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The cue-ball effect: How an advantaged firm's closer competitors can propagate the impact of its advantage to more distant competitors

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Abstract

Research Summary: Cost advantage helps a firm at the expense of its rivals, but may hurt some rivals worse than others. Conventional wisdom suggests that an advantaged firm will do more harm to closer competitors, but the opposite may occur if competitors can reposition themselves. Closer competitors have stronger incentives to reposition away from the advantaged firm, thereby potentially encroaching on rivals more distant from the advantaged firm and propagating the harm to them like the cue ball in billiards transfers energy from cue stick to target ball. Our formal model compares an advantaged firm's closer and farther competitors, when repositioning is allowed or prohibited, and demonstrates when its advantage hurts farther competitors worse than closer ones. We provide an illustrative case study from grocery retailing.

Managerial Summary: When Walmart brought its advantage in distribution efficiency to the low end of the grocery retailing industry, it displaced the inefficient downscale incumbent Winn-Dixie in many geographic areas. One might have expected such increased efficiency at the low end of the market to hurt midscale supermarkets like Kroger more than premium grocers like Whole Foods, yet the opposite occurred. Why? In a word, repositioning. Midscale competitors retreated away from Walmart by repositioning upscale via renovations, which thereby transferred the impact to premium rivals who could not escape any further upscale. Our economic model of this "cue-ball effect" predicts that the impact propagated onto upper-end competitors is greater in markets with less income inequality, and our empirical results are consistent with this prediction.

KEYWORDS

competitive advantage, formal modeling, repositioning, rivalry, vertical differentiation

"[W]here the other firms are located nearby in product space, theory predicts that equilibrium prices will be closer to marginal cost. In other words, there is a first-order effect that drives down the price of similar competitors... "

Mazzeo (2002, p.717)

"*The more similar a focal organization is to its competitors, the greater the intensity of competition it will experience....* "

Baum and Mezias (1992, pp. 581–582)

1 | INTRODUCTION

A firm's competitive advantage boosts its own performance while diminishing the performance of competitors. Yet all rivals are not necessarily affected equally by that advantage. Some rivals may be hurt worse than others. As suggested by the quotations above, it is natural to assume that the competitors with which an advantaged firm competes more directly—that is, more proximate rivals, which are positioned closer to it in terms of similarity in product attributes, target customers, or geographic location—will be hurt worse by its advantage. But is this assumption always valid? Or could there be some circumstances where a firm's advantage actually hurts more distant rivals worse than closer rivals? If so, then distant rivals who assume that they enjoy a well-protected niche could be unexpectedly blindsided.

For instance, consider the scenario of a vertically differentiated triopoly, with low-end, middle-market, and high-end competitors. If the low-end firm gains a cost advantage, then the high-end rival might assume that it is well-protected from that advantage, or at least better protected than the middle-market firm, but is it? In an actual example of this scenario, which we will explore more thoroughly later, Walmart brought its huge efficiency advantage to the low end of the US grocery retailing industry via its Supercenter store format, so one might have expected middle-market supermarkets like Kroger to be hurt worse than high-end grocers like Whole Foods Market. Yet the reverse actually happened. Despite its seemingly well-protected high-end niche, Whole Foods unexpectedly suffered a huge performance decline, to the point where it almost certainly would have failed if it had not been bailed out via acquisition by Amazon. However, Kroger adapted to Walmart's threat by repositioning itself farther upscale to compete less directly with Walmart but more directly with high-end grocers—in effect, betting that it could compete better against Whole Foods than against Walmart. This bet paid off handsomely, as indicated by the stark contrast between Kroger's continued success and Whole Foods Market's near-failure.

Unfortunately, in such situations, existing research provides no clear guidance about whether the emergence of a firm's advantage will hurt worse for its closer rivals or for its more distant rivals. On the one hand, research across the economics, strategic management, and organizational ecology literatures all suggest that competitive actions affect the closer competitors more and that the intensity of competition diminishes as the "distance" between the competitors increases. For instance, in models of horizontally differentiated spatial competition (D'Aspremont et al., 1979; Hotelling, 1929) and quality-based competition (Shaked & Sutton, 1982), firms' locational proximity or product similarity intensifies their competition. Likewise, in strategic management research, one of the important effects of strategic similarity—defined as "similarity in the general pattern of resource deployment and competitive orientation" (Gimeno & Woo, 1996: p. 324)—is intensified competition (see also Deephouse, 1999). Studies in organizational ecology also arrive at similar conclusions (e.g., Baum & Mezias, 1992; Carroll, 1985). These findings suggest that in our vertical triopoly scenario, the middle-market firm would be hurt worse since it is closer to the firm with the advantage—also consistent with being "stuck in the middle" (Porter, 1980).

On the other hand, early studies of vertical differentiation (e.g., Gabszewicz & Thisse, 1979; Shaked & Sutton, 1983) and more recent empirical evidence on the same (Mazzeo, 2002) suggest that sufficiently intense competitive interaction between two or more high-quality firms can harm a low-quality firm, possibly even forcing it out of the market. These results indicate that firms at one end of a vertical market can be affected by the intensity of inter-firm rivalry at the opposite end, but do not directly address the question of whether (and when or how) the unique advantage of a firm at one end can have a bigger impact on the performance of firms at the opposite end than on firms in the middle of the market.

We tackle these questions directly by using formal economic modeling to examine the possibility of a firm's advantage hurting distant rivals worse than closer ones. The key to our analysis is the recognition that if firms can reposition themselves in response to another firm's advantage and consequent actions, then those advantages and actions can be propagated *through* closer competitors to impact more distant competitors, much like the movement of the cue ball in billiards transfers energy from the cue stick to the target ball. As in the grocery retailing example discussed above, when a low-end firm like Walmart wields a cost advantage, then a middle-market competitor like Kroger can reposition itself upscale in order to avoid competing so directly with the advantaged low-end firm, in which case its upward repositioning pushes it into more direct competition with high-end rivals like Whole Foods. In this way, the low-end firm's advantage *indirectly* affects the high-end rival by being propagated *through* the repositioning of a middle-market competitor. Based on the billiards metaphor, we refer to this propagation as the "cue-ball effect." Although repositioning has been studied as a way for a firm to respond to its immediate competitor (e.g., Cong & Zhou, 2019; Du et al., 2019; Gimeno et al., 2006; Makadok & Ross, 2013; Menon & Yao, 2017; Wang & Shaver, 2014), existing repositioning literature has largely ignored how repositioning differentially affects multiple competitors, and thus has never examined how repositioning can function as a propagation mechanism for an intermediate firm to transfer the impact of competition to more distant firms.

Our formal model studies a cue-ball effect in the type of vertically differentiated triopoly envisioned above. Initially, all three firms have identical cost functions. We analyze how their profits change if the low-end firm then unexpectedly enjoys a cost advantage. We compare the impact of that advantage on the other two rivals when firms either can or cannot reposition themselves. We find a pattern of results where the middle-market firm is always hurt worse than the high-end firm when firms cannot reposition, but the high-end firm is generally hurt worse than the middle-market firm when firms can reposition.[1] This latter effect occurs because the high-end firm already starts near the upper edge of the demand distribution, which limits its freedom to retreat upscale from the middle-market firm's upward encroachment. By contrast, a middle-market firm's more central initial position gives it ample latitude for upward repositioning to retreat from the advantaged low-end firm. But without repositioning, no such retreat is possible, so the middle-market firm has no choice but to absorb the bulk of the impact from the low-end firm's advantage.

To better understand the mechanisms underlying this pattern of results, and how robust it is, we develop three extensions by adding parameters to vary different demand-side and supply-side aspects of the model. First, it is generally understood that income inequality skews the distribution of customer willingness to pay (WTP) for higher quality in a vertically differentiated market, which in turn influences the optimal positioning of firms relative to each other (Schubert, 2017). So, our first extension of the model examines how the cue-ball effect changes as the skewness of the demand distribution (i.e., degree of income inequality) varies. We find that a skewed distribution gives a high-end firm more latitude to move further upscale, which helps it to retreat from the middle-market firm, thereby weakening or even reversing the cue-ball effect. In the second extension, we examine whether a simpler change in the demand distribution—namely, increasing its variance—might also eliminate or reverse the cue-ball effect by similarly giving the high-end firm more space to move further upscale. However, we find that it does not. Although raising the variance diminishes the magnitude of the cue-ball effect, it nevertheless still remains intact at any variance. Intuitively, this result makes sense because higher skewness increases the latitude to reposition much more for a high-end firm than for other firms, while higher variance more equally increases the various firms' latitude to reposition. Higher variance in the demand distribution motivates firms to stay further apart, thereby softening competition, so we interpret this weakening of the cue-ball effect as resulting from reduced competitive intensity. Conversely, increased competitive intensity (i.e., lower variance) amplifies the cue-ball effect. Finally, in our third extension, we consider whether a similar amplification of the cue-ball effect can arise from supply-side impediments to repositioning, rather than demand-side factors. In particular, this final extension varies how much a firm's cost accelerates as a function of its quality—that is, convexity in the cost of quality

[1]Because the middle-market and high-end firms differ greatly in their initial scale, we define "hurt worse" in terms of *percentage* declines in the two firms' performance. For reasons explained later, we argue that this is more meaningful than using *absolute* declines to compare changes in performance of two firms whose initial scale differs so much at the start. However, for the sake of transparency, we also report (in Online Appendix B) how the results differ when "hurt worse" is redefined in terms of absolute performance declines, even though this is a less meaningful comparison for firms that differ so much in their initial scale.

improvement. Increasing this convexity impedes upward repositioning, and does so more for a high-end firm than for its rivals, thereby strengthening the cue-ball effect.

