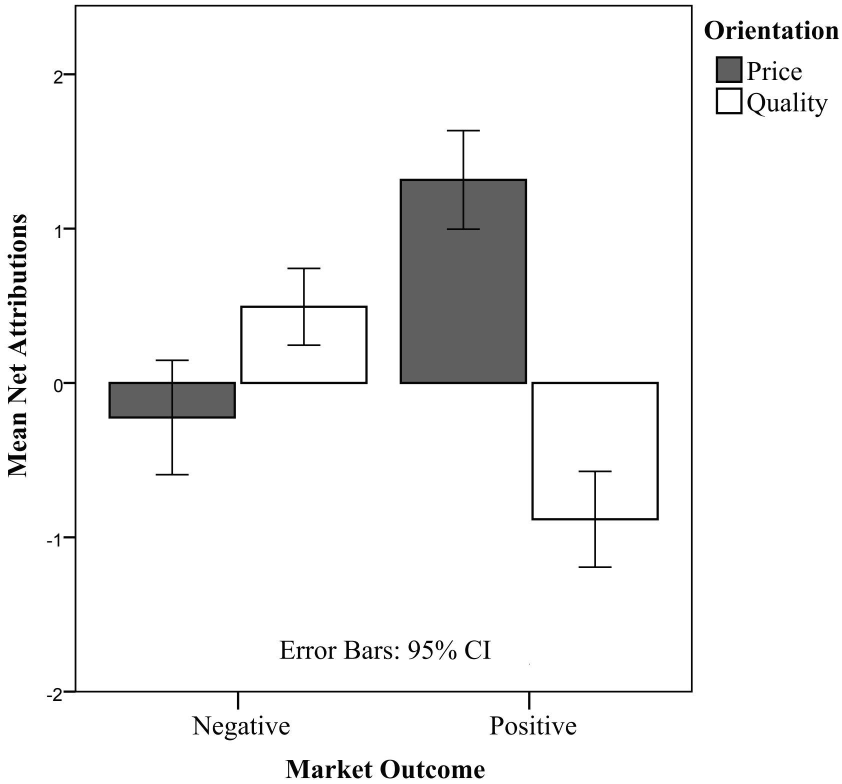

Figure 1: The effect of orientation on net attributions, moderated by market outcome.

difference between price and quality on locus, stability, and (the inverted scores of) control, combined into one measure and mean centered (Cronbach's $\alpha = .75$). The dependent variable is Net Attributions.

An interesting initial observation is that participants expressed stronger beliefs for quality than they did for price on all causal dimensions: one-sample t-tests comparing the overall mean of the difference between these factors to zero, the neutral point of the scale, shows a significant difference for locus ($M = -.46$, $SD = 2.23$; $t(305) = -3.62$, $p < .001$), stability ($M = -.52$, $SD = 2.44$; $t(305) = -3.70$, $p < .001$), and control ($M = -1.04$, $SD = 1.75$; $t(305) = -10.37$, $p < .001$).

Muller et al. (2005) argue that moderated mediation is substantiated by (a) evidence of moderation in at least one path in the causal chain linking the independent variable to the dependent variable through the mediator, and (b) evidence that the remaining path is statistically different from zero. Consistent with these criteria, the data show that the effect of Net Beliefs on Net Attributions is moderated by Market Outcome ($\beta = .48$, $SE = .10$, 95% CI $[.29, .68]$, $p < .001$), and that Orientation has a significant impact on Net Beliefs ($\beta = 1.15$, $SE = .19$, 95% CI $[.78, 1.53]$, $p < .001$).

Alternatively, Hayes (2015) specifies an "index of moderated mediation" that quantifies the relationship between the moderator and the size of the indirect effect of the independent variable on the dependent variable. Specifically, moderated mediation is substantiated when any two conditional indirect effects estimated at different values of the moderator are significantly different from each other. In our data, the conditional indirect effects of Orientation are $\beta = -.14$ ($SE = .10$, 95% CI $[-.35, .04]$) in the negative Market Outcome condition and $\beta = .42$ ($SE = .13$, 95% CI $[.20, .69]$) in the positive Market Outcome condition. Accordingly, the index of moderated mediation is .56 ($SE = .18$). Because the bootstrap confidence interval does not include zero (95% CI $[.24, .95]$), we again find support for the second prediction.

Adjustments. The final prediction is a significant and positive effect of Attributions on Adjustments. We tested this simple relationship by regressing Net Adjustments on Net Attributions. In the regression, Net Adjustments is the difference between the participants' price and quality responses, each expressed in absolute terms. The two variables are related as expected: $\beta = .12$, $SE = .05$, $p = .013$.

2.2 Replication

The second experiment serves as a replication. The sample comprised 194 experienced professionals rather than students. They were recruited at three open-enrollment executive education programs taught at the same business school, and the average work experience was 17.6 years ($n = 57$), 16 years ($n = 68$), and 11.5 years ($n = 69$).[5] The scenario and measures were the same except that we did not manipulate the orientation of the firm.

[5] All of the analyses that we report controlled for program. This variable did not influence any result.

Given the experience of the audience, we used their existing beliefs about price and quality on locus, stability, and control directly as the independent variable. Finally, we administered several additional background checks.

Participants in the first and second group judged the gap in demand on the same scale used in the first experiment. The data again show a higher mean score in the context of a positive result ($M = 1.69$, $SD = .88$) than a negative one ($M = -.89$, $SD = 1.22$; $F(1,123) = 183.88$, $p < .001$, $\eta_p^2 = .60$), with both values significantly different from the neutral midpoint of the scale ($t(61) = 15.16$, $p < .001$ and $t(62) = -5.79$, $p < .001$, respectively). In addition, we asked participants in the first group "To what extent do you relate to the situation?" (1 = "Not at all, the situation mirrors reality poorly" to 7 = "Completely, the situation mirrors reality well"). A one-sample t-test comparing the overall mean ($M = 4.79$, $SD = 1.36$) to the midpoint of the scale suggests that the scenario was sufficiently realistic ($t(56) = 4.39$, $p < .001$), with no significant difference between experimental conditions ($p = .522$). The same participants also reported whether market outcomes of the type portrayed in the scenario are explained by differences in price and quality among competing products (1 = "Not at all, price and quality differences matter slightly" to 7 = "Completely, price and quality differences matter greatly"). Again, on average responses were significantly higher than the midpoint of the scale ($M = 4.79$, $SD = 1.36$; $t(56) = 4.39$, $p < .001$) and independent of the experimental condition ($p =$ .655).

Finally, participants in the third group expressed their confidence in the attributions of the market outcome (1 = "Not at all" to 7 = "Completely") and whether the scenario provided sufficient information to express these judgments (1 = "Definitely not" to 7 = "Definitely yes"). A one-sample t-tests show that overall mean confidence ($M = 4.71$, $SD = 1.59$) is significantly higher than the midpoint of the scale ($t(68) = 3.71$, $p < .001$). The same is true for impressions of the information provided ($M = 4.68$, $SD = .96$; $t(68) = 5.88$, $p < .001$). In both cases, we did not observe a significant difference between experimental conditions ($p = .182$ and $p = .835$, respectively).

We tested the first prediction of our theory by regressing Net Attributions on Net Beliefs (Cronbach's $\alpha = .73$), Market Outcome, and the corresponding interaction term. The regression shows a simple negative effect of Market Outcome ($\beta = -.54$, $SE = .09$; $p < .001$) and, importantly, a significant interaction ($\beta = .21$, $SE = .06$; $p < .001$). Consistent with our argument, the slope of Net Beliefs is significant and positive in the positive outcome condition ($\beta = .20$, $SE = .08$; $p = .013$), and significant and negative in the negative outcome condition ($\beta = -.22$, $SE = .08$; $p = .010$). This pattern implies that an increase in the perception that price is more internal, stable, and controllable relative to quality increased the use of the former as the explanation for the strong result and the latter for the weak result. Note that we again find that participants expressed stronger beliefs for quality than they did for price on all causal dimensions: one-sample t-tests comparing the overall mean of the difference between these factors to zero shows a significant difference for locus ($M = -.76$, $SD = 1.64$; $t(193) = -6.47$, $p < .001$), stability ($M = -1.96$, $SD = 2.33$; $t(193) = -11.69$, $p < .001$), and control ($M = -1.03$, $SD = 1.63$; $t(193) = -8.84$, $p < .001$).

