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# Choosing not to compete: Can firms maintain high prices by confusing consumers?

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**Abstract**
Firms with very similar products often present their products in different ways. This makes it difficult for consumers to find out which product fits their needs best, or which one is the cheapest. Why is there no convergence toward common ways to present products? Is it possible for firms to maintain high prices by confusing consumers? We run a market experiment to investigate those questions. In our market, firms choose how to present their products in addition to choosing their price. We find that firms maintain different ways to present their products and that this allows them to maintain high prices. This behavior is not consistent with competitive behavior, such as when firms adopt best responses to each other, imitate the most successful firm, or learn the best strategy over time. Rather, our results are only consistent with cooperation between firms. Firms cooperate by not imitating the way other firms present their products. Cooperation is maintained by the threat of tough competition if a firm makes its product easy to compare with others. Firms are all the more likely to maintain such cooperation if their products do not actually differ much. This is because in that case, maintaining differences in the presentation of their products is the only way to maintain profits.

## 1 | INTRODUCTION

Firms compete not only in terms of price and product quality but also in the way they present their product and price to consumers. Prices may be set per kilogram, per pound, or per liter. Users may be offered subscriptions or charged on a per-usage basis. After-sale services, insurance, and extended guarantees may be included or sold as add-ons. Firms can use different package shape and size, different metrics in describing the product, different locations on supermarket shelves, and different categories in online listings. All those different pricing schemes and different presentations can reflect real differences in their products. However, they may also not reflect any real underlying differences in what is being offered.

In an ideal world, firms would adopt common ways to present their products and their prices. Consumers would then make accurate comparisons and select the best product. They would not have to do complicated calculations and search for information to find out how to compare products accurately. However, firms as a whole may want to prevent easy comparisons. Indeed, buyer ignorance—in the inability to judge the quality of a product by its intrinsic merit—is a source of oligopoly power (Scitovsky, 1950). Imperfect consumer information allows firms to maintain prices above marginal costs (Stiglitz, 1989).

  

Spurious differentiation can work as well as real product differentiation in helping to maintain high prices and a profit margin (Perloff & Salop, 1985, section 6).

The following example illustrates why firms may prefer to adopt different ways to present their products. Suppose two competing sodas are alike in every respect except the color of their packaging. "Red" is sold in a red package and "Blue" is sold in a blue package. Some consumers only buy "Red," others only buy "Blue." A third producer, with essentially the same product, wants to enter the market. He has to choose the color of his packaging. If he chooses red, then "Red" consumers will not see the difference with the existing red product and will then simply choose the cheaper of the two red products. This will lead to a downward price spiral. Therefore, the third producer may prefer to choose green, for example, in order to avoid direct competition with either of the two incumbents. Another example illustrates the same principle: Two yogurt manufacturers with identical products have to choose whether to market their product as a health product or a dessert. If they choose the same category, then their products are direct competitors. If they choose different categories, then they do not have to compete as hard.

Such spurious differentiation can be difficult to maintain however. Any one firm can profit by lowering its prices and making it easy for consumers to compare its product with the competition. This attracts "savvy" consumers, that is, those consumers who, whenever possible, compare products by their objective characteristics. However, if a firm does this, then other firms will start price wars in order to regain savvy consumers. In the long term, this leads to lower profits. Anticipating this, firms may choose not to compete for savvy consumers in the first place.

Price wars are all the more costly when real product differences are minimal. This is why such markets can paradoxically exhibit the most spurious differentiation and the highest profit margins (Møllgaard & Overgaard, 2001). For example, most participants in blind tests cannot perceive the difference between Coca-Cola and Pepsi. However, the two companies have been able to maintain profit margins by choosing different logos, colors, bottle sizes, advertising, marketing campaigns, and distribution channels. This has reduced the share of consumers who choose between the two based on prices.

In this paper, we present experimental evidence that firms can cooperate in maintaining high prices and different ways to present their products. We find that this happens if firms are well informed about the behavior of their competitors. Rather counterintuitively, an increase in the share of savvy consumers—who choose based on price if products are presented the same way—does not lead to lower prices and profits. Indeed, our experimental markets with full market information and many savvy consumers were the ones with the highest prices and the least uniformity in the presentation of products. The presence of savvy consumer discourages firms from making their products easy to compare, as this leads to tough competition. However, we find that such cooperation is maintained only if firms are well informed about the behavior of their competitors. If firms cannot observe each other, then they cannot deter imitation by others. The presence of savvy consumers then encourages firms to choose common ways to present their products. This is why our experimental markets with no market information and many savvy consumers were the ones with the lowest profits.