We supplement this economic modeling with a detailed empirical case study from the grocery-retailing industry, in a way that builds on the first extension's predictions about demand skewness. This case study suggests that the cue-ball effects observed in our formal model also occur in real life and are not outcomes confined to theoretically possible parameter spaces. As mentioned earlier, Wal-Mart entered the low end of the grocery market, using its Supercenter store format, with a strong cost advantage based on its efficiency in distribution. Soon after Wal-Mart's entry, middle-market competitor Kroger embarked on a massive repositioning, by renovating and upgrading its stores with a new décor and new departments targeted toward a more upscale clientele, such as organic foods, cheese bars, olive bars, salad bars, and gourmet prepared foods. This upward repositioning moved Kroger into more direct competition with the high-end incumbent Whole Foods Market, whose performance then precipitously declined to the point where it was at risk of bankruptcy even after closing numerous stores, and likely only survived due to being rescued by Amazon's acquisition. Whole Foods may not have felt threatened by Walmart's advantage, since its high-end niche was distant and therefore seemingly insulated from the impact of Walmart's low-end entry. Yet that impact simply got propagated to Whole Foods via Kroger's upward repositioning from the middle. We conduct geographic statistical analyses to provide suggestive evidence about each of the steps in this process, by showing that renovations of Kroger stores increased after nearby Wal-Mart Supercenter openings and that the performance of Whole Foods stores declined after renovations of nearby Kroger stores. To capture demand skewness, we measure local variation in income inequality, and observe that, in local markets where Kroger renovated, greater inequality was associated with less severe performance declines for Whole Foods, consistent with predictions from our formal model's first extension.

Our analyses and findings make three related contributions. First, we shed new light on the possibility of a focal firm's actions and advantages affecting a distant firm, including highlighting some conditions that may aggravate or mute such effects. Although some vertical differentiation research considers competition's effects on distant rivals (e.g., Gabszewicz & Thisse, 1979; Mazzeo, 2002; Shaked & Sutton, 1983), they neglect the possibility of a cue-ball-style mechanism. Similarly, more recent studies such as Liu and Zhang (2013) and Zeithammer and Thomadsen (2013) have examined price and quality competition in vertically differentiated duopolies, but do not consider the possibility of distant effects on a third firm. Second, we highlight a new role for competitive repositioning. Although researchers have considered repositioning from a variety of perspectives (Cong & Zhou, 2019; Du et al., 2019; Gimeno et al., 2006; Makadok & Ross, 2013; Menon & Yao, 2017; Wang & Shaver, 2014), it has never been studied as a propagation mechanism to transfer the impact of a firm's advantage to its distant competitors. Third, our focus on distant rivals and recognition of a new role for repositioning strongly suggest that proximate rivals may not always be the most affected by a firm's advantage, notwithstanding conventional wisdom about closer effects exceeding more distant effects. Our analyses suggest that this conventional wisdom makes the most sense in markets or industries where repositioning a firm is either impossible or prohibitively expensive. An inability to reposition seems to be an implicit assumption underlying many of the studies discussed earlier, which would make sense in many of the industries that they investigate, such as hotels or motels. After all, physically relocating a hotel or motel is prohibitively costly, and even changing its size can be very expensive. Nevertheless, repositioning in response to a competitor's action is possible in many other industries, particularly along the quality (or vertical) dimension, as in our grocery retailing example. Thus, it is important for both strategic management researchers and managers to consider the strategic impact of repositioning, not just on the firm or its immediate competitors, but also on distant ones.

The remainder of this paper is organized as follows: We present an overview of the formal model in the next section, followed by the empirical illustration in the subsequent section. We then discuss the implications of our results. Technical details for the derivation of the model are relegated to an accompanying Online Appendix, along with some details about our empirical illustration.

2 | MODEL

In its simplest form, the cue-ball effect requires three firms—an advantaged firm (the cue stick in our metaphor) and its two disadvantaged rivals, one that is closer to the advantaged firm (the cue ball), and another that is farther away (the target ball).[2] The cue-ball effect is easiest to demonstrate in situations where the firms are aligned in such a way that, if the closer rival repositions away from the advantaged firm, then it will necessarily move closer to the more distant rival. Such alignment occurs naturally under vertical differentiation, where competitors offer products of different quality levels to serve the needs of customers with different WTP for quality (Sutton, 1986). So, we model a vertically differentiated triopoly market where customers with heterogeneous WTP are served by three firms—a low-end firm whose basic product satisfies the modest needs of (presumably poorer) customers who are more sensitive to price than to quality, a high-end firm whose premium product delights the refined desires of (presumably wealthier) customers who are more sensitive to quality than to price, and between these two, a middle-market firm whose intermediate product suits the preferences of (presumably bourgeois) customers with moderate sensitivity to both quality and price. This quality differentiation restrains price rivalry between firms by splitting the market into semi-independent segments according to customer WTP, so that firms only really compete to attract a small number of customers who are on the cusp of indifference between two competitors. With fewer marginal customers being "in play," there is less benefit for firms to gain from price cutting, so they can enjoy more market power within their respective segments. (By contrast, in the absence of vertical differentiation—i.e., if all firms' products had to provide identical quality levels—then all customers would be "in play" and price rivalry would intensify since firms would have no lever other than price to attract them.) So, a desire to restrain margin-destroying price rivalry motivates vertically differentiated rivals to position their quality levels farther apart, but this distancing is not unlimited. After all, profit is driven by both margin and market share, and firms may seek to gain market share by positioning themselves closer to the middle of the demand distribution, and thereby closer to each other. Thus, competitors must counterbalance these two conflicting pressures—spreading their quality levels farther apart to preserve high margins versus gathering together toward mid-level quality in hope of gaining market share (Makadok & Ross, 2013). For more extensive reviews of basic economic models and mechanisms of vertical differentiation, see Beath and Katsoulacos (1991): pp. 109–134 and Waterson (1989): pp. 17–23).

[2]As mentioned in the "Discussion" section, more elaborate forms with multiple intermediate "cue ball" firms may also be possible.

2.1 | Assumptions

Our model is a variation on existing conventional models of vertical differentiation (e.g., Tirole, 1988, pp. 296–299, Section 7.5), where each customer buys exactly one unit of a good, but customers differ in their WTP for improvements in its quality, which we denote as x dollars of WTP for each measure of increased quality. Customers are arranged along a continuum, according to each customer's specific value of x. Following the standard model of vertical differentiation, our baseline model assumes a uniform WTP distribution, as shown in Figure 1, whose density function is:

$$f(x) = \begin{cases} \beta & \text{if } (\mu-\alpha) \leq x < (\mu+\alpha) \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

where μ is the mean WTP, and α and β are positive constants such that $2\alpha\beta = 1$ to ensure that $f(x)$ integrates to 1. So, a customer located at a given value of x is willing to pay up to vx for a good of quality level v. We later relax this uniform distribution assumption in order to introduce demand skewness in Extension 1. The variance of $f(x)$ is $\sigma^2 = \alpha^2/3$, and we calibrate the distribution by using the median coefficient of variation (standard deviation divided by mean) from the income distributions of OECD member countries (σ/μ=0.47), except in Extension 2 (where this parameter is allowed to vary).[3]

We modify existing conventional models in two ways on the supply side. First, because our interest is on repositioning and distant competitors, it is not possible to restrict the model to two firms, as is often done in vertical differentiation models (e.g., Kurokawa & Matsubayashi, 2018). Hence, we assume that there are three profit-maximizing firms L, M, and H—abbreviating low-end, middle-market, and high-end, respectively—that compete in a two-stage game with simultaneous moves in each stage, as shown in Figure 2. Each firm $i \in \{L, M, H\}$ chooses its quality level v_i in the first stage, which requires a constant marginal cost per unit of ωv_i^2 in the second stage, at which time it then chooses its price p_i. This quadratic function captures the idea of diminishing returns to quality-improvement efforts and is like those in studies such as Motta (1993) and Schubert (2017). We assume that this marginal cost function is identical across firms initially and that the initial state of the market, in terms of the

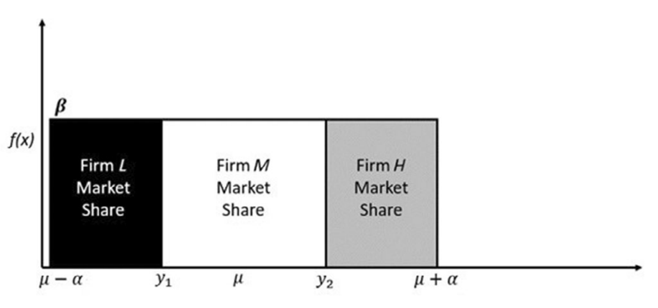

FIGURE 1 Baseline model: Density function of willingness-to-pay (WTP) per unit of quality (x).

[3]Section A5 of the Online Appendix provides a table to summarize and explain the model's various parameters and the relevant constraints on those parameters under all versions of the model (baseline and the three extensions).

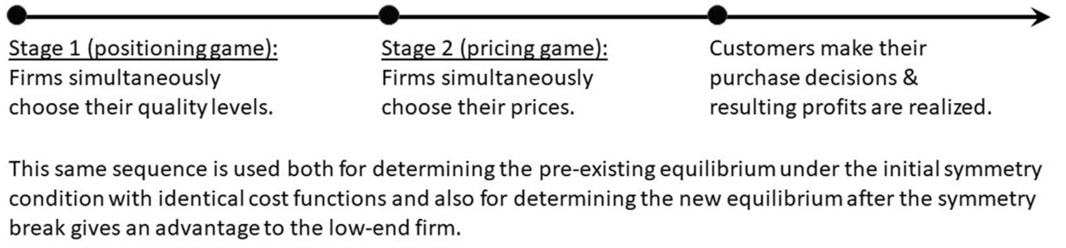

FIGURE 2 Model timeline.

firms' starting prices and quality levels, reflects their positions in a pre-existing equilibrium based on this initial cost condition. After firms set their quality levels and prices, each consumer then chooses which firm to buy from, and profits are realized.

Our second supply-side difference from conventional models is to introduce a cost advantage for the low-end firm, which is essential to answer our research question. Specifically, we assume that the low-end firm unexpectedly gains a cost advantage, so that its marginal cost is reduced by an amount ε, to $\omega v_L^2 - \epsilon$. Once this unexpected[4] advantage emerges, firms go through the same two-stage game that had produced the initial pre-existing equilibrium, as illustrated in Figure 2—that is, first repositioning themselves by simultaneously[5] choosing new quality levels, then simultaneously choosing new prices, followed by consumers making new product choices and the firms' new profits being realized. We give the cost advantage to firm L—that is, making it the "cue stick" in our metaphor—for two reasons: First, in a model with only three firms, the cue-ball effect cannot be illustrated by advantaging the middle firm, because then it would be the cue stick rather than the cue ball. Only a middle firm can transfer a shock from one side to another. So, to illustrate the cue-ball effect in a triopoly, we must give the "cue stick" of cost advantage to one of the two firms at the ends of the market. Second, we give the advantage to the low-end firm, rather than the high-end firm, because this choice is consistent with the common empirical pattern of disruptive innovation (Christensen, 1997), and also with the empirical illustration that we present later, where the cost advantage arises from Walmart's entry into the low end of the grocery retailing market.