Finally, we tested the third prediction by regressing Net Adjustments on Net Attributions and found the expected positive effect: $\beta = .23$, $SE = .07$, $p = .001$.

3 Monopoly

Given the results of the experiments, the next objective is to understand how the attributions and adjustments of self-serving managers impact firm performance in a monopoly setting. We first describe the interaction between the firm and consumers, and then formalize the notions of optimal attributions—the benchmark case—and self-serving attributions. Finally, we compare the profits across the benchmark and self-serving cases. We use backward induction.

3.1 Assumptions

Consider a profit-maximizing monopoly firm that offers a product (or service) to potential consumers over two periods, indexed by $t = 1,2$. In each period, the manager designs the product by choosing the price p_t and the quality q_t. The unit production cost is constant and normalized to zero. Providing quality q_t requires an investment and costs $\kappa(q_t) = \frac{k}{2}q_t^2$, where $k > 0$.

In line with standard arguments in behavioral research (Hoyer, MacInnis, and Pieters 2012), consumers form subjective valuations of price and quality that may vary from the actual levels set by the firm. We let ε_p and ε_q denote the corresponding deviations, which are drawn in the first period from independent normal distributions with mean zero and variances σ_p^2 and σ_q^2. Consumers have private information about ε_p and ε_q, but the respective parameters of the distributions are common knowledge. The demand for the product in each period is given by

$$D_t(p_t, q_t) = \max\{\alpha + (q_t + \varepsilon_q) - (p_t + \varepsilon_p), 0\}, \tag{1}$$

where $\alpha > 0$ is an exogenous parameter that we view as a proxy for market size.[6] Therefore, the profit to the firm can be expressed as

$$\pi_t(p_t, q_t) = p_t D_t(p_t, q_t) - \frac{k}{2}q_t^2.$$

We impose the assumption that $k > \frac{1}{2}$ such that the profit function is concave and thus has a unique global maximizer.

At the beginning of the first period, the manager chooses p_1 and q_1 based on expected profit. Consumers in turn make purchase decisions based on their subjective valuations $p_1 + \hat{\varepsilon}_p$ and $q_1 + \hat{\varepsilon}_q$.[7] The resulting market outcome, expressed as the difference between realized and expected profit, is

$$\pi_1^r - \pi_1^e = p_1(\hat{\varepsilon}_q - \hat{\varepsilon}_p), \tag{2}$$

[6]Appendix A derives this demand function from model primitives.

[7]Realizations of random variables are denoted with a "hat."

where $\hat{\varepsilon}_q - \hat{\varepsilon}_p$ is the discrepancy between realized and expected demand. Because the gap in profit is proportional to the gap in demand, we can capture the market outcome simply by $\hat{m} = \hat{\varepsilon}_q - \hat{\varepsilon}_p$. Using properties of the normal distribution, $\hat{m}$ is the realization of a normally-distributed random variable with mean zero and variance $\sigma_m^2 = \sigma_p^2 + \sigma_q^2$, where we require that $\sigma_m \leq \frac{\alpha}{4}$ to focus on the interesting case where the firm faces positive demand.[8]

Importantly, the manager observes the market outcome $\hat{m}$ and knows that it is caused by the consumers' subjectivity toward price and quality, yet cannot identify $\hat{\varepsilon}_p$ and $\hat{\varepsilon}_q$ separately to derive the corresponding valuations. One argument is that the manager commissions market research to estimate $\hat{\varepsilon}_p$ and $\hat{\varepsilon}_q$. However, to the extent that research is a statistical exercise, the uncertainty about $\hat{m}$ cannot be eliminated and forces the manager to explain $\hat{m}$ by inference.

3.2 Optimal Attributions

The standard assumption in statistical inference is that people use Bayes' rule to update beliefs in light of data (DeGroot and Schervish 2011). The orientation of the firm is irrelevant in this setting. Therefore, $\hat{\varepsilon}_p$ and $\hat{\varepsilon}_q$ are estimated from $\hat{m}$ using

$$\varepsilon_p^o \equiv E[\varepsilon_p|\hat{m}] = E[\varepsilon_p] - \frac{\sigma_p^2}{\sigma_p^2 + \sigma_q^2}\hat{m} \quad (3)$$

$$\varepsilon_q^o \equiv E[\varepsilon_q|\hat{m}] = E[\varepsilon_q] + \frac{\sigma_q^2}{\sigma_p^2 + \sigma_q^2}\hat{m}. \quad (4)$$

These attributions of the market outcome to price and quality are intuitive.[9] First, if $\hat{\varepsilon}_p$ and $\hat{\varepsilon}_q$ are equal to their respective means, then ε_p^o and ε_q^o are equal to zero (since $E[\varepsilon_p] = E[\varepsilon_q] = 0$). Second, in the event of a positive market outcome ($\hat{\varepsilon}_q - \hat{\varepsilon}_p > 0$), (3) and (4) imply that ε_p^o is below its mean and ε_q^o is above its mean. The opposite is true in the case of a negative market outcome ($\hat{\varepsilon}_q - \hat{\varepsilon}_p < 0$). Third, σ_p^2 and σ_q^2 determine

[8] Appendix B shows that using the normal distribution rather than the truncated normal distribution does not qualitatively affect the results under this condition.

[9] Appendix C derives these rules using the properties of the bivariate normal distribution.

any difference between $\hat{\varepsilon}_p$ and $\hat{\varepsilon}_q$ and their respective means. In the extreme case where $\sigma_p^2 \to 0$ or $\sigma_q^2 \to 0$, the manager attributes the market outcome exclusively to quality ($\varepsilon_p^o = 0$ and $\varepsilon_q^o = \hat{m}$) or price ($\varepsilon_p^o = -\hat{m}$ and $\varepsilon_q^o = 0$), respectively.

The manager adjusts price and quality in the second period given the information learned from $\hat{m}$ according to (3) and (4). Specifically, the manager solves

$$\begin{aligned} \max_{p_2, q_2} \quad \pi_2(p_2, q_2; \hat{m}) &= p_2(\alpha + (q_2 + \varepsilon_q^o) - (p_2 + \varepsilon_p^o)) - \frac{k}{2} q_2^2. \\ &= p_2(\alpha + \hat{m} + q_2 - p_2) - \frac{k}{2} q_2^2, \end{aligned} \tag{5}$$

where $\varepsilon_q^o - \varepsilon_p^o = \hat{m}$ by construction. The profit-maximizing price and quality are denoted by $p_2^*(\hat{m})$ and $q_2^*(\hat{m})$, respectively. The optimized profit in the second period is $\pi_2^*(\hat{m})$.

In the first period, the manager sets price and quality to maximize the expected overall profit

$$\begin{aligned} \max_{p_1, q_1} \quad \Pi_1(p_1, q_1) &= p_1(\alpha + q_1 - p_1) - \frac{k}{2} q_1^2 \\ &\quad + \int_{-\infty}^{\infty} \pi_2^*(\hat{m}) f(\hat{m}) d\hat{m}, \end{aligned} \tag{6}$$

where the last summand is the expected second-period profit derived from adding (the density-weighted) $\pi_2^*(\hat{m})$ across all possible market outcomes. As price and quality do not carry over to the second period, this term is a constant that can be ignored when setting p_1 and q_1. We denote the expected first-period profit by π_1^*, and the optimized expected overall profit by Π_1^*. The next result captures the profit impact of optimal attributions.

Lemma 1. *When the manager uses optimal attributions to explain firm performance, the optimized expected overall profit of a monopolist is*

$$\Pi_1^* = \frac{(2\alpha^2 + \sigma_m^2)k}{2(2k-1)}.$$

Proof. The proof of this and all other results are provided in Appendix D. □

Lemma 1 implies that a larger market size or lower investment cost makes the firm better off. The impact of uncertainty is less intuitive but follows from the fact that a higher

σ_m^2 increases the likelihood of a higher price and demand in the second period, which translates into a higher expected profit π_2^*, and thus a higher expected overall profit Π_1^*.