## 1.1 | Literature

Our results are interesting because economists have long asserted that savvy consumers force firms to keep prices low (Armstrong, 2015). This is because competition for savvy consumers drives prices down (Salop & Stiglitz, 1977; Varian, 1980). Furthermore, competition becomes tougher as consumers learn to avoid products that are presented in unusual ways (Gaudeul & Sugden, 2012). Finally, if some firms try to confuse consumers, then new firms with more transparent offers enter the market (Wenzel, 2014).

Recent work challenges the faith in those assertions. A developing theoretical literature in behavioral industrial organization deals with firms that exploit the cognitive limitations of consumers to establish market power. Markets in which firms evade competitive forces by confusing consumers have been called "confusopolies" (Adams, 1997). In such markets, firms make it difficult for consumers to consider all options. They use complex price schedules, hide some of the costs of using their product, or make it difficult to compare products (Bar-Isaac, Caruana, & Cuñat, 2010; Carlin, 2009; Chioveanu & Zhou, 2013; Ellison, 2005; Ellison & Wolitzky, 2012; Gabaix & Laibson, 2006; Heidhues, Kőszegi, & Murooka, 2017; Piccione & Spiegler, 2012; Spiegler, 2006).

Empirical evidence shows that intentional obfuscation does occur (Célérier & Vallée, 2013; Ellison & Ellison, 2009; Hossain & Morgan, 2007; McDonald & Wren, 2013; Muir, Seim, & Vitorino, 2013; Wenzel, 2013; Woodward & Hall, 2010). Books, reviews, and policy papers explore how firms manipulate and deceive consumers who "search too little, become confused comparing prices" and fail to switch from their default options (Akerlof & Shiller, 2015; Beales, Craswell, & Salop, 1981; Garrod, Hviid, Loomes, & Price, 2009; Grubb, 2015; Spiegler, 2015). Indeed, "the common use of tariff proliferation (...) is collusive in nature" according to Siciliani (2014). Competition and market authorities in the United States, United Kingdom, Australia, Sweden, and elsewhere have all expressed concerns about marketing strategies that magnify limitations in the ability of consumers to make rational and well informed choices.[1]

In this paper, we do not look at empirical evidence but rather generate and analyze data from a market experiment. This allows us to make sure that differences between products in our experimental market are purely spurious. In real markets, it is difficult to make the distinction between spurious and real product differentiation. For example, the design of Coca-Cola's contour bottle makes it difficult to compare its volume with that of bottles used by other brands. This design could therefore be spurious differentiation. However, this design also makes Coca-Cola bottles objectively more attractive to some people. This design could therefore be real product differentiation. We avoid such identification problems in our experiment by making the value of a product completely independent of the way it is presented. Running an experiment also allows us to manipulate different aspects of our experimental markets independently of each other, which is not possible in real markets.

The use of the laboratory comes at a cost, however. Results from a controlled setting carry out to the real world only if the experiment captures the key elements of real-world situations. The behavior of participants in the experiment must also be similar to that of managers out in the wild. This can be a problem, as we recruit student participants who lack experience, are risk or inequality averse, have a tendency to reciprocate, or to be altruistic. This is not typically the case of firms. However, past research shows that incentives and a certain market moral code crowd out those motives in market experiment (Holt, 1995; Roth, Prasnikar, Okuno-Fujiwara, & Zamir, 1991). Furthermore, professional managers do not behave in ways that are systematically different from students when playing market experiments (Abbink & Rockenbach, 2006; Fréchette, 2015; Siegel & Harnett, 1964).

A few other experiments investigate how firms exploit and maintain confusion in their markets. In an experiment by Kalaycı and Potters (2011), firms make it overly difficult for buyers to assess the quality of their goods. Prices are higher when buyers are human, and thus liable to be confused, than when buyers are computers programmed to choose the best price. However, in a follow-up study, human consumers seem to learn to associate high complexity with high prices, thus disciplining firms (Kalaycı, 2015b). In Shchepetova (2012), market with more firms exhibit higher product complexity and higher prices. However, in Kalaycı (2015a), increasing the number of firms does not increase the complexity of offers.

Those experiments show that firms can maintain high prices by confusing consumers, and that more competition does not necessarily lead to more transparent markets. Our experiment differs from those previous works because we want to test whether firms confuse consumers to avoid competition with other firms, rather than doing so only to encourage mistakes by consumers. Indeed, a possible motivation for confusing consumers is simply to encourage mistakes by consumers, such that at least some of them overestimate the value of a firm's product and pay more for it.[2] In experiments where firms manipulate the level of product complexity, it is difficult to know if firms design complex offers only to make it difficult for consumers to *evaluate* the value of their product, or if they do so to make it difficult for consumers to *compare* the value of their product with the value of the products of other firms.