After firms set their quality levels and prices, each customer on the distribution of x chooses one firm from whom to purchase her one unit of product, by selecting the firm $i \in \{L, M, H\}$ that maximizes her surplus, which is defined as $xv_i - p_i$ (i.e., the difference between total WTP and price). As shown in Figure 1, these choices by individual customers split the WTP continuum into three ranges of customers—those at the upper end of the WTP distribution who

[4]Since the cost advantage is unexpected, it is not reflected in firms' initial positioning or pricing in the pre-existing equilibrium.

[5]The assumption of simultaneous positioning decisions does not fully capture the sequence implicit in the cue-ball metaphor, but we assume simultaneity for two reasons beyond just simplifying the analyses. First, sequential moves in the pre-existing equilibrium (when firms have identical cost functions) would induce asymmetries among the firms even though they are otherwise identical, which would make the initial configuration dependent on an arbitrary sequence of entry. Second, sequential moves in the new equilibrium after the unexpected emergence of the low-end firm's advantage would also imply some rigidity in repositioning (e.g., it will initially require us to assume that the low-end firm repositions given the initial positions of the other two firms; this will be followed by the middle firm repositioning assuming the other two firms do not change, and so on), which would make it difficult to compare the case of "no-repositioning" with the case of "repositioning."

purchase from firm H, those at the lower end of WTP who purchase from firm L, and those with intermediate WTP who purchase from firm M. The two threshold values of x that separate these three ranges, labeled as y_1 and y_2 in Figure 1, represent indifference points; a customer at the lower threshold y_1 is indifferent between purchasing from firms L or M, and a customer at the upper threshold y_2 is indifferent between purchasing from firms M or H. We impose whatever parameter constraints are needed to ensure that all three firms have strictly positive output. For tractability, we also assume the ordering $y_2 > \mu > y_1$, so firm M's customers span both sides of the WTP distribution, and we impose any parameter constraints required to guarantee this ordering.[6] We further assume the market is "covered," so that no customers remain unserved. After the low-end firm gains an advantage, we assume the competitive landscape does not change so dramatically that any firm is induced to exit, nor that the firms' quality ordering changes from the initial pre-existing equilibrium (so, for example, the low-end firm in the initial pre-existing equilibrium cannot switch to choosing the highest quality level in the new equilibrium). So, we focus on the set of parameter combinations where there are three firms that together fully cover the market, and the condition $v_H > v_M > v_L$ is met.

In this section, we provide a rough sketch of our solution procedure, which we use for deriving both the initial pre-existing equilibrium under identical cost functions and the new equilibrium after the cost advantage emerges. To simplify our exposition, we relegate technical details of our proofs to Online Appendix A, and Mathematica code for the derivations is available from the authors upon request. We solve the equilibrium using standard backward induction techniques. We first solve for the customer indifference points y_1 and y_2 as functions of the model's exogenous parameters and whatever quality levels and prices the firms might have previously chosen in the game's first and second stages. These indifference points determine the demand functions for the three firms' products as well as their final profit functions. We then derive the second-stage pricing in which the firms simultaneously maximize their profits, as functions of exogenous parameters and the firms' previously chosen quality levels. We substitute these second-stage equilibrium prices back into the firms' profit functions to determine their first-stage profit functions. Finally, the firms simultaneously choose quality levels to maximize their first-stage profit functions, and we substitute their chosen quality levels back into the first-stage profit functions to derive the equilibrium profit functions, which we analyze for our results.

2.2 | Baseline model: Cost advantage for low-end firm with uniform distribution

Starting from the initial pre-existing equilibrium, we now examine the impact of introducing a cost advantage for the low-end firm. As mentioned earlier, we assume the low-end firm reduces its marginal cost by $\varepsilon > 0$, while the other two firms' cost functions remain unchanged. We compare two cases. We first examine the case where the three firms can only adjust their prices in response to this newly introduced cost advantage, but they cannot reposition

[6] A more general model could relax this constraint. Allowing firm M greater mobility would in general increase the range of parameter values over which firm M performs better than firm H. Thus, in this regard, our results are conservative, since relaxing the constraint would likely increase the range of parameter values where the cue-ball effect occurs.

themselves on the quality dimension—that is, the “no-repositioning” case. Then, we consider the case where the three firms can adjust both their quality positions and their prices in response to the low-end firm's advantage—that is, the “repositioning” case. So, in effect, we compare the two limiting cases of zero repositioning costs versus infinite repositioning costs. However, even in industries where repositioning is viable, the no-repositioning case may still be relevant in capturing a cost advantage's short-run impact, since firms can adjust their prices faster than their positions.

Due to tractability challenges from the highly nonlinear nature of the model, we use numerical methods similar to those of Schmidt et al. (2016)[7] to derive equilibrium solutions, which are illustrated graphically in Figure 3a–d, where the red lines show results for the no-repositioning case and blue lines show results for the repositioning case. Figure 3a–d, respectively, show each firm's quality positions, price levels, market shares, and profits. In all these figures (and subsequent figures), we normalize the cost advantage parameter ε by dividing it by the constant μ (average WTP) to reduce the number of parameters, as explained in Online Appendix A.

Starting with the no-repositioning case, the similarity of Figure 3c, d (red lines) show that as the low-end firm gains a cost advantage, it increases both market share and profit. In contrast, because the other two firms cannot reposition, they cannot offset any part of their cost disadvantage by retreating away from the low-end firm, so they both lose market share and profits. Note that by assumption, quality is unaffected when firms cannot reposition, so all red quality lines are flat in Figure 3a. For this no-repositioning case, the downward-sloping red price lines in Figure 3b show the low-end firm cutting its price in proportion to its cost advantage, and the other firms responding with price cuts of their own. However, in the repositioning case, the blue price curves in Figure 3b closely track the upward-sloping blue quality curves in Figure 3a.

Now we compare the middle-market and high-end firms, and examine under what conditions the high-end firm is hurt worse than the middle-market firm by the introduction of the low-end firm's cost advantage—even though the high-end firm is farther from that advantage than the middle-market firm. Before proceeding further, we must pause to define what “hurt worse” means and to explain a feature of the model that makes it more challenging to define this term. In the initial pre-existing equilibrium, prior to the low-end firm gaining a cost advantage, the high-end firm and the middle-market firm automatically start out at different sizes, with the middle-market firm being about twice as large as the high-end firm. This inherent scale difference between firms M and H is due to an “edge effect” where firm M, by virtue of serving the middle of the demand distribution, can efficiently attract a larger number of customers than firm H, which serves the edge of the demand distribution. Since these firms inherently differ in their initial scale, it would be inappropriate to determine which one gets “hurt worse” by simply comparing the respective changes in their absolute levels of performance. That comparison would not be meaningful for firms of such different initial sizes. After all, a $200,000 decline in the annual profit of a tiny five-room boutique bed-and-breakfast hotel would be devastatingly huge, while a dollar-equivalent $200,000 decline in the annual profit of the gigantic 7000-room Venetian Resort Hotel in Las Vegas would be a tiny, hardly noticeable change. So, instead of comparing the absolute profit decline of firm H to that of firm M, we compare the *percentage* profit decline

[7]See the Online Appendix for a detailed explanation about the specific numerical methods we used.

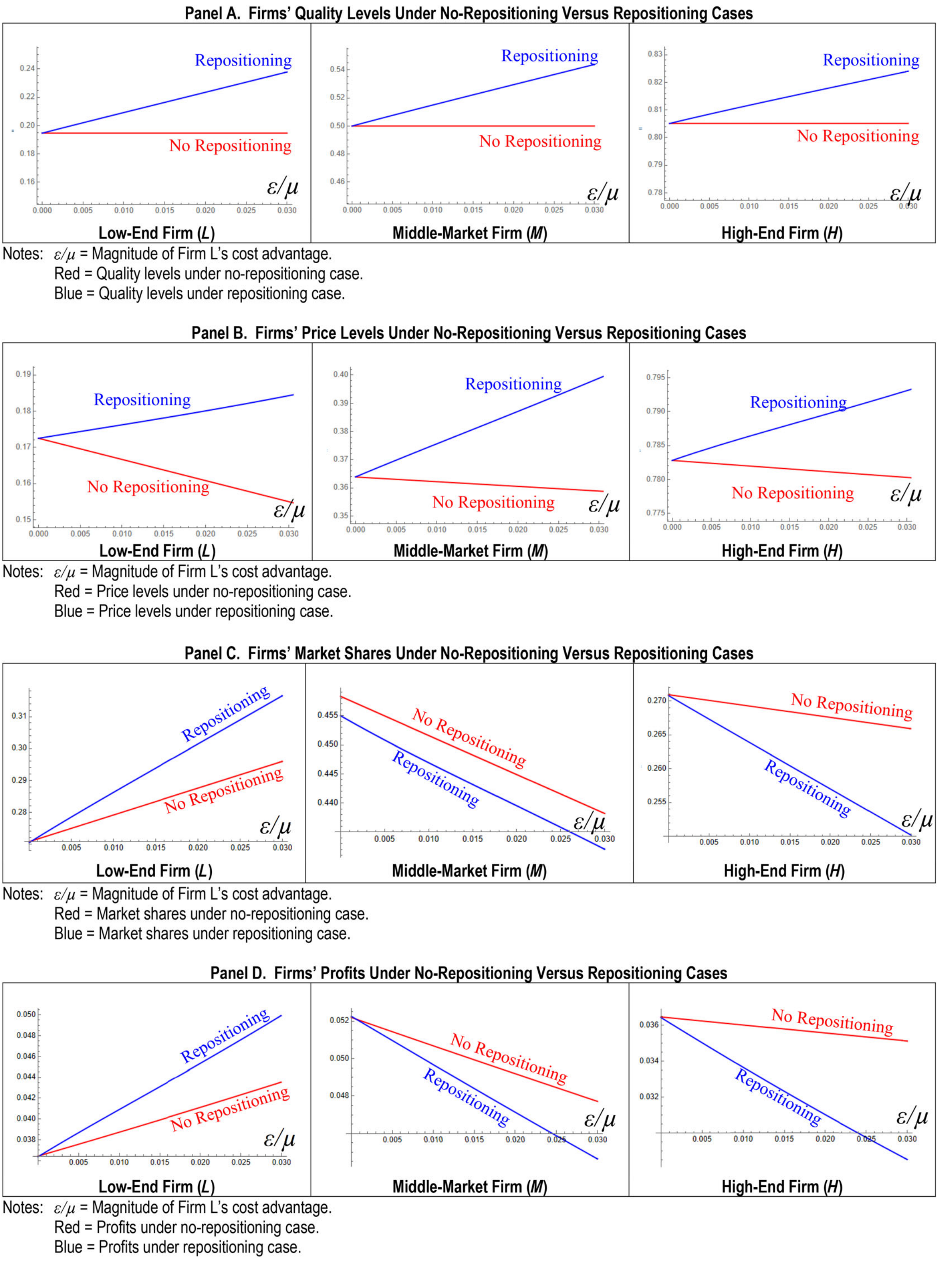

FIGURE 3 Baseline model: Comparison of no-repositioning and repositioning cases

of firm H to that of firm M, and we use the difference between these two *percentage* declines to define which firm gets "hurt worse" when firm L gains its advantage. This difference between the two firms' percentage declines in profit is shown as the dependent variable on the vertical axis in Figure 4 for the baseline model, and also later in Figures 6–8 for the three model extensions.[8]