3.3 Self-Serving Attributions

The experiments reported in Section 2 suggest that managers update their beliefs about market outcomes in a manner that is inconsistent with Bayes' rule. Based on this evidence, a self-serving manager estimates $\hat{\varepsilon}_p$ and $\hat{\varepsilon}_q$ from $\hat{m}$ using

$$\varepsilon_p^s \equiv E[\varepsilon_p|\hat{m},\gamma] = \begin{cases} -\dfrac{(1-\gamma)\sigma_p^2}{(1-\gamma)\sigma_p^2+\gamma\sigma_q^2}\hat{m}, & \text{if } \hat{m}>0 \\ -\dfrac{\gamma\sigma_p^2}{\gamma\sigma_p^2+(1-\gamma)\sigma_q^2}\hat{m}, & \text{if } \hat{m}<0 \end{cases} \tag{7}$$

$$\varepsilon_q^s \equiv E[\varepsilon_q|\hat{m},\gamma] = \begin{cases} \dfrac{\gamma\sigma_q^2}{(1-\gamma)\sigma_p^2+\gamma\sigma_q^2}\hat{m}, & \text{if } \hat{m}>0 \\ \dfrac{(1-\gamma)\sigma_q^2}{\gamma\sigma_p^2+(1-\gamma)\sigma_q^2}\hat{m}, & \text{if } \hat{m}<0, \end{cases} \tag{8}$$

where $\gamma \in \{0,1\}$ reflects the orientation of the firm: $\gamma = 0$ denotes a "price orientation" and $\gamma = 1$ a "quality orientation." To grasp the intuition behind these attributions, suppose that $\hat{m} > 0$. (The logic is the same when the firm experiences $\hat{m} < 0$, but leads to the opposite pattern of attributions.) Because the self-serving manager prefers to attribute a positive result to the product factor that matches the orientation of the firm, $\hat{m}$ is explained by price when $\gamma = 0$ and by quality when $\gamma = 1$.[10] Note that this updating rule thus captures the idea that a self-serving motivation alone is not sufficient to produce self-serving attributions; it must be that candidate explanations differ in ways that the decision-maker can exploit (Weiner 1985, 1986).

The self-serving manager adjusts price and quality given the information learned from the market outcome $\hat{m}$ according to (7) and (8). We use the superscripts '$-$' and '$+$' to index variables according to the valence of $\hat{m}$.

[10] Self-serving attributions are equivalent to optimal attributions when price and quality are equally important ($\gamma = \frac{1}{2}$).

Price Orientation. In the second period, the manager considers adjusting price (but not quality) in response to $\hat{m}^+$ and quality (but not price) in response to $\hat{m}^-$, solving the constrained optimization problems

$$\max_{p_2} \quad \pi_2(p_2; q_1|\hat{m}^+) \quad = \quad p_2(\alpha + \hat{m} + q_1 - p_2) - \frac{k}{2}q_1^2 \tag{9}$$

$$\max_{q_2} \quad \pi_2(q_2; p_1|\hat{m}^-) \quad = \quad p_1(\alpha + \hat{m} + q_2 - p_1) - \frac{k}{2}q_2^2. \tag{10}$$

The corresponding optimized profits are denoted by $\pi_2^+(q_1^*|\hat{m})$ and $\pi_2^-(p_1^*|\hat{m})$.

We assume that the manager does not anticipate making self-serving attributions or, for that matter, the adjustments prompted by these attributions. This is line with the repeated observation that people seldom introspect (Meyer and Hutchinson 2016). In fact, the argument in social psychology is that people's tendency to be self-serving leads them to think that they are not self-serving, or at least to think that they are less susceptible than the average peer—the bias "blind spot" (Pronin, Lin, and Ross 2002). Accordingly, in the first period the manager sets price and quality to maximize

$$\max_{p_1, q_1} \quad \Pi_1(p_1, q_1) \quad = \quad p_1(\alpha + q_1 - p_1) - \frac{k}{2}q_1^2 + \int_{-\infty}^{\infty} \pi_2^*(\hat{m}) f(\hat{m}) d\hat{m}.$$

This objective function is the same as (6) in the benchmark case, which implies that price and quality in the first period are also the same. Given that the manager makes self-serving attributions in the second period, the optimized expected overall profit is in effect given by

$$\Pi_1^s = \pi_1^* + \int_{-\infty}^{0} \pi_2^-(p_1^*|\hat{m}) f(\hat{m}) d\hat{m} + \int_{0}^{\infty} \pi_2^+(q_1^*|\hat{m}) f(\hat{m}) d\hat{m}. \tag{11}$$

The next result captures the profit impact of optimal attributions.

Lemma 2. *When the manager uses self-serving attributions to explain firm performance, the optimized expected overall profit of a monopolist is*

$$\Pi_1^s = \frac{8\alpha^2 k + (2k-1)\sigma_m^2}{8(2k-1)}.$$

This result shows that Π_1^s has the same qualitative properties as Π_1^* in the benchmark case: the optimized expected overall profit increases in market size and uncertainty about the market outcome, and decreases in the cost parameter.

Quality Orientation. In the second period, the manager considers adjusting quality (but not price) in response to $\hat{m}^+$ and price (but not quality) in response to $\hat{m}^-$, solving

$$\max_{q_2} \quad \pi_2(q_2; p_1|\hat{m}^+) = p_1(\alpha + \hat{m} + q_2 - p_1) - \frac{k}{2}q_2^2 \tag{12}$$

$$\max_{p_2} \quad \pi_2(p_2; q_1|\hat{m}^-) = p_2(\alpha + \hat{m} + q_1 - p_2) - \frac{k}{2}q_1^2. \tag{13}$$

The corresponding optimized profits are denoted by $\pi_2^+(p_1^*|\hat{m})$ and $\pi_2^-(q_1^*|\hat{m})$. In the first period, using a similar logic as in the case of a price orientation, the manager sets the same price and quality as in the benchmark case.

3.4 The Impact of the Bias

We now compare the optimized expected overall profits across the benchmark and self-serving cases. First, we establish the following result:

Lemma 3. *When the manager uses self-serving attributions to explain firm performance, the expected overall profit under a price orientation and a quality orientation are the same.*

Note that Lemma 3 has an important managerial implication: in a monopoly market, the choice of the orientation does not affect the performance of the firm when managers make self-serving attributions. This implies the following proposition:

Proposition 1. *The optimized expected overall profit of a monopolist is lower in the context of self-serving attributions than of optimal attributions, as*

$$\Pi_1^* - \Pi_1^s = \frac{(2k+1)\sigma_m^2}{8(2k-1)} > 0.$$

Proposition 1 shows that the managerial bias reduces profit and thus results in a cost to the firm. Intuitively, because the manager does not foresee making self-serving adjustments following the market outcome, the price and quality chosen in the first period are the same across the two scenarios. This implies that the cost of the bias is caused by distorted adjustments in the second period: While the expected price is excessively high compared to the benchmark in the case of a price orientation, the price is excessively low in the case of a quality orientation. Since the expected quality is set at the optimal level under both orientations, this in turn implies that the overall expected profit with distorted price adjustments is lower than in the benchmark case.

Proposition 1 also shows how the cost of the bias is driven by uncertainty and investment cost. First, higher uncertainty increases the cost of the bias: it reinforces excessive adjustments to price and, therefore, further distorts profit. Second, a higher investment cost has the opposite effect: it discourages the manager from investing in quality in the first period, and, therefore, it reduces the distortion of price in the second period. Finally, note that the cost of the bias does not depend on market size. This is intuitive: In the absence of uncertainty, profits in the benchmark and self-serving cases must be the same.

4 Competition

We extend the initial analysis to include competition. We first describe the interaction between the firms and the consumers, and then study the impact of self-serving attributions on profit. Finally, we analyze the optimal choice of orientation.