In this paper, we therefore do not investigate product complexity as such, but rather the decision to make offers comparable, as this is what matters from a strategic point of view. Comparability is easier to define than product complexity. Indeed, there are many different dimensions of complexity, but even a very complex product can still be compared with another product. Their performance only needs to be expressed in terms of a common unit. For example, a Ferrari and a Porsche differ in many respects, but they can be compared by racing one against the other.

By focusing on comparability, we simplify the choice by firms: either imitate the presentation of another firm, or not. In our experiment, firms simply choose between imitating another firm's way to present its product and devising their own way. That does not change the ease with which a consumer can evaluate the value of the product when it stands on its own. By isolating the effect of comparability from the effect of complexity, we are able to focus on why and when firms strategically refrain from making their product easy to compare with others. We can thus better test our main hypothesis, which is that firms manipulate the ease with which their product can be compared with others in order to change the intensity of competition in their market. This additional strategic variable allows them to better deter price competition and maintain high prices.

Another difference with previous experiments is that we do not face firms with human consumers. This is because under our theory, firms can all the more easily deter price competition if there are many savvy consumers. Testing our theory therefore requires us to manipulate the share of savvy consumers. Unlike Shchepetova (2012) therefore, we fix the share of savvy consumers in each treatment rather than let the share of informed consumers depend on the level of product complexity that arises in the market. However, we use a realistic model of behavior for our robot consumers. This model is based on our own preliminary work on this topic (Crosetto & Gaudeul, 2016).

Finally, unlike previous experiments, we also manipulate the ease with which firms can react to strategic moves by other firms. We compare an environment with full information, which is conducive to the maintenance of high prices, with a baseline environment where firms do not obtain information about other firms. In that baseline environment, firms must deduce the action of others from their own sales: lower sales mean some other firm decreased its price or made its product easy to compare with one's product. Difficulties in inferring the action of others make cooperation more difficult to sustain. By varying the amount of information that firms get, we are able to determine if cooperation is a factor. Indeed, if that is the case, profits under full information will be higher than those under no information.

## 2 | A MARKET WITH ENDOGENOUS SPURIOUS DIFFERENTIATION

We present a simple model of competition with spurious product differentiation, consumer loyalty, and savvy consumers. We first present the case where only two firms compete. We then move on to the more complex case with three firms. This is the context we consider in our experiment because the experimental literature shows that markets with three to four players generate competitive behavior that is more realistic and more in line with empirical data (Huck, Normann, & Oechssler, 2004).

### 2.1 | The duopoly

Consider two competing soda manufacturers with the same product which they present in different ways. Some consumers prefer the product as presented by one firm, others like the other presentation better. However, some consumers—we call them "savvy"—are indifferent between the two products if they are both presented the same way. Other consumers—we call them "naive"—stick to their favorite brand even if they are both presented the same way. Those naive consumers may have developed loyalty to one manufacturer, or they do not take the time to look at the products of different manufacturers than the one they usually buy from.[3] Firms then have a choice. They can maintain different ways to present their product and sell only to those consumers who prefer their way to present their product. Or they can present their products the same way as their competitor and set a lower price to also attract their competitor's savvy consumers.

More formally, two firms, A and B, operate in the same market and decide on both the price of their product and on the way it is presented (the "format"). They do this simultaneously, independently, and without knowing the choice of the other firm. Firms can choose between two ways to present products, format A and format B. Firm A must adopt format A whereas firm B can choose to adopt either format B or format A.[4]

There are two types of consumers, type $A$ and type $B$, both in equal numbers normalized to 1. Portion $\mu$ of consumers of each type are savvy. We denote $p_A$ the price set by firm $A$, $p_B$ the price set by firm $B$, $v > 0$ the utility of the product to the consumer, and $e > 0$ a measure of *spurious* product differentiation. $e$ measures by how much a consumer believes the product of his preferred firm is better than others.

- If firm $A$ and firm $B$ adopt different formats, then consumers of type $A$ buy from firm $A$ as long as $v + e - p_A \geq v - p_B$. Conversely, consumers of type $B$ buy from firm $B$ as long as $v + e - p_B \geq v - p_A$.
- If firm $A$ and firm $B$ both adopt format $A$, then naive consumers of type $A$ buy from firm $A$ as long as $v + e - p_A \geq v - p_B$, whereas savvy consumers of type $A$ buy from firm $A$ only as long as $v - p_A \geq v - p_B$. Conversely, naive consumers of type $B$ buy from firm $B$ as long as $v + e - p_B \geq v - p_A$, whereas savvy consumers of type $B$ buy from firm $B$ only as long as $v - p_B \geq v - p_A$.

This specification of consumer preferences leads to the following schedules of demand for the product of firm $B$, as a function of its price $p_B$ and its choice of format (Figure 1). In the graphs, we assume that $v = 5$, $e = 1$, $\mu = 30\%$, and $p_A = 2$.