In Figure 4, the red curve represents the "no-repositioning" case, while the blue curve represents the "repositioning" case. Observe that the red curve (when firms cannot reposition) is always negative, indicating that the middle-market firm M is always hurt worse than the high-end firm H (i.e., firm M's percentage decline is always greater than firm H's). This occurs because M's proximity to the low-end firm L causes it to bear the brunt of L's price reduction, and its inability to reposition means that it cannot escape from this impact. This difference can also be seen in the red curves of Figure 3c, and 3d, where H's performance only declines marginally while M shows a much sharper decline. This reflects the classic thesis that competition has a greater impact on closer rivals than on farther ones, so we propose:

> **Proposition 1.** *Ceteris paribus, if firms cannot reposition, then an increase in the cost advantage of the low-end firm causes a larger percentage decrease in profit for the middle-market firm than for the high-end firm.*

We now relax the assumption that firms cannot reposition, and examine their repositioning decisions, which are shown as blue lines in Figure 3. Intuitively, the low-end firm's cost advantage allows it to offer customers a better price/quality trade-off, so it exploits this advantage by increasing its quality to capture more customers from the middle-market firm. In response, the middle-market firm mitigates its cost disadvantage by raising its quality as well, in order to both (1) retreat away from the advantaged low-end firm, and (2) compensate for its loss of customers to the low-end firm by capturing some customers from the high-end firm. The middle-market firm's upscaling motivates the high-end firm to raise its quality as well, in order to reduce their competition with each other; otherwise, the high-end firm would absorb more of the shock transferred from the low-end firm than necessary. This leaves the high-end firm with fewer customers, but they are less price-sensitive and more quality-sensitive customers, which lets the high-end firm partly compensate for its lower market share with higher margin. However, Figure 3a shows, the high-end firm's movement upscale is much smaller in magnitude than that of the other two firms. This smaller response is due to the fact that firm H is closer to the upper edge of the market than its competitors, and therefore simply has less space available for it to move upscale. (Also, convexity in the quadratic cost of quality improvements makes it more expensive for H to execute each unit of improvement than it is for M.)

[8]Nevertheless, for the sake of transparency, Part B of the Online Appendix also provides alternative versions of these four figures in which "hurt worse" is redefined in terms of absolute performance declines rather than relative performance declines, despite the fact that such absolute comparisons between different-sized firms are not very meaningful. This redefinition affects some of our results, but not others. The results for the repositioning advantage of the middle-market firm (which are based on the relative positions of the red curves/surfaces versus the blue curves/surfaces in our graphs) are unaffected by this redefinition. The results for the cue-ball effect (which are based on the absolute position of the blue curves/surfaces) are unaffected by this redefinition when the low-end firm's cost advantage is sufficiently small and when competitive intensity is sufficiently low. However, this redefinition changes the cue-ball effect results when the low-end firm's cost advantage is sufficiently large or when competitive intensity is sufficiently high.

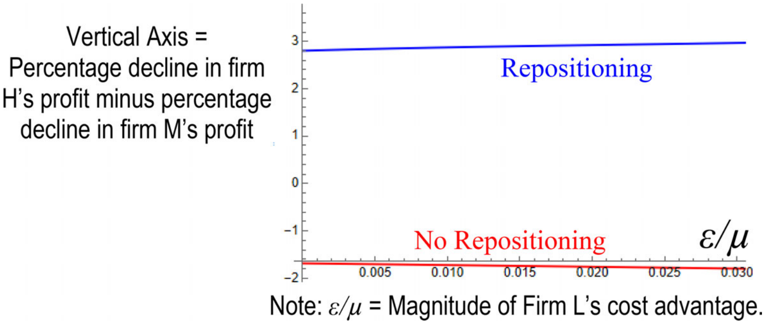

FIGURE 4 Baseline model: Difference between firms H and M in their percentage profit declines when firm L gains a cost advantage. ε/μ = Magnitude of firm L's cost advantage.

Turning to market shares and profits, when all three firms can reposition in response to the low-end firm's cost advantage, the pattern of effects is a more amplified version of the pattern when firms cannot reposition (Proposition 1), as shown in the blue lines from Figure 3c and 3d. The low-end firm always enjoys *higher* market share and profit when firms can reposition than when they cannot. By contrast, the other two firms always have *lower* market shares and profits when firms can reposition than when they cannot. The intuitive rationale for this amplification is that, although repositioning allows firms M and H to retreat from firm L, it also allows firm L to attack more aggressively. When no firm can reposition, firm L can only attack through price cutting, but repositioning also allows it to attack through quality improvement.

While repositioning unambiguously helps L and hurts M and H, the relative profits of the latter two firms are starkly different from the case when no repositioning is allowed. The blue curve in Figure 4 is always positive, which means that when firms can reposition themselves, firm L's advantage causes a larger percentage decline in profit for the high-end firm H than for the middle-market firm M. Intuitively, this difference between M and H occurs because M is able to move away from the low-end firm (by increasing its quality), which increases the competitive pressure on H, but H is less able to move away sufficiently from M to fully mitigate the impact of that increased competition, due to the "edge effect" of serving the upper end of the customer distribution rather than its middle. In other words, when firm M moves upscale, it loses customers to firm L below but compensates for this loss by gaining customers from firm H above; yet when firm H moves upscale, it loses customers to firm M below with no compensating gain of customers from above—because there are none to gain. So, firm H must limit the magnitude of its upward repositioning in order to keep any customers at all, since it is already operating at the upper boundary of customers' WTP, which restrains its ability to escape from firm M's encroachment. In this way, even though M and H both have the option to reposition upward, M can exploit this option more fully than H can. To extend the billiards metaphor, further repositioning by firm H would send its ball flying off the table, so instead it clings desperately to the table's edge, where it is forced to absorb the impact from firm M. Thus, under repositioning, H winds up bearing the brunt of L's cost advantage, even though M is closer to L. In other words, when firms can reposition, the bulk of the impact of firm L's cost advantage gets propagated to firm H through firm M's upscale repositioning, since the percentage performance decline is greater for firm H than for firm M (as indicated by the blue repositioning curve in Figure 4 being above zero). We denote this propagation via repositioning as the "cue-ball effect."

Moreover, the difference between the percentage profit declines for H and M is greater when firms can reposition than when they cannot (as indicated by the blue repositioning curve in Figure 4 being above the red no-repositioning curve). So, the option for firms to reposition themselves benefits the middle-market firm at the expense of the high-end firm, because the "edge effect" reduces the high-end firm's ability to exploit this option. We denote this benefit as the "repositioning advantage of the middle-market firm."

So, we offer two interrelated propositions, one for the cue ball effect (which pertains to the location of the blue repositioning curve) and another for the repositioning advantage of the middle-market firm (which pertains to the difference between the blue repositioning curve and the red no-repositioning curve):

Proposition 2. *Ceteris paribus, as the low-end firm's cost advantage increases*:

a. *If firms can reposition, then the high-end firm's profit will decline by a larger percentage than the middle-market firm's. (Cue-ball effect)*
b. *The difference between the percentage profit decline of the high-end firm and that of the middle-market firm is greater if firms can reposition than if they cannot. (Repositioning advantage of the middle-market firm)*

2.3 | Extension 1: Cost advantage for low-end firm with varying demand skewness

As discussed earlier, when customers differ in their WTP for quality, firms split the market into vertical segments by offering (in equilibrium) different price/quality combinations. So, the distribution of WTP is a key driver of product positioning in vertically differentiated markets. A key parameter of the WTP distribution is its skewness, which is often driven by the degree of income inequality in the market. Since it is understood, both theoretically (Schubert, 2017; Sutton, 1986; Yurko, 2011) and empirically (Becerril-Arreola et al., 2021), that income-inequality-based skewness of the WTP distribution may influence the availability of products at different quality levels, it is natural to suspect that it might also influence the cue-ball effect. Moreover, skewness captures an important aspect of reality: Income and wealth distributions are bounded below (usually somewhere in the vicinity of zero, depending upon policies for income/wealth redistribution and bankruptcy), which suggests that one should naturally expect WTP distributions to have a positive skewness. (Indeed, with many countries experiencing significant increases in income inequality, such skewness may become more common.) To capture this, we use the simplest possible continuous distribution of x that allows us to independently vary the mean, variance, and skewness, which is a piecewise-uniform distribution, as shown in Panel A of Figure 5, with a density of:

$$f(x)=\begin{cases}\beta_1 \text{ if } (\mu-\alpha_1)\leq x<\mu \\ \beta_2 \text{ if } \mu\leq x\leq(\mu+\alpha_2) \\ 0 \text{ otherwise}\end{cases}, \tag{2}$$

where μ is the mean WTP, and β_1, β_2, α_1, and α_2 are positive constants. To make our comparative statics exercises more intuitive, rather than directly change β_1, β_2, α_1, and α_2, which are not easily relatable to real-life counterparts, we instead work with the moments of the distribution (variance and skewness). So, in Part A of the Online Appendix, Equations (A7) and (A9) derive the values of these four constants as functions of those moments—the standard deviation, denoted as σ, and the skewness, denoted as γ. As skewness increases, low-end customers with WTP below the mean form a larger share of the total market. Consistent with the baseline model, we normalize the coefficient of variation (σ/μ) in this WTP distribution to match the median value of the coefficient of variation from the income distributions of OECD countries.