4.1 Assumptions

We consider now a market with two single-product firms $i = A, B$ that compete on price and quality over two periods. In each period, the managers choose the price p_{it} and quality q_{it} of the product sold by their respective firm. The investment to provide quality q_{it} is $\kappa(q_t) = \frac{k}{2} q_{it}^2$, where $k > \frac{2}{3}$. This parameter restriction ensures that the profit function of each firm is concave and thus has a unique global maximizer.

The products are differentiated horizontally and vertically. Horizontal differentiation is à la Hotelling, with the firms located at the extremes of the characteristics space $[0,1]$, that is, $x_A = 0$ and $x_B = 1$. Vertical differentiation reflects the notion that higher quality enhances the worth of the product in the minds of consumers. The market consists of a mass of consumers, which we normalize to unity. Each consumer purchases one unit of the preferred product in each period. Individual preferences are described by a conditional indirect utility function of the form

$$v_{it}(x) = q_{it} + \varepsilon_{iq} - (p_{it} + \varepsilon_{ip}) - \frac{1}{2}|x - x_i|, \tag{14}$$

where $x \in [0,1]$ is the consumer's preferred product characteristic and $|x - x_i|$ describes the horizontal mismatch of the consumer from purchasing the product of firm i. We assume that the preferred product characteristics are drawn independently across consumers from a uniform distribution over the interval $[0,1]$. We let ε_{ip} and ε_{iq} denote the difference between the subjective valuations of price and quality by consumers and the corresponding levels set by firms. These deviations are drawn in the first period from independent normal distributions with mean zero and variances $\sigma_p^2/2$ and $\sigma_q^2/2$, respectively. Consumers have private information about x, ε_{ip}, and ε_{iq}, but their distributions are assumed to be common knowledge.

The demand for the product of firm i in period t as a function of prices $\mathbf{p}_t = (p_{At}, p_{Bt})$ and qualities $\mathbf{q}_t = (q_{At}, q_{Bt})$ is derived from the conditional indirect utility function in (14) as

$$D_{it}(\mathbf{p}_t, \mathbf{q}_t) = \frac{1}{2} + (q_{it} - p_{it}) - (q_{jt} - p_{jt}) + \xi_{iq} - \xi_{ip},$$

where $\xi_{iq} \equiv \varepsilon_{iq} - \varepsilon_{jq}$ and $\xi_{ip} \equiv \varepsilon_{ip} - \varepsilon_{jp}$. The market outcome to firm i is defined as $\hat{m}_i = \hat{\xi}_{iq} - \hat{\xi}_{ip}$. Note that $\hat{m}_i = -\hat{m}_j$, which implies that the two firms experience opposite outcomes. The market outcome $\hat{m}_i$ is normally distributed with mean zero and variance $\sigma_m^2 \equiv \sigma_p^2 + \sigma_q^2$, where we require that $\sigma_m \leq \frac{3k-2}{8k}$.

4.2 Optimal Attributions

In the second period, the manager of firm i adjusts price and quality given the information learned from $\hat{m}_i$ using Bayes' rule according to (3) and (4).[11] Specifically, the manager solves

$$\max_{p_{i2},q_{i2}} \quad \pi_{i2}(p_{i2},q_{i2}|\hat{m}_i) = p_{i2}D_{i2}(\mathbf{p}_2,\mathbf{q}_2|\hat{m}_i) - \frac{k}{2}q_{i2}^2. \tag{15}$$

The optimized profit in the second period is denoted by $\pi_{i2}^*(\hat{m}_i)$.

In the first period, the manager of firm i sets price and quality to maximize the expected overall profit

$$\begin{aligned}\max_{p_{i1},q_{i1}} \quad \Pi_{i1}(p_{i1},q_{i1}) = p_{i1}D_{i1}^e(\mathbf{p}_1,\mathbf{q}_1) - \frac{k}{2}q_{i1}^2 \\ + \int_{-\infty}^{\infty} \pi_{i2}^*(\hat{m}_i) f(\hat{m}_i) d\hat{m}_i,\end{aligned} \tag{16}$$

where D_{i1}^e is the expected demand. We denote the expected first-period profit by π_{i1}^*, and the optimized expected overall profit by Π_{i1}^*. The analysis leads to this result.

Lemma 4. *When managers use optimal attributions to explain firm performance, the optimized expected overall profit of firm i in a duopoly is*

$$\Pi_{i1}^* = \frac{2k-1}{4k}\left(1 + \frac{2k^2\sigma_m^2}{(3k-2)^2}\right).$$

Lemma 4 shows that the properties of the monopoly profit Π_1^* under optimal attributions carry over to a competitive market environment: a lower investment cost and greater uncertainty result in a higher profit for the firm. Note that Π_{i1}^* increases with the mass of consumers if the size of the market is not normalized.

4.3 Self-Serving Attributions

Managers who are self-serving adjust price and quality given the information learned from $\hat{m}_i$ according to (7) and (8). We assume again that the choice of variable to adjust is

[11] In contrast to the monopoly case, the manager estimates $\hat{\xi}_{ip}^o$ and $\hat{\xi}_{iq}^o$ at the market level, not $\hat{\varepsilon}_{ip}^o$ and $\hat{\varepsilon}_{iq}^o$ at the firm level.

discrete, and that managers do not anticipate making or acting on self-serving attributions. In a competitive setting with two firms where each firm can either have a price orientation or a quality orientation, there are four possible combinations of orientations: both firms have a price orientation (*PO*,*PO*), both firms have a quality orientation (*QO*,*QO*), or one firm has a quality orientation while the other firm has a price orientation—the "mixed orientations" (*PO*,*QO*) and (*QO*,*PO*). Figure 2 summarizes the possible combinations of orientations, and we now address each of them in turn.

Matching Price Orientation. In the second period, the manager of firm i adjusts price (but not quality) in response to $\hat{m}_i^+$ and quality (but not price) in response to $\hat{m}_i^-$. Following the definition of Nash equilibria, we assume that managers hold correct beliefs about the adjustments of their counterparts. Intuitively, this means that managers put themselves in the shoes of the opponent and correctly predict its self-serving adjustments given its orientation and market outcome. Said differently, managers believe that the competitor acts in the same way as they do. Because managers do not see their own bias, they do not see it in the competitor either. The manager of firm i therefore solves the constrained optimization problems

$$\max_{p_{i2}} \quad \pi_{i2}(p_{i2}, q_{j2}|\hat{m}_i^+) \quad = \quad p_{i2}D_{i2}(p_{i2}, p_{j1}, q_{i1}, q_{j2}) - \frac{k}{2}q_{i1}^2 \tag{17}$$

$$\max_{q_{i2}} \quad \pi_{i2}(p_{j2}, q_{i2}|\hat{m}_i^-) \quad = \quad p_{i1}D_{i2}(p_{i1}, p_{j2}, q_{i2}, q_{j1}) - \frac{k}{2}q_{i2}^2. \tag{18}$$

The corresponding optimized profits are denoted by $\pi_{i2}^+(\hat{m}_i)$ and $\pi_{i2}^-(\hat{m}_i)$.

In the first period, the manager of firm i sets the price and quality according to (16), while the optimized expected overall profit is in effect given by

$$\Pi_{i1}^{PP} = \pi_{i1}^* + \int_{-\infty}^{0} \pi_{i2}^-(\hat{m}_i) f(\hat{m}_i) d\hat{m}_i + \int_{0}^{\infty} \pi_{i2}^+(\hat{m}_i) f(\hat{m}_i) d\hat{m}_i, \tag{19}$$

as indicated in Figure 2. We derive the following result.

Proposition 2. *When both firms have a price orientation, the optimized expected overall profit of firm i in a duopoly is higher in the context of self-serving attributions than of optimal attributions.*

		Firm B	
		PO	*QO*
Firm A	*PO*	Π_{A1}^{PP} Π_{B1}^{PP}	Π_{A1}^{PQ} Π_{B1}^{PQ}
	QO	Π_{A1}^{QP} Π_{B1}^{QP}	Π_{A1}^{QQ} Π_{B1}^{QQ}

Figure 2: Possible combinations of orientations and corresponding profits. The acronym *PO* denotes a price orientation, whereas *QO* stands for a quality orientation.

Proposition 2 shows that the firms benefit from the decisions of self-serving managers. The profit for each firm is higher than in the benchmark case, as self-serving adjustments increase the expected prices, while the expected qualities and demands are the same. Intuitively, the upward pressure on price results from an excessive increase in price following a positive market outcome. Said differently, when both firms have a price orientation the managerial bias softens price competition, which yields higher profits.

Matching Quality Orientation. In the second period, the manager of firm i adjusts quality (but not price) in response to $\hat{m}_i^+$ and price (but not quality) in response to $\hat{m}_i^-$. The manager of firm i therefore solves

$$\max_{q_{i2}} \quad \pi_{i2}(p_{j2}, q_{i2} | \hat{m}_i^+) \quad = \quad p_{i1} D_{i2}(p_{i1}, p_{j2}, q_{i2}, q_{j1}) - \frac{k}{2} q_{i2}^2 \tag{20}$$

$$\max_{p_{i2}} \quad \pi_{i2}(p_{i2}, q_{j2} | \hat{m}_i^-) \quad = \quad p_{i2} D_{i2}(p_{i2}, p_{j1}, q_{i1}, q_{j2}) - \frac{k}{2} q_{i1}^2. \tag{21}$$

In the first period, the manager sets the same price and quality as in the case where both firms have a price orientation—a consequence of ignoring that decisions carry over to the second period. The analysis leads to the following result.

Proposition 3. *When both firms have a quality orientation, the optimized expected overall profit of firm i in a duopoly is lower in the context of self-serving attributions than of soptimal attributions.*

Taken together, Propositions 2 and 3 show that the cost of the managerial bias in a competitive setting depends on the orientation of the firm. This stands in contrast to result in the monopoly setting. While a price orientation helps the firms to increase profit over the benchmark of optimal attributions, a quality orientation has the opposite effect. The profit for each firm is lower than in the benchmark case as self-serving adjustments decrease the expected prices, while the expected qualities and demands are the same. Intuitively, the downward pressure on price results from an excessive reduction in price in response to a positive market outcome.

Mixed Orientation. So far, we have focused on symmetric orientations. We now explore the asymmetric cases where one firm has a price orientation while the other firm has a quality orientation. We present the case where firm i has a quality orientation and firm j has a price orientation. The manager of firm i therefore solves

$$\max_{q_{i2}} \quad \pi_{i2}(q_{i2}, q_{j2}|\hat{m}_i^+) = p_{i1} D_{i2}(p_{i1}, p_{j1}, q_{i2}, q_{j2}) - \frac{k}{2} q_{i2}^2 \tag{22}$$

$$\max_{p_{i2}} \quad \pi_{i2}(p_{i2}, p_{j2}|\hat{m}_i^-) = p_{i2} D_{i2}(p_{i2}, p_{j2}, q_{i1}, q_{j1}) - \frac{k}{2} q_{i1}^2. \tag{23}$$

Again, the manager does not consider that the decisions carry over to the second period when making setting price and quality in the first period. The following result holds.

Proposition 4. *When the firms have opposite orientations in a duopoly, the optimized expected overall profit of the firm with the quality orientation is higher in the context of self-serving attributions than of optimal attributions, whereas the optimized expected overall profit of the firm with the price orientation is lower compared to the benchmark case.*

Proposition 4 shows that the firm with the quality orientation (firm i) benefits from the managerial bias, while the opposite holds for the firm with the price orientation (firm j). Intuitively, the manager of firm i prices more aggressively than its rival in the event of a negative market outcome, while qualities are set at the same level in the event of a positive market outcome. This competitive advantage of firm i translates into a higher demand for firm i. Overall, this results in a higher profit for firm i (the reduction in revenue is offset by the increase in sales) and a lower profit for firm j (the increase in revenue is offset by the reduction in sales).

4.4 Equilibrium Orientation

Unlike the monopoly setting, orientation matters for profitability in a competitive market. Conventional wisdom suggests that firms should strive for an asymmetric orientation to exploit "market niches" (Porter 2004). However, the next result shows that this intuition does not necessarily apply.

Proposition 5. *In a competitive market environment, the unique pure-strategy Nash equilibrium in orientations is that both firms adopt a price orientation.*

The interesting aspect of Proposition 5 is that the firms benefit from managers who are self-serving. The reason for this is that self-serving adjustments create upward pressure on equilibrium prices under a price orientation—a positive externality.

5 Conclusion

Just as people see themselves readily as the origin of good effects and reluctantly as the origin of ill effects, managers see the firms that employ them readily as the origin of success and reluctantly as the origin of failure. In our research, managers act on their self-serving nature when they assess the impact of prior price and quality decisions. If the performance of their firms is surprisingly favorable, then managers want to credit the dominant, "strategic" factor. If the performance is surprisingly unfavorable, then they prefer to blame the factor that was discarded. In both cases, the choice of orientation is vindicated, which is psychologically gratifying. However, distorting reality presumably carries a cost, as biased explanations of the market outcome imply biased adjustments to these product factors.

The paper first reports experiments that provide support for three predictions. First, that causal attributions are determined by the orientation of the firm and the valence of the market outcome. Second, that this inferential process is mediated by beliefs about locus, stability, and control. Third, that there is a positive relationship between attributions and the type of adjustment: participants indicate stronger adjustments to the factor they deemed responsible for the market outcome.

As noted, one interesting aspect of the data is that participants consistently rated quality as more internal, stable, and controllable than price. One possible explanation is that firms have more opportunities to stand out on quality than they do on price, making the former more salient. At the same time, there may be a belief among managers that price is tantamount to "market conditions" and therefore more situational in nature, while quality better reflects the values of a firm and therefore is more dispositional in nature. While casual observation lends credence to this idea, an interesting avenue for future research is to test its validity and possible ramifications.

The paper then develops a model to understand the impact of the bias. In the model, the uncertainty necessary for managers to behave in a self-serving manner stems from the fact that consumers perceive price and quality differently to the levels set by the firm. Managers must infer these deviations, but their estimates are skewed by the valence of the market outcome and the orientation of the firm toward either product factor. One key finding is that orientation does not affect the cost of self-serving attributions in a monopoly setting, but it does under competition. A second finding is that this "cost" is in fact negative in the second scenario: competing firms profit from the biased adjustments of their managers.

The analytical results are to some extent driven by the assumption that managers resolve to adjust price or quality, but not both. This stems from the premise that managers focus only on the factor that they believe caused the market outcome. While this approach improves tractability and provides a natural upper bound for the cost of the bias, allowing for continuous adjustments is likely to be a relevant topic for future research. In our mind, one option is to make adjustments that are proportional to the extent of the attributions. A second option is to put a cap on any given adjustment. A third option is to let managers adjust freely, but incur a non-monetary cost if they correct the "wrong" factor.

A second limitation of the model is that the parameters of the distributions of the consumers' subjective deviations from the price and quality set by the firm is common knowledge. Relaxing this assumption would certainly complicate the inference process for managers: they would need to estimate the mean and the variance of the subjective deviations as well as make attributions to price and quality. Analyzing the interplay of market research and self-serving attributions is certainly an interesting area for future research.

Third, while we are interested in the effect of orientation, there are other ways for managers to exploit their self-serving tendency. For example, one could envision a manager who credits success to the firm and blames failure on competition. Alternatively, the firm cold allocate price and quality decisions to different internal units, and these then conflict in their explanations of success and failure. Such perspectives reflect other setting in practice and would generate results that complement our approach.

At a more conceptual level, one may argue that market forces crowd out most psychological phenomena, including the type of positivism described in our research. In contrast, the managers surveyed in our second experiment are clearly self-serving, despite their experience. One explanation for this contradiction is that most markets afford few opportunities to learn from mistakes and, when they occur, there is too much ambient noise to learn from them (Meyer and Hutchinson 2016). Second, questioning the resilience of a behavioral anomaly makes more sense when the effect is self-defeating. This is not the case here. The way to settle the debate is to check whether the phenomenon exists in the real world. However, field experiments that study managerial decisions present nontrivial challenges in logistics and tractability. One alternative is to gather data from simulation games. On the contrary, studying financial communications such as letters to shareholders or earnings reports is unlikely to provide great insight because they do not record the actions of managers following their attributions.