Next, consider the impact of demand skewness on firm performance. Increased skewness affects the demand distribution in two ways, as shown in panel (b) of Figure 5. First, it increases the percentage of customers in the lower side of the demand distribution (i.e., with WTP below the mean). In Figure 5b, this increase is shown by the solid-line rectangle to the left of the mean μ (labeled by its height β_1) transforming into a taller but narrower dashed-line rectangle with a larger area, which represents a larger percentage of customers below the mean WTP. So, as skewness increases, the greater number of low-end customers allows the low-end firm to better translate its cost advantage into higher profit, which in turn worsens the middle-market firm's profit decline as firm L captures more of *M*'s customers. So, higher skewness makes the middle-market firm more vulnerable to the low-end firm's advantage.

The second way that higher skewness affects the demand distribution is by increasing the maximum WTP of the customers at the very top of the market. In Figure 5b, this increase is shown by the solid-line rectangle to the right of the mean μ (labeled by its height β_2) transforming into a wider but shorter dashed-line rectangle, whose greater width represents a larger maximum WTP at the top of the market. This reduced price sensitivity and increased quality sensitivity of top-end customers enables the high-end firm to move further upscale than it otherwise would, giving it a more effective escape route to retreat from the upward encroachment of the middle-market firm. So, in contrast to the middle-market firm, greater demand skewness makes the high-end firm *less* vulnerable when the low-end firm gains an advantage.

Comparing the middle-market and high-end firms, Figure 6 shows the difference between firms *H* and *M* in their percentage declines in profit. The red surface (or cross-sectional curve) represents the "no-repositioning" case, while the blue surface (or cross-sectional curve) represents the "repositioning" case. Note that the red surface is always negative, indicating that when firms cannot reposition themselves, the middle-market firm *M* is always hurt worse than the high-end firm *H* (i.e., *M*'s percentage decline is always greater than *H*'s), as in Proposition 1 from the baseline case.

As the low-end firm's cost advantage increases, higher skewness (γ) benefits the low-end and high-end firms, but for different reasons—greater density of customers for the low-end firm, but higher customer WTP for the high-end firm. Both of these benefits are enhanced when firms can reposition: The increased WTP of high-end customers gives the high-end firm more market space into which it can escape away from the middle-market firm's upward encroachment. Greater density of low-end customers means that the low-end firm can capture more market share for each incremental unit of quality improvement. Since that market share is captured from the middle-market firm, skewness damages the middle-market firm's defense against the low-end firm's advantage, So, both the repositioning (blue) and no-repositioning (red) surfaces in Figure 6 slope downward as skewness (γ) rises. The cue-ball effect appears for sufficiently low levels of skewness, where the repositioning (blue) surface is above zero (gray horizontal plane), that is, firm *H* suffers greater percentage declines in profit than firm *M* in response to firm *L*'s advantage when skewness is low. This low-skewness part of the repositioning surface is consistent with Proposition 2 from the baseline model (whose uniform distribution had zero skewness). However, at higher levels of skewness, the repositioning (blue) surface drops below zero, indicating that firm *M* suffers greater percentage declines in profit than firm *H* in response to firm *L*'s advantage when skewness is high, despite the

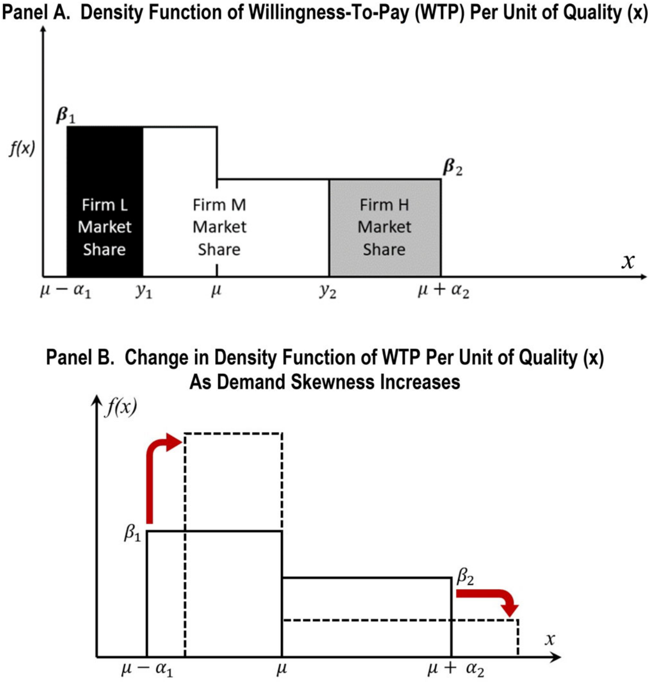

FIGURE 5 Demand structure for extension 1. Panel (A) Density function of willingness-to-pay (WTP) per unit of quality (x). Panel (B) Change in density function of WTP per unit of quality (x) as demand skewness increases.

firms' ability to reposition. So, high skewness eliminates and eventually reverses the cue-ball effect. Note that both surfaces in Figure 6 slope downward as skewness increases, but this downward slope is steeper for the repositioning case (blue) than for the no repositioning case (red). So, at extremely high levels of skewness, the repositioning (blue) surface drops below the no-repositioning (red) surface, thereby reversing the repositioning advantage of the middle firm. So, we propose:

> **Proposition 3a.** *Increasing demand skewness diminishes, and can eventually even reverse, the cue-ball effect.*[9]

> **Proposition 3b.** *Increasing demand skewness diminishes, and can eventually even reverse, the repositioning advantage of the middle-market firm.*[10]

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[9]A more technically detailed version of Proposition 3a would be: Ceteris paribus, if firms can reposition, then as the low-end firm's cost advantage rises, an increase in demand skewness diminishes the difference between the percentage profit decline of the high-end firm and that of the middle-market firm. When skewness reaches and then exceeds a sufficiently high threshold level, this difference goes to zero and then becomes negative—that is, the cue-ball effect disappears and then is reversed.

[10]A more technically detailed version of Proposition 3b would be: Ceteris paribus, as the low-end firm's cost advantage rises, an increase in demand skewness causes the difference between the percentage profit decline of the high-end firm and that of the middle-market firm to diminish more quickly when firms can reposition than when they cannot. When skewness reaches and then exceeds a sufficiently high threshold level (which is higher than the threshold level from Proposition 3a above), this difference between the repositioning case and the no repositioning case goes to zero and then becomes negative—that is, the repositioning advantage of the middle-market firm disappears and then is reversed.

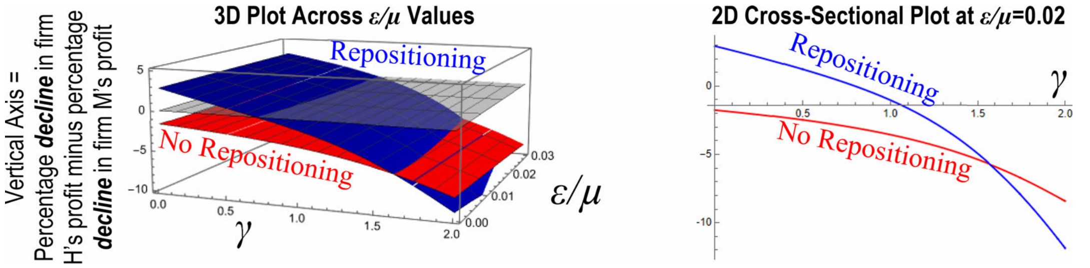

FIGURE 6 Extension 1: Difference between firms H and M in their percentage profit declines when firm L gains a cost advantage, depending on demand skewness. ε/μ = Magnitude of firm L's cost advantage, and γ = Demand skewness.

2.4 | Extension 2: Cost advantage for low-end firm with varying competitive intensity

In our second extension, we return to the baseline assumptions of uniform demand distribution, but we now vary the market's competitive intensity. We proxy competitive intensity by using the spread of customers' willingness to pay. To reduce the number of parameters, we scale the spread to average WTP by using the coefficient of variation σ/μ to capture the *inverse* of competitive intensity: As σ/μ *decreases*, competitive intensity *rises* because customers are compressed into a smaller range, forcing firms to position themselves closer together, with less room to avoid each other. Conversely, as σ/μ *increases*, competitive intensity *declines* since firms can spread themselves farther apart from each other.

One might intuitively expect that such spreading apart would have a similar impact on the cue-ball effect as increasing demand skewness would have. After all, both an increase in σ/μ and an increase in γ give the high-end firm more latitude to position away from the middle-market firm, so it would seem plausible to think that lowering competitive intensity (i.e., higher σ/μ) might erase and eventually reverse both the cue-ball effect and the repositioning advantage of the middle-market firm, just as raising demand skewness (i.e., higher γ) does. However, this intuition turns out to be incorrect because it is incomplete—that is, it focuses exclusively on the high-end firm's ability to retreat away from the middle-market firm without also considering the middle-market firm's ability to retreat away from the low-end firm. On one hand, an increase in σ/μ and an increase in γ both have the same beneficial effect on the high-end firm's ability to retreat away from the middle-market firm, but on the other hand, increases in σ/μ and γ have *opposite* effects on the middle-market firm's ability to retreat away from the low-end firm. After all, increasing σ/μ spreads out the demand distribution in a *symmetrical* fashion, with the top and bottom of the market both moving away from the middle, but increasing γ spreads out the demand distribution in an *asymmetrical* fashion, with the top of the market moving away from the middle while the bottom of the market moves closer to the middle (see Figure 5b). The symmetric spreading due to higher σ/μ (i.e., lower competitive intensity) enhances the middle-market firm's ability to retreat away from the low-end firm, while the asymmetric spreading due to higher γ (i.e., greater skewness) diminishes the middle-market firm's ability to retreat away from the low-end firm. In other words, the symmetric effect of reducing competitive intensity shields both the middle-market and high-end firms from harm, while the asymmetric effect of increasing skewness shields only the high-end firm while simultaneously exposing the middle-market firm to greater harm. So, unlike in the skewness case, neither the cue-ball effect nor the repositioning advantage of the middle-market firm ever get erased at any level of competitive intensity. However, they do both get diminished at lower levels of competitive intensity.