Finally, it would be interesting to test personality traits that are likely to play a moderating role. For example, to the extent that managers hold a positive view of their abilities, the upshot is a stronger and more permanent asymmetry between price and quality in terms of attributions and adjustments. Second, a manager's tendency to be self-serving may depend on the capacity to exert self-control, as overriding the urge is cognitively taxing. Third, the degree to which managers are self-serving is probably affected by their acknowledgement and appreciation of the problem. We already pointed out that people struggle to spot their traits. In addition, motivated reasoning probably skews the search for information and the standards of proof in favor of hypotheses that reinforce past behaviors, which again weakens the ability to introspect. An interesting approach would be to build a model of introspection, where managers learn their bias over time.

Appendix A Demand

Suppose that there are $\alpha + (q_t + \varepsilon_q)$ potential consumers whose willingness to pay for the product is uniformly distributed over the interval $[0, \frac{\alpha+(q_t+\varepsilon_q)}{\beta}]$. Given ε_p, the consumers' perceived price is $p_t + \varepsilon_p$ and demand is

$$D_t(p_t, q_t) = \max\{\alpha + (q_t + \varepsilon_q) - \beta(p_t + \varepsilon_p), 0\},$$

where the max function ensures that demand is non-negative. Setting β to unity yields the demand function in (1).

Appendix B Market Outcome

The market outcome can be viewed as a realization of a normally-distributed random variable if the realized demand is positive with probability one. Intuitively, this requires that the market outcome is not "too negative."

Using a standard result, the probability that a normally-distributed random variable with mean zero and variance σ_m^2 takes a value smaller than $n \geq 1$ standard deviations from the mean is

$$\Pr\{\hat{m} \leq -n\sigma_m\} = \frac{1}{2}(1 - Erf(\frac{n}{\sqrt{2}})), \tag{B.1}$$

where

$$Erf(x) := \frac{2}{\sqrt{\pi}} \int_0^x \exp(-t^2)dt$$

is the error function encountered in integrating the normal distribution (see, for instance, Greene 1995, p. 921). It is well known that the probability in (B.1) rapidly converges to zero as n increases. For example, if $n = 3$ the probability is already as low as 1.35×10^{-3}, meaning that, on average, less than two out of a 1,000 draws can be expected to be smaller than $-3\sigma_m$.

Throughout the paper, we make the conservative assumption that $n = 4$. In this case $\Pr\{\hat{m} \leq -4\sigma_m\} = 31.67 \times 10^{-6}$, which is essentially zero for our purpose. Therefore, by putting an upper bound on the variance of the market outcome, realized demand is positive with probability tending to one, and the market outcome can be viewed as a draw from an untruncated normal distribution.

Appendix C Optimal Attributions

Recall that, if X and Y are jointly normal random variables, then the conditional expectation of X given $Y = y$ is normal with

$$E[X|Y] = E[X] + \rho \frac{\sigma_X}{\sigma_Y}(y - E[Y]), \tag{C.2}$$

where $\rho = E[XY](\sigma_X \sigma_Y)^{-1}$ is the correlation coefficient of X and Y (Mood and Graybill 1963, Theorem 9.3, p. 202).

To establish (3), set $X \equiv \varepsilon_p$, $Y = \varepsilon_q - \varepsilon_p$, and $y = \hat{\varepsilon}_q - \hat{\varepsilon}_p$. The distributional assumptions imply $E[\varepsilon_p] = E[\varepsilon_q - \varepsilon_p] = 0$, $E[\varepsilon_p(\varepsilon_q - \varepsilon_p)] = -\sigma_p^2$ and $\sigma_Y^2 = \sigma_p^2 + \sigma_q^2$. Therefore, the conditional expectation in (C.2) can be expressed as

$$E[\varepsilon_p|\hat{m}] = E[\varepsilon_p] - \frac{\sigma_p^2}{\sigma_p^2 + \sigma_q^2}\hat{m},$$

where $\hat{m} = \hat{\varepsilon}_q - \hat{\varepsilon}_p$. The proof of (4) is similar and therefore omitted.

Appendix D Proofs

Proof of Lemma 1. In the second period, the optimal price and quality follow from the (necessary and sufficient) first-order conditions of profit maximization. Solving (5) yields the optimal price and quality

$$p_2^*(\hat{m}) = \frac{(\alpha + \hat{m})k}{2k-1} \tag{D.3}$$

$$q_2^*(\hat{m}) = \frac{\alpha + \hat{m}}{2k-1}. \tag{D.4}$$

By substitution, the second-period demand and the optimized profit are given by

$$D_2^*(\hat{m}) = \frac{(\alpha + \hat{m})k}{2k-1} \tag{D.5}$$

$$\pi_2^*(\hat{m}) = \frac{(\alpha + \hat{m})^2 k}{2(2k-1)}. \tag{D.6}$$

Note that $D_2^*(\hat{m}) \geq 0$ if and only if $\hat{m} \geq -\alpha$. Using Appendix B and the assumption that $\sigma \leq \frac{\alpha}{4}$, demand is positive with probability one.

By definition, the expected second-period profit is given by

$$\int_{-\infty}^{\infty} \pi_2^*(\hat{m}) f(\hat{m}) d\hat{m}. \tag{D.7}$$

Because the market outcome $\hat{m}$ follows a normal distribution with mean zero and variance σ_m^2, the density of $\hat{m}$ is given by

$$f(\hat{m}) = \frac{1}{\sqrt{2\pi\sigma_m^2}} \exp\left(-\frac{\hat{m}^2}{2\sigma_m^2}\right) d\hat{m}. \tag{D.8}$$

Using (D.6) and (D.8), the expected second-period profit in (D.7) can be written as

$$\int_{-\infty}^{\infty} \pi_2^*(\hat{m}) f(\hat{m}) d\hat{m} = \frac{k}{2(2k-1)} \int_{-\infty}^{\infty} (\alpha^2 + 2\alpha\hat{m} + \hat{m}^2) f(\hat{m}) d\hat{m}. \tag{D.9}$$

Since the density integrates to one by definition,

$$\alpha^2 \int_{-\infty}^{\infty} f(\hat{m}) d\hat{m} = \alpha^2,$$

and noting that

$$\int_{-\infty}^{\infty} \hat{m} f(\hat{m}) d\hat{m} \equiv E[\hat{m}] = 0$$

and

$$\int_{-\infty}^{\infty} \hat{m}^2 f(\hat{m}) d\hat{m} \equiv E[\hat{m}^2] = \sigma_m^2$$

under our distributional assumption, the expected second-profit in (D.9) simplifies to

$$\int_{-\infty}^{\infty} \pi_2^*(\hat{m}) f(\hat{m}) d\hat{m} = \frac{(\alpha^2 + \sigma_m^2)k}{2(2k-1)}. \tag{D.10}$$

Given that the expected second-period profit is simply a constant, the optimal price and quality levels can be obtained from (D.3) and (D.4) by setting $\hat{m} = 0$:

$$p_1^* = \frac{\alpha k}{2k-1} \tag{D.11}$$

$$q_1^* = \frac{\alpha}{2k-1}. \tag{D.12}$$

Similarly, the expected first-period demand and profit can be derived as:

$$D_1^* = \frac{\alpha k}{2k-1} \tag{D.13}$$

$$\pi_1^* = \frac{\alpha^2 k}{2(2k-1)}. \tag{D.14}$$

Finally, the expected overall profit follows from adding up the profits in (D.10) and (D.14), and is given by

$$\Pi_1^* = \frac{(2\alpha^2 + \sigma_m^2)k}{2(2k-1)}.$$

Clearly, Π_1^* is increasing in market size α and uncertainty σ_m^2, while it is decreasing in the cost parameter k. □

Proof of Lemma 2. In the event of a positive market outcome, the manager solves (9) to find the optimal price

$$p_2^+(q_1^*) = \frac{1}{2}(\alpha + \hat{m} + q_1^*). \tag{D.15}$$

By substitution,

$$\pi_2^+(q_1^*|\hat{m}) = \frac{1}{4}\left((\alpha + \hat{m} + q_1^*)^2 - 2k(q_1^*)^2\right). \tag{D.16}$$

Substituting q_1^* given in (D.12) into (D.16) and averaging across positive market outcomes yields

$$\int_0^\infty \pi_2^+(q_1^*|\hat{m})f(\hat{m})d\hat{m} = \frac{2\alpha^2 k + 4\sqrt{\frac{2}{\pi}}\alpha k \sigma_m + (2k-1)\sigma_m^2}{8(2k-1)}. \tag{D.17}$$

In the event of a negative market outcome, the manager solves (10) to find the optimal quality

$$q_2^-(p_1^*) = \frac{p_1^*}{k}.$$

By substitution,

$$\pi_2^-(p_1^*|\hat{m}) = \frac{p_1^*(p_1^* + 2(\alpha + \hat{m} - p_1^*)k)}{2k}. \tag{D.18}$$

Substituting p_1^* given in (D.11) into (D.18) and averaging across negative market outcomes yields

$$\int_{-\infty}^0 \pi_2^-(p_1^*|\hat{m})f(\hat{m})d\hat{m} = \frac{\alpha\left(\sqrt{2\pi}\alpha - 4\sigma_m\right)k}{4\sqrt{2\pi}(2k-1)}. \tag{D.19}$$

The expected second-period profit that results from self-serving attributions follows from adding up (D.17) and (D.19):

$$\int_{-\infty}^0 \pi_2^-(p_1^*|\hat{m})f(\hat{m})d\hat{m} + \int_0^\infty \pi_2^+(q_1^*|\hat{m})f(\hat{m})d\hat{m} = \frac{4\alpha^2 k + (2k-1)\sigma_m^2}{8(2k-1)}. \tag{D.20}$$

Finally, the optimized expected overall profit in (11) can be derived as

$$\Pi_1^s = \frac{8\alpha^2 k + (2k-1)\sigma_m^2}{8(2k-1)} \tag{D.21}$$

from adding up (D.14) and (D.20). □

Proof of Lemma 3. In the event of a positive market outcome, the manager solves (12) to find the optimal quality

$$q_2^+(p_1^*) = \frac{p_1^*}{k}.$$

By substitution,

$$\pi_2^+(p_1^*|\hat{m}) = \frac{p_1^*(p_1^* + 2(\alpha + \hat{m} - p_1^*)k)}{2k}. \tag{D.22}$$

Substituting p_1^* given in (D.11) into (D.22) and averaging across positive market outcomes yields

$$\int_0^\infty \pi_2^+(q_1^*|\hat{m}) f(\hat{m}) d\hat{m} = \frac{\alpha\left(\sqrt{2\pi}\alpha + 4\sigma_m\right)k}{4\sqrt{2\pi}(2k-1)}. \tag{D.23}$$

In the event of a negative market outcome, the manager solves (13) to find the optimal price

$$p_2^-(q_1^*) = \frac{1}{2}(\alpha + \hat{m} + q_1^*).$$

By substitution,

$$\pi_2^-(q_1^*|\hat{m}) = \frac{1}{4}\left((\alpha + \hat{m} + q_1^*)^2 - 2k(q_1^*)^2\right). \tag{D.24}$$

Substituting q_1^* given in (D.12) into (D.24) and averaging across negative market outcomes yields

$$\int_{-\infty}^0 \pi_2^-(q_1^*|\hat{m}) f(\hat{m}) d\hat{m} = \frac{2\alpha^2 k - 4\sqrt{\frac{2}{\pi}}\alpha k \sigma_m + (2k-1)\sigma_m^2}{8(2k-1)}. \tag{D.25}$$

The expected second-period profit that results from self-serving attributions follows by adding up (D.23) and (D.25) as follows:

$$\int_{-\infty}^0 \pi_2^-(q_1^*|\hat{m}) f(\hat{m}) d\hat{m} + \int_0^\infty \pi_2^+(q_1^*|\hat{m}) f(\hat{m}) d\hat{m} = \frac{4\alpha^2 k + (2k-1)\sigma_m^2}{8(2k-1)}. \tag{D.26}$$

Since the expected second-period profit under a price orientation in (D.26) coincides with the corresponding profit under a price orientation in (D.20), the optimized expected overall profit under a quality orientation is the same as Π_1^s in (D.21). □

Proof of Proposition 1. The proof of Lemma 3 shows that the expected overall profit under a price or quality orientation are the same. Therefore, it suffices to compare Π_1^*

(given in Lemma 1) to Π_1^s (given in Lemma 2) to calculate the profit impact of self-serving attributions to the firm, which is given by

$$\Pi_1^* - \Pi_1^s = \frac{(2k+1)\sigma_m^2}{8(2k-1)}.$$

The cost of the managerial bias to the firm is positive as $\sigma_m^2 > 0$ and $k > \frac{1}{2}$ by assumption.

□

Proof of Lemma 4. In the second period, the managers solve (15) to determine the optimal adjustments to price and quality as a function of the market outcome. The optimal price and quality are

$$\begin{aligned} p_{i2}^*(\hat{m}_i) &= \frac{1}{2} + \frac{k\hat{m}_i}{3k-2} \\ q_{i2}^*(\hat{m}_i) &= \frac{1}{2k} + \frac{\hat{m}_i}{3k-2}. \end{aligned}$$

By substitution, the demands and profits can be derived as

$$\begin{aligned} D_{i2}^*(\hat{m}_i) &= \frac{1}{2} + \frac{k\hat{m}_i}{3k-2} \\ \pi_{i2}^*(\hat{m}_i) &= \frac{(2k-1)((3+2\hat{m}_i)k-2)^2}{8(3k-2)^2k}. \end{aligned} \tag{D.27}$$

The expected second-period profit can be found by adding up the profits across market outcomes, that is

$$\int_{-\infty}^{\infty} \pi_{i2}^*(\hat{m}_i) f(\hat{m}_i) d\hat{m}_i = \frac{(2k-1)((3k-2)^2 + 4k^2\sigma_m^2)}{8(3k-2)^2k}. \tag{D.28}$$

The prices, qualities, and demands are positive if $|\hat{m}_i| \leq \frac{3k-2}{2k}$; a condition that holds with probability tending to one as $\sigma_m \leq \frac{3k-2}{8k}$ (see Appendix B). Specifically, note that $\Pr\{|\hat{m}_i| \geq 4\sigma_m\} = 63.34 \times 10^{-6}$, which is essentially zero.

In the first period, the managers solve (16) to determine the optimal price and quality. Noting that the expected second-period profit is simply a constant, it thus follows from (D.27) that $\pi_{i1}^* = \pi_{i2}^*(0)$. Finally, the optimized expected overall profit Π_{i1}^* can be obtained by adding up π_{i1}^* and the expected second-period profit in (D.28). □

Proof of Proposition 2. In the event of a positive market outcome, the manager of firm i solves (17) to find the optimal price

$$p_{i2}^{+}(q_{i1}^{*}) = \frac{1}{4}(1+2\hat{m}_i+2p_{j1}^{*}+2q_{i1}^{*}-2q_{j2}).$$

The manager of firm j chooses the optimal quality according to

$$q_{j2}^{+}(p_{j1}^{*}) = \frac{p_{j1}^{*}}{k}.$$

By substitution,

$$\pi_{i2}^{+}(\hat{m}_i) = \frac{2k(1+\hat{m}_i)^2-1}{8k}. \tag{D.29}$$

In the event of a negative market outcome, the manager of firm i solves (18) to find the optimal quality

$$q_{i2}^{+}(p_{i1}^{*}) = \frac{p_{i1}^{*}}{k}.$$

The manager of firm j chooses its optimal price according to

$$p_{j2}^{-}(q_{j1}^{*}) = \frac{1}{4}(1-2\hat{m}_i+2p_{i1}^{*}-2q_{i2}+2q_{j1}^{*}).$$