Observe in Figure 7 that, consistent with the baseline model, the blue repositioning surface is always positive and the red no-repositioning surface is always negative. As the market's competitive intensity increases—that is, as σ/μ decreases—the red no-repositioning surface becomes more negative.[11] This occurs because, when firms cannot reposition, the middle-market firm absorbs the lion's share of the impact from the low-end firm's advantage, and this impact is greater when market rivalry becomes more intense, similar to the effect found in Makadok (2010). Also, as competitive intensity increases (lower σ/μ) the blue repositioning surface becomes more positive. This occurs because it becomes more difficult for the high-end firm to respond by increasing quality further due to the reduced WTP of customers at the top of the market. Conversely, when competitive intensity declines (as reflected in higher σ/μ), the market is more dispersed. So, the cost advantage of the low-end firm only has a small impact on the relative performance difference between the other two firms, since both firms are able to move away sufficiently (M from L, and H from M) so that the negative effects are muted. Thus, increased competitive intensity strengthens the cue-ball effect by making the blue repositioning surface more positive, while also strengthening the repositioning advantage of the middle-market firm by moving the blue repositioning surface further apart from the red no-repositioning surface. So, we propose:

Proposition 4. *Ceteris paribus, an increase in competitive intensity increases both the cue-ball effect and the repositioning advantage of the middle-market firm.*

2.5 | Extension 3: Cost advantage for low-end firm with varying cost function convexity

Returning to the baseline model's uniform demand distribution (again, as normalized to the median coefficient of variation from OECD countries' income distributions), we now extend the model in a different direction to focus instead on the supply side, by varying the convexity of firms' cost function. We generalize the quadratic cost-of-quality function into a power function of the form ωv^b whose convexity b captures the extent of diminishing returns to quality-improvement efforts—that is, as b increases, the costs required to achieve each incremental unit of quality increases and it becomes increasingly harder to improve quality.

As before, when the low-end firm gets a cost advantage, all three firms reposition to higher quality levels, but as the convexity b increases, it becomes increasingly difficult for the high-end firm to respond with higher quality because the cost of increasing quality further rises as convexity increases. Observe that the blue repositioning surface in Figure 8 is always positive (consistent with the baseline model), and is generally increasing in b, so that the high-end firm H is always hurt worse than the middle-market firm M when firms can reposition themselves, and higher cost convexity tends to strengthen this effect. Also note that the red no-repositioning

[11]The two axes are independent; ε is a supply side parameter affecting only the costs while σ is a demand side parameter.

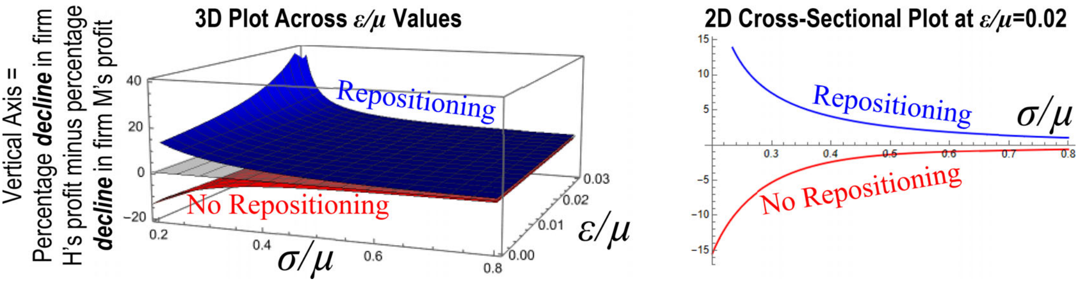

FIGURE 7 Extension 2: Difference between firms H and M in their percentage profit declines when firm L gains a cost advantage, depending on competitive intensity. ε/μ = Magnitude of firm L's cost advantage, and σ/μ = *Inverse* of competitive intensity of the market (i.e., *lower* σ/μ indicates *more intense* competition).

surface in Figure 8 is always negative (also consistent with the baseline model), and is consistently decreasing in b, indicating that the middle-market firm M is always hurt worse than the high-end firm H when firms cannot reposition themselves, and higher cost convexity strengthens this effect. Taken together, these results indicate that higher levels of cost convexity enhance both the cue-ball effect and the repositioning advantage of the middle-market firm. So, we propose:

> **Proposition 5.** *Ceteris paribus, an increase in the convexity of the cost function increases both the cue-ball effect and the repositioning advantage of the middle-market firm.*

3 | EMPIRICAL ILLUSTRATION

This section provides a detailed case example from the US grocery retailing industry that illustrates the upward movement of a middle-market firm in response to a change in cost advantage at the low end of the market, and how that movement affects the high-end firm. Given the theoretical focus of this paper, this example is merely intended to be illustrative of the phenomenon described by the model and does not constitute a test of any specific proposition from the model.

We examine three firms in the US grocery retailing industry—Kroger, Walmart (limited to its Supercenter grocery business), and Whole Foods Market (prior to its acquisition by Amazon). We use this industry for three reasons: First, each local area can be treated as a separate market because customers rarely travel more than a few miles to buy groceries unless they live in remote rural locations (Zhu & Singh, 2009), so we can construct a sample consisting of a large number of local markets. Second, this industry is vertically differentiated, which allows us to find firms in all three tiers of the quality distribution: Walmart is generally recognized as a "low-end" competitor while Kroger is positioned as a middle-market player, and Whole Foods Market is such a high-end competitor that it earned the nickname "Whole Paycheck" in US popular culture and business press. Third, the industry experienced a shock at the low end of the market when the highly efficient Walmart started proliferating its Supercenter format in

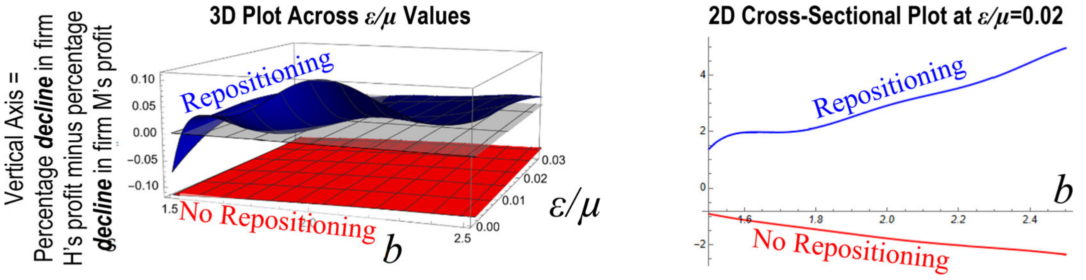

FIGURE 8 Extension 3: Difference between firms H and M in their percentage profit declines when firm L gains a cost advantage, depending on cost function convexity. ε/μ = Magnitude of firm L's cost advantage, and b = Cost function convexity.

the 1990s, and eventually displaced inefficient low-end incumbents (Ellickson & Grieco, 2013). For example, in Online Appendix D, we find a suggestive (but not causally conclusive) statistical association between the opening of Walmart Supercenter stores and the subsequent exit of nearby stores of the low-end incumbent Winn-Dixie chain.[12]

The remainder of this section is devoted to statistically documenting a two-part chain of events: First, we show that the geographic pattern of Kroger's store repositioning via renovations followed the opening of nearby Walmart Supercenters. Second, we show that the geographic pattern in the declining performance of Whole Foods Market stores was associated with recent renovations of nearby Kroger stores. Part C of the Online Appendix presents a detailed description of our data and summary statistics of the samples. Bearing in mind that this empirical exercise is merely intended to illustrate an example suggestive of the cue-ball effect and that it cannot be interpreted as a test of our theoretical model or its predictions, we consider each of the events from this sequence in turn.

3.1 | Repositioning of the middle-market firm

We first illustrate that Kroger, the middle-market player, is more likely to reposition itself upscale in locations where a Walmart Supercenter enters. To do so, we examine how the probability of a Kroger store being renovated (data from Dodge–McGraw Hill) is related to its distance from a new Walmart Supercenter. In particular, we estimate the following store-level specification for the period 2004–2013:

$$\text{RENOV}_{ijt} = \alpha \text{PostWMSC}_{it} + \beta \text{PostWMSC}_{it} \text{lnd}_{\text{WMSC}i} + \boldsymbol{\Gamma} \boldsymbol{Z} + \delta_t + \omega_i + \epsilon_{ijt}, \tag{3}$$

where RENOV_{ijt} is a dummy variable that indicates whether a Kroger store i (in market j, defined as a zip code) was renovated, $\text{lnd}_{\text{WMSC}i}$ is the (log) distance from the nearest Walmart Supercenter (calculated as the great-circle distance between two points on a sphere, using the

[12]Walmart's superiority over companies it displaced (e.g., Winn-Dixie) was likely due to lower costs across the board, and not a lower marginal cost of quality. This is consistent with our assumption that marginal cost in the second stage changes from ωv_L^2 (in the case where firms are identical) to $\omega v_L^2 - \epsilon$(when the low-end firm has the advantage). Future research can examine contexts where innovations may influence the marginal cost of quality, for example, by modeling a cost function like $(\omega - \epsilon) v_L^2$.

haversine formula), PostWMSC is a dummy variable that is 0 before that nearest Walmart Supercenter opens and 1 otherwise, $\boldsymbol{Z}$ is a vector of controls including (log) mean income, (log) number of households and population density in that zip code, and their interactions with PostWMSC, as well as the (log) distance from the nearest Whole Foods store, and δ_t and ω_i are year and store fixed effects. Hence, β indicates how the probability that a Kroger store is renovated subsequently to Walmart Supercenter's opening varies with the distance between the two stores. The storefixed effects control for any other unobserved store-level variations such as differences in local preferences for groceries and differences in average store performance (hence, coefficients on the direct terms of time-invariant controls will be subsumed in the store fixed effects).

The results presented in Table 1 show that the probability of a Kroger renovation after the opening of a Walmart Supercenter is negatively correlated with its distance from the Supercenter. So, these results indicate that the opening of a nearby Supercenter is associated with an upward movement by Kroger.