By substitution,

$$\pi_{i2}^{-}(\hat{m}_i) = \frac{1}{8}\left(2-\frac{1}{k}+2\hat{m}_i\right). \tag{D.30}$$

The expected second-period profit follows by adding up (D.29) and (D.30) as follows:

$$\int_{-\infty}^{0} \pi_{i2}^{-}(\hat{m}_i)f(\hat{m}_i)d\hat{m}_i + \int_{0}^{\infty} \pi_{i2}^{+}(\hat{m}_i)f(\hat{m}_i)d\hat{m}_i = \frac{1}{8}\left(2-\frac{1}{k}+\sqrt{\frac{2\sigma_m^2}{\pi}}+\sigma_m^2\right).$$

In the first period, the manager of firm i solves (16) to determine the optimal price and quality. From Lemma 4, we know that $\pi_{i1}^{*} = \pi_{i2}^{*}(0)$. The optimized expected overall profit then follows from adding up π_{i1}^{*} and the expected second-period profit in (D.30):

$$\Pi_{i1}^{PP} = \frac{1}{8}\left(4-\frac{2}{k}+\sqrt{\frac{2\sigma_m^2}{\pi}}+\sigma_m^2\right). \tag{D.31}$$

Comparing Π_{i1}^{PP} to the corresponding profit Π_{i1}^{*} in the benchmark case yields

$$\Pi_{i1}^{*} - \Pi_{i1}^{PP} = \frac{1}{8}\left(\frac{((8-k)k-4)\sigma_m^2}{(3k-2)^2}-\sqrt{\frac{2\sigma_m^2}{\pi}}\right).$$

This difference is negative under our assumptions that $k > \frac{2}{3}$ and $\sigma_m \leq \frac{3k-2}{8k}$. □

Proof of Proposition 3. In the event of a positive market outcome, the manager of firm i solves (20) to find the optimal quality

$$q_{i2}^{+}(p_{i1}^{*}) = \frac{p_{i1}^{*}}{k}.$$

The manager of firm j chooses the optimal price according to

$$p_{j2}^{-}(q_{j1}^{*}) = \frac{1}{4}(1 - 2\hat{m}_j + 2p_{i1}^{*} - 2q_{i2} + 2q_{j1}^{*}).$$

By substitution,

$$\pi_{i2}^{+}(\hat{m}_i) = \frac{1}{8}\left(2 - \frac{1}{k} + 2\hat{m}_i\right). \tag{D.32}$$

In the event of a negative market outcome, the manager of firm i solves (21) to find the optimal price

$$p_{i2}^{-}(q_{i1}^{*}) = \frac{1}{4}(1 + 2\hat{m}_i + 2p_{j1}^{*} + 2q_{i1}^{*} - 2q_{j2}).$$

The manager of firm j chooses its optimal quality according to

$$q_{j2}^{+}(p_{j1}^{*}) = \frac{p_{j1}^{*}}{k}.$$

By substitution,

$$\pi_{i2}^{-}(\hat{m}_i) = \frac{2k(1+\hat{m}_i)^2 - 1}{8k}. \tag{D.33}$$

The expected second-period profit follows by adding up (D.32) and (D.33) as follows:

$$\int_{-\infty}^{0} \pi_{i2}^{-}(\hat{m}_i) f(\hat{m}_i) d\hat{m}_i + \int_{0}^{\infty} \pi_{i2}^{+}(\hat{m}_i) f(\hat{m}_i) d\hat{m}_i = \frac{1}{8}\left(2 - \frac{1}{k} - \sqrt{\frac{2\sigma_m^2}{\pi}} + \sigma_m^2\right).$$

Using a similar logic as in Proposition 2, the optimized expected overall profit can be derived as

$$\Pi_{i1}^{QQ} = \frac{1}{8}\left(4 - \frac{2}{k} - \sqrt{\frac{2\sigma_m^2}{\pi}} + \sigma_m^2\right). \tag{D.34}$$

Comparing Π_{i1}^{QQ} to the corresponding profit Π_{i1}^{*} in the benchmark case yields

$$\Pi_{i1}^{*} - \Pi_{i1}^{PP} = \frac{1}{8}\left(\frac{((8-k)k-4)\sigma_m^2}{(3k-2)^2} + \sqrt{\frac{2\sigma_m^2}{\pi}}\right).$$

This difference is positive under our assumptions that $k > \frac{2}{3}$ and $\sigma_m \leq \frac{3k-2}{8k}$. □

Proof of Proposition 4. In the event of a positive market outcome, the manager of firm i solves (22) to find the optimal quality

$$q_{i2}^{+}(p_{i1}^{*}) = \frac{p_{i1}^{*}}{k}.$$

The manager of firm j chooses the optimal quality according to

$$q_{j2}^{-}(p_{j1}^{*}) = \frac{p_{j1}^{*}}{k}.$$

By substitution,

$$\pi_{i2}^{+}(\hat{m}_i) = \frac{1}{8}\left(2 - \frac{1}{k} + 4\hat{m}_i\right)$$

and

$$\pi_{j2}^{-}(\hat{m}_i) = \frac{1}{8}\left(2 - \frac{1}{k} - 4\hat{m}_i\right).$$

In the event of a negative market outcome, the manager of firm i solves (23) to find the optimal price

$$p_{i2}^{-}(q_{i1}^{*}) = \frac{1}{6}(3 + 2\hat{m}_i + 2q_{i1}^{*} - 2q_{j1}^{*}).$$

The manager of firm j chooses its optimal price according to

$$p_{j2}^{+}(q_{j1}^{*}) = \frac{1}{6}(3 - 2\hat{m}_i - 2q_{i1}^{*} + 2q_{j1}^{*}).$$

By substitution,

$$\pi_{i2}^{-}(\hat{m}_i) = \left(\frac{1}{2} + \frac{\hat{m}}{3}\right)^2 - \frac{1}{8k}$$

and

$$\pi_{j2}^{+}(\hat{m}_i) = \left(\frac{1}{2} - \frac{\hat{m}}{3}\right)^2 - \frac{1}{8k}.$$

Similar analysis as in Propositions 2 and 3 yields the corresponding optimized expected overall profits. Specifically, we obtain

$$\Pi_{i1}^{QP} = \frac{1}{36}\left(18 - \frac{9}{k} + 3\sqrt{\frac{2\sigma_m^2}{\pi}} + 2\sigma_m^2\right) \tag{D.35}$$

and

$$\Pi_{j1}^{QP} = \frac{1}{36}\left(18 - \frac{9}{k} - 3\sqrt{\frac{2\sigma_m^2}{\pi}} + 2\sigma_m^2\right). \tag{D.36}$$

Finally, under our assumptions that $k > \frac{2}{3}$ and $\sigma_m \leq \frac{3k-2}{8k}$, it follows that $\Pi^*_{i1} - \Pi^{QP}_{i1} < 0$ and $\Pi^*_{j1} - \Pi^{QP}_{j1} > 0$, which establishes the claim. □

Proof of Proposition 5. We establish the claim by showing that using a price orientation (PO) is a dominant strategy for each firm. For firm A, this is the case if $\Pi^{PP}_{A1} - \Pi^{QP}_{A1} > 0$ and $\Pi^{PQ}_{A1} - \Pi^{QQ}_{A1} > 0$ (see Figure 2). Using (D.31) and (D.35), we obtain

$$\Pi^{PP}_{A1} - \Pi^{QP}_{A1} = \frac{1}{72}\left(3\sqrt{\frac{2\sigma^2_m}{\pi}} + 5\sigma^2_m\right).$$

Next, using (D.34) and (D.36), we have that

$$\Pi^{PQ}_{A1} - \Pi^{QQ}_{A1} = \frac{1}{72}\left(3\sqrt{\frac{2\sigma^2_m}{\pi}} - 5\sigma^2_m\right).$$

Note that these conditions are independent of the cost parameter k. Since $\sigma_m \leq \frac{3k-2}{8k} \leq \frac{3}{8}$, using a PO is indeed a dominant strategy for firm A. Since the payoffs are symmetric, the same holds for firm B, which establishes the claim. □

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