3.2 | Impact on the performance of the high-end firm

At the high end of the market, signs of trouble for Whole Foods Market began in mid-2013, when the *Wall Street Journal* said its

> competition has ramped up from other natural grocers as well as traditional supermarkets that are expanding their selection of natural and organic products. Kroger Co., the country's largest traditional grocery chain, has been trying to attract a more affluent clientele in certain markets with items like dry-aged beef, fancy cheese, and a larger vitamin section
>
> (Jargon, 2013).

In the first 4 months of 2014, Whole Foods Market stock gradually declined by 32%. Then on May 7, 2014, after reporting flat earnings and slow sales growth and after lowering its sales and earnings outlooks for the third consecutive quarter, Whole Foods Market stock price suffered a further 19% one-day plunge, slashing its market value by over $3 billion, which the *Wall Street Journal* attributed to "broad new competition, from mainstream retailers like Kroger" (Gasparro, 2014). By March 2017, its stock price had declined a further 25% and one stock analyst called its decline in customer traffic "staggering" (Levisohn, 2017). The next month, a group of activist investors acquired a 9% stake in Whole Foods Market with the intention of forcing a sale of the company, a goal that was accomplished within 2 months via the company's acquisition by Amazon, without which the company would likely have soon failed.

So, the second part of our empirical example illustrates the association between Kroger's upward movement and Whole Foods' performance. In particular, we present evidence that suggests a decline in the store Annual Commodity Volume (ACV) subsequent to a renovation by a Kroger located close by (excluding any gas station renovations). We use store-level ACV data for Whole Foods for the period 2009–2014, combined with data on renovations for the same period at Kroger in our analysis. However, compared with our previous analyses of Kroger's repositioning in response to Walmart, we have far fewer observations for this analysis due to the much smaller number of Whole Foods' stores and the shorter time period of data availability. Hence, our inferences from these analyses are more guarded.

TABLE 1 Walmart supercenter (WMSC) openings and Kroger renovations.

	(1)	(2)
$\text{Post}_{\text{WMSC}}$	0.019	0.478
	[0.098]	[0.090]
$\text{Post}_{\text{WMSC}}$ × Distance to nearest WMSC	−0.008	−0.009
	[0.112]	[0.089]
$\text{Post}_{\text{WMSC}}$ × Distance to nearest WFM		−0.016
		[0.000]
$\text{Post}_{\text{WMSC}}$ × Log num. of households		−0.006
		[0.585]
$\text{Post}_{\text{WMSC}}$ × Log mean income		−0.031
		[0.193]
$\text{Post}_{\text{WMSC}}$ × Population density[a]		−0.003
		[0.144]
N	35,763	35,763
R^2	0.636	0.636
Fixed effects	Store, Year	Store, Year

Note: The dependent variable is a dummy that is 1 if a Kroger renovates in a given year, and 0 otherwise. Direct terms associated with interactions presented above are subsumed in the store fixed effects. *P*-values based on heteroskedasticity robust standard errors clustered by store in parentheses.
[a]This coefficient is multiplied by 1000 for presentation purposes.

To study the role of skewness and variance, we use data on the local (zip code) income distribution as a proxy for the underlying distribution of demand for groceries. Since we only have mean income and quintile income shares, we use the share of population below the mean as our measure of skewness.[13] In particular, the greater this share, the higher is the skewness. This is consistent with our model where a higher skewness is equivalent to a higher percentage of customers being at the lower end of the market. We compute variance assuming that the income distribution is a component mixture of the five uniform distributions (corresponding to each quintile).[14] In our regressions, we use the logarithm of variance because its distribution is skewed.

To examine how renovations at the nearest Kroger are associated with commodity volumes at Whole Foods stores, we use split samples and estimate the following equation:

$$\ln \text{ACV}_{ijt} = \alpha \text{PostRENOV}_{it} + \beta D_{\text{KR}i} + [\theta_1 \text{PostRENOV}_{it} D_{\text{KR}i}] + \boldsymbol{\Gamma Z} + \delta_t + \omega_i + \epsilon_{ijt}, \quad (4)$$

where the dependent variable $\ln \text{ACV}_{ijt}$ is the log of the ACV at Whole Foods store i, in market (zip code) j, in year t, PostRENOV_{it} is a dummy variable that is 0 if the year is before the nearest Kroger store is renovated (or if the nearest store is not renovated in the sample timeframe) and 1 after the nearest Kroger store is renovated, $D_{\text{KR}i}$ is a dummy that is 1 if the nearest Kroger

[13]Specifically, if the overall mean income (m) falls in quintile k with income limits $[i_L, i_U]$, then we compute the share of population below the mean as $0.2*[(k\text{-}1) + (i_U\text{-}m)/(i_U\text{-}i_L)]$.
[14]Specifically, we compute variance as $\sum_{j=1}^{5}\left(s_j\left(m_j^2 + \frac{(i_{Uj}-i_{Lj})^2}{12}\right)\right)$, where m_j is mean income of quintile j, and i_{Uj} and i_{Lj} are the quintile income limits. We set $i_L = 0$ for the lowest quintile and $i_U = m_5$ for the highest quintile.

store is within 1 mile, and $\boldsymbol{Z}$ is a vector of controls including (log) mean income, (log) number of households and population density in the zip code, and their interactions with $\text{Post}_{\text{RENOV}}$ and D_{KR}, and δ_t and ω_i are year and store fixed effects.[15]

We first estimate Equation (4) without controls for high-skew and low-skew markets (based on the 75th percentile of skewness) and present the regression coefficients in columns 1 and 2 of the top panel of Table 2. Focusing on the coefficient on $\text{Post}_{\text{RENOV}} \times D_{\text{KR}}$, the results suggest that for Whole Foods stores located near a renovated Kroger store, the commodity volume decreased after the renovation in both low-skew and high-skew markets. This is consistent with the Kroger renovation drawing customers away from the nearby Whole Foods store. The corresponding coefficient in high-skew markets is much smaller, about a third of the magnitude in low-skew markets (*p-value* of χ^2 test of difference in coefficients: 0.107). We then repeat the exercise for variance based on the 75th percentile of variance and find the same pattern (columns 3 and 4; *p-value* of χ^2 test of coefficient difference: 0.001). The pattern persists when controls are included (bottom panel; *p-values* of χ^2 test of coefficient difference <0.005). This is consistent with our model, which suggests the high-end firm is likely to be more protected from the movement of the middle firm when skewness is higher or when the variance is higher.[16]

Although our illustrative example does not prove the existence of a cue-ball effect with statistical certainty (given the lack of exogenous variation), it nonetheless provides indicative evidence that connects an increase in cost advantage at the low end of the market (Walmart's entry by opening Supercenters) to the performance of the high-end firm (decrease in Whole Foods ACV), through the mediating mechanism of an upward repositioning of the middle-market firm (Kroger renovating), in a manner similar to our model.[17]

4 | DISCUSSION

In a narrow sense, this paper is about the specific counterintuitive phenomenon that we call the cue-ball effect—namely, that a firm's cost advantage can hurt a farther rival worse than a closer rival if firms can reposition themselves. But in a broader sense, this paper is about expanding our view on the full range of consequences of competitive advantage, which are still not fully understood even after decades of study. Much research has examined how competitive advantage affects the performance of the advantaged firm and, to some extent, the performance of its disadvantaged rivals. Yet relatively less research has focused on the question of how those disadvantaged rivals adapt in response to their disadvantage (e.g., via repositioning), and little if any research has studied the question of how those adaptations by one disadvantaged rival affect other disadvantaged rivals. These latter questions offer a new direction for strategy research. This paper takes a first step in this new direction by proposing that: (1) disadvantaged rivals are not merely passive

[15]Since the income distribution is bounded below at zero, the mean and variance are highly correlated in our sample ($\rho = 0.89$). Hence, we present estimates with and without controls to assess robustness.

[16]Given our small sample, we can only split by one variable (skewness or variance) at a time. In Online Appendix Table C3, we present specifications with triple interactions that include both skewness and variance.

[17]One alternative explanation is that Kroger may have decided to reposition because it spotted a weak rival in Whole Foods. While we cannot rule this out, there are at least two reasons that make it less likely. First, Kroger's renovations started in 2004, long before WFM's troubles, and they covered a much larger geographic area than WFM. Second, during most of our sample period, WFM appears to be a fairly strong player at least based on share price, which increased steadily until mid-2013 before declining. This is consistent with accounts in the business press mentioned earlier.

TABLE 2 Market characteristics and performance of whole foods stores after Kroger renovation.

Without controls	Low-skew	High-skew	Low-variance	High-variance
$\text{Post}_{\text{RENOV}} \times D_{\text{KR}}$	−0.395	−0.132	−0.393	0.059
	[0.013]	[0.118]	[0.003]	[0.395]
$\text{Post}_{\text{RENOV}}$	0.287	0.100	0.294	−0.018
	[0.069]	[0.218]	[0.026]	[0.642]
With controls	**Low-skew**	**High-skew**	**Low-variance**	**High-variance**
$\text{Post}_{\text{RENOV}} \times D_{\text{KR}}$	−0.549	−0.041	−0.318	0.049
	[0.000]	[0.756]	[0.008]	[0.000]
$\text{Post}_{\text{RENOV}}$	6.928	−0.469	−2.990	−0.879
	[0.090]	[0.834]	[0.574]	[0.132]
$\text{Post}_{\text{RENOV}}$ × Log mean income	−1.012	−0.021	−0.049	0.237
	[0.000]	[0.868]	[0.910]	[0.000]
$\text{Post}_{\text{RENOV}}$ × Log num. of households	0.560	0.092	0.412	−0.210
	[0.097]	[0.671]	[0.208]	[0.000]
$\text{Post}_{\text{RENOV}}$ × Population density[a]	−0.021	−0.016	−0.016	0.005
	[0.023]	[0.428]	[0.054]	[0.000]
N	1343	445	1341	447
R^2	0.905	0.919	0.903	0.914
Fixed effects	Store, Year	Store, Year	Store, Year	Store, Year

Note: The dependent variable is log annual commodity volume. *P*-values based on heteroskedasticity robust standard errors clustered by store in parentheses. Direct terms associated with interactions presented above are subsumed in the store fixed effects.

[a]This coefficient is multiplied by 1000 for presentation purposes.

recipients of harm from another firm's advantage, but rather may play an active role in adapting via repositioning, and (2) those repositioning adaptations may, in turn, impact other disadvantaged rivals. So, a firm's advantage not only has a direct effect each disadvantaged rival's performance, but it also has indirect effects since those disadvantaged rivals, via their repositioning moves, affect each other. Such indirect effects have not previously, to our knowledge, been studied.

Moreover, the total combined impact of the direct and indirect effects can yield counterintuitive results. In particular, our theoretical model predicts, and our empirical example illustrates, that a firm's cost advantage can hurt its farther rivals worse than its closer rivals, due to the impact being propagated via repositioning. Some studies of vertical differentiation, such as Gabszewicz and Thisse (1979), Mazzeo (2002), and Shaked and Sutton (1983), hint at the possibility of other types of distant effects (specifically, competition among high-quality firms displacing low-quality firms), but no prior study, to our knowledge, has considered the questions of whether, when, and how an advantaged firm's farther rivals may be hurt worse than its closer rivals. We answer this question by observing that when closer rivals mitigate the impact of the advantage on themselves by repositioning away from the advantaged firm, they may transfer that impact to more distant competitors—much like a cue ball transmits the impact of the cue stick to a target ball in billiards. In our empirical example, the entry of Walmart (cue stick) appears to be associated with an indirect effect on Whole Foods (target ball) through Kroger (cue ball), whose upscale repositioning away from Walmart moved it closer to Whole Foods. So, it is important for both managers of companies like Whole Foods and researchers to recognize the potential indirect impact of distant rivals.

Our results also suggest that researchers' understanding of competition has suffered from a blind spot by failing to consider the possibility of competitive repositioning acting as a propagating mechanism that transfers the impact of changes in a firm's advantage beyond its proximate competitors. So, strategy research has largely been silent on how a change in a firm's competitive advantage may affect its distant rivals, which may seem surprising considering how many studies have examined the origins of competitive advantage (e.g., Barney, 1986; Coff & Kryscynski, 2011; Dierickx & Cool, 1989; Peteraf, 1993) and how it affects a firm's performance (e.g., Coff, 1999) and those of its proximate rivals (e.g., Smith et al., 1991). Although some researchers have begun to study various aspects of competitive repositioning (Cong & Zhou, 2019; Du et al., 2019; Gimeno et al., 2006; Makadok & Ross, 2013; Menon & Yao, 2017; Wang & Shaver, 2014), fully correcting this blind spot will require further theoretical and empirical work, which may reveal more surprises like the cue-ball effect described here.

Our results also contribute to the "stuck in the middle" debate. Early research in this area (e.g., Dess & Davis, 1984; Porter, 1980) argues that a middle-market position is unfavorable since specializing in being a high-quality or a low-cost provider allows firms to outcompete firms in the middle that offer neither highest quality nor lowest cost. More recent work by Adner et al. (2016) argues that the middle position can be advantageous under certain conditions of demand heterogeneity and technology scalability. Neither side of this debate has considered how the middle-market firm's performance may be affected by having some degree of flexibility to reposition itself as Kroger did—that is, if it is not permanently "stuck" at one particular middle position. In this regard, our model adds the option to reposition as a second counterargument against rigid "stuck in the middle" logic. Moreover, our empirical illustration suggests that, in contrast to "stuck in the middle" logic, firms that are positioned on a market's periphery—for example, either at the very top or the very bottom of a vertically differentiated market—may be the most vulnerable to a rival's advantage because they have the least latitude to reposition themselves away from an advantaged rival. Indeed, in our grocery retailing example, the two firms that were hurt worst by Walmart's entry were the high-end incumbent Whole Foods and the low-end incumbent Winn-Dixie, since the former could not retreat any further upscale, and the latter could not retreat any further downscale.

4.1 | Boundary conditions and extensions

As a highly simplified abstraction constructed to illustrate the particular idea of a cue-ball effect, our model cannot capture all potentially relevant aspects of real-world competition. For example, we assume an industry populated by exactly three firms, with no possibility of entry, exit, or mergers. Extending the model to allow for different numbers of firms, with entry, exit, and merger options, might yield results that differ from ours in interesting ways. We conjecture that allowing for the possibility of exit is likely to give similar inferences to ours. Specifically, if exit decisions are based on meeting an absolute profit threshold, which would be consistent with firms incurring positive per-period fixed costs, then a decline in profits will broadly correlate with the probability of exit. Furthermore, given its smaller size, firm H would be more likely to exit than firm M for a given level of profit decline, which might have the effect of increasing the range of parameter spaces over which firm *M* does better than firm *H*. We leave verification of this conjecture to future research. Similarly, allowing for free entry (e.g., by modeling an initial entry stage that precedes the quality choice stage in our model), which can result in more than three firms in equilibrium, may help shed light on whether the propagation of the low-end firm's advantage eventually dissipates as it passes through multiple competitors. We conjecture that this may depend on some of the factors we have modeled here.

A related boundary condition is that, for reasons of tractability, our model does not allow dramatic shifts in the competitive landscape. For instance, we constrain firm M to operate around the mean. This may not always be true in general since *M* may choose to completely exit the low-end portion of the market. We speculate that if *M* were not constrained to operate around the mean, there would likely be a greater range of parameter values over which firm *M* performs better than firm *H*. This conclusion arises from the fact that *M*'s performance from a solution to an unconstrained problem will in general be better than its performance based on a solution to a constrained problem. Likewise, we constrain the quality ordering of firms to remain unchanged. Allowing for more general repositioning, including "leapfrogging" cases where the low-end firm chooses the highest quality after it gains an advantage, may yield interesting insights.

Similarly, our formal model assumes that firms' products differ only along a single dimension of product differentiation and that this dimension is vertical (i.e., valued positively by all potential customers) rather than horizontal (i.e., valued positively by some customers and negatively by others). Extending the model to allowing firms to differ simultaneously along multiple dimensions, vertical and/or horizontal, might change our results in interesting ways. In our unidimensional model, there is only one direction in which to retreat, so it is impossible for the middle firm to move away from the low-end firm without simultaneously moving closer to the high-end firm, which helps to focus and strengthen the propagation effect for a more cue-ball-like impact. In contrast, a higher-dimensional model would give an advantaged firm's competitor more latitude to choose its retreat vector, which (depending upon the overall configuration of competitors in the space) might allow it to retreat in a direction that would not move it much closer to more distant rivals, thereby diffusing and weakening the propagation effect. For example, Wang and Shaver (2014) consider a multidimensional empirical context (television programming) where competitors could reposition along at least 87 measured dimensions, and they did not report any cue-ball-like effects. Likewise, Seamans and Zhu (2017) report similar results in an empirical context (newspaper publishing) with 11 measured dimensions of differentiation. So, the way that repositioning-driven propagation affects the distribution of an advantaged firm's impact on its competitors may depend upon the dimensionality of the product space, with lower dimensionality increasing the likelihood of a cue-ball-like effect.

In addition, our formal model imposes restrictive assumptions about competition, diversification, and dynamics. First, it assumes that firms compete only on price, although other forms of competition are certainly possible and might yield different results. For example, Motta (1993) finds that, in comparison to price competition, quantity competition yields less vertical differentiation, since distancing from rivals is less necessary when rivalry is less intense. This result suggests that firms may have more inertia in their positioning, and less motivation to reposition themselves, under quantity competition than under price competition. If so, then quantity competition might dampen the cue-ball effect. Second, the model also limits each firm to offering only one product at only one quality level, whereas allowing firms to diversify into broader product lines may yield interesting new results. Also, the dynamics of our model are limited to a single exogenous efficiency shock asymmetrically affecting only the low end of the market, followed by endogenous repositioning by the competing firms. Additional insights might be obtained by extending the model to include a broader range of types of shocks or asymmetries (e.g., giving the advantage to the high-end firm instead of the low-end firm) for a broader range of players and/or a broader range of possible endogenous responses to those shocks. The model could also be expanded to allow firms to invest in imitating each other's advantages or innovating new advantages. For instance, firms may be able to invest in cost-reducing technologies, in which case such cost reductions and quality repositioning could be substitute responses. Broadly speaking, allowing for potential investments in cost-reduction technologies would likely result in a scenario somewhere between our model (which assumes that the middle-market and high-end firms cannot reduce their costs) and a case of instantaneous and costless ability to lower costs (which would result in no cost advantage for the low-end firm). More specifically, if adopting such cost-reducing technologies involves large fixed-cost investments, then the middle firm, due to its larger size, is more likely to adopt them than the high-end firm (assuming the cost reduction is uniform across the quality distribution). Thus, it is likely to increase the likelihood of the cue-ball effect. We leave a formal verification of this conjecture to future research.

Another possible extension relates to contingency factors. Our model only studies the impact of three such factors on the cue-ball effect—demand skewness, cost convexity, and competitive intensity—whereas innovation diffusion research suggests that the rate of diffusion of an innovation depends on other characteristics, such as uncertainty (Mansfield, 1961), network externalities (Mahajan, 2010), and social networks (Abrahamson & Rosenkopf, 1997). Given the link between innovation and competitive advantage, modeling these factors may yield insights about how they affect propagation of an advantage's impact.

Finally, our empirical example in the grocery retailing industry differs from our model in some important ways. For instance, our model assumes it is the same low-end firm before and after the cost shock, but our empirical illustration uses the entry of Walmart Supercenters to proxy for the cost shock. Repositioning is assumed to be costless and instantaneous in the model, but in reality, Kroger's renovations were costly and time-consuming. Moreover, our empirical example merely illustrates the general idea of the cue-ball effect, but it does not provide an actual test of any specific propositions from the model. Nor can it rule out alternative explanations due to its small sample size and lack of exogenous variation. Future work can scrutinize the validity of the cue-ball effect via direct, improved empirical testing. One potential approach to such a test would be an event study, focusing on what happens before and after specific events associated with a change in a firm's competitive advantage. Stock market responses to strategic announcements may be helpful in this regard. For instance, Chatterjee (1986) examines the impact of a merger announcement on rivals and briefly compares the effect between two different types of rivals. Other studies have examined the effect of bankruptcy announcements (Lang & Stulz, 1992) and patents (Megna & Klock, 1993) on rivals but have not undertaken a deeper examination of inter-competitor heterogeneity. Future research could examine other important strategic announcements by firms, and investigate whether and why more distant competitors might be more affected than closer competitors.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the first author upon reasonable request.

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