On the left-hand side of Figure 1 is demand $Q_B$ as a function of $p_B$ if firms adopted different formats. In this case, firm $B$ must set its price as low as $p_A - e$ in order to attract consumers of type $A$.[5] The demand schedule is

$$\begin{cases} Q_B = 2 & \text{if } p_B < p_A - e, \\ Q_B = 1 & \text{if } p_B \in ]p_A - e, p_A + e[, \\ Q_B = 0 & \text{if } p_B > p_A + e. \end{cases}$$

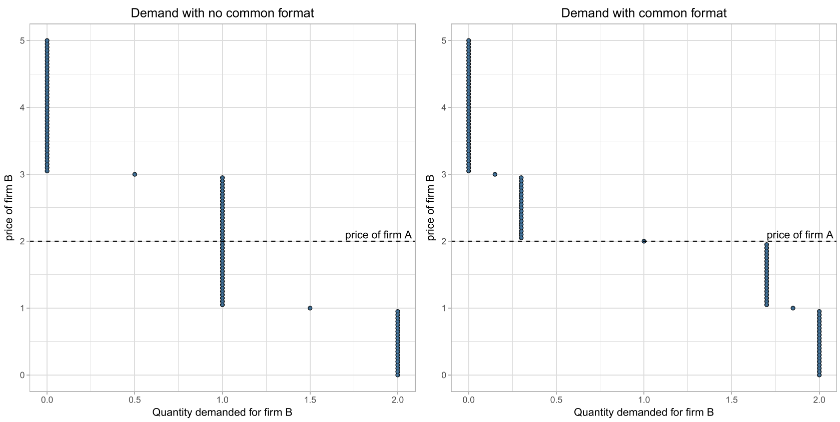


**FIGURE 1** Demand for firm $B$ in a duopoly given $v = 5$, $e = 1$, $\mu = 30\%$, and $p_A = 2$ [Color figure can be viewed at wileyonlinelibrary.com]

On the right-hand side of Figure 1 is demand $Q_B$ as a function of $p_B$ if firms both adopt common format $A$. In this case, firm $B$ attracts savvy consumers of type $A$ as soon as $p_B < p_A$. It must however still set $p_B < p_A - e$ to attract naive consumers of type $A$. The demand schedule is

$$\begin{cases} Q_B = 2 & \text{if } p_B < p_A - e, \\ Q_B = 1 + \mu & \text{if } p_B \in ]p_A - e, p_A[, \\ Q_B = 1 - \mu & \text{if } p_B \in ]p_A, p_A + e[, \\ Q_B = 0 & \text{if } p_B > p_A + e. \end{cases}$$

Demand is therefore more sensitive to prices when firms adopt a common format than when they maintain different formats. This is because choosing the same format makes savvy consumers indifferent between the two firms, so the demand of that section of the consumers becomes very elastic.

## 2.2 | The triopoly

Consider now the case of a triopoly as implemented in our experiment. There are three firms, with three different ways to present products (formats $A$, $B$, and $C$). Firms $B$ and $C$ can adopt format $A$ but firm $A$ cannot change its format. There may therefore be cases in which two firms share a common format whereas the third sticks to its own format. This is relevant because real markets often see a dominant system of comparable products coexisting with idiosyncratic products that are difficult to compare with the rest—the case of Apple versus PCs comes to mind. In such a setting, consumers will be subject to the asymmetric dominance effect ("ADE") (Huber, Payne, & Puto, 1982; Huber & Puto, 1983; Simonson, 1989; Tversky & Simonson, 1993). Also known as the decoy or attraction effect in consumer and marketing research, this is a robust effect of the context in which decisions are taken. Under the ADE, consumers prefer the better option of two products that are easy to compare to a third option that is more difficult to compare.

- If all firms adopt their own idiosyncratic formats, then consumers of each type perceive the product of the firm corresponding to their type as being superior to the others by a margin of $e$. For example, a consumer of type $A$ buys from firm $A$ as long as $v + e - p_A \geq \max(v - p_B, v - p_C)$.
- If all firms adopt format $A$, then savvy portion $\mu$ of consumers choose the product with the lowest price, whereas naive portion $1 - \mu$ of consumers of each type behave as if products were not being presented the same way.
- If only two firms adopt format $A$ and one keeps its own idiosyncratic format, then savvy consumers face a choice between two comparable offers and one that is not comparable. They are then subject to the ADE. They apply a penalty to the firm with the idiosyncratic format. The penalty is such that they behave as if price $p$ of the product with an idiosyncratic format was $(1 + \lambda) \cdot p$, with $\lambda > 0$.

Parameter $\lambda > 0$ measures what we call the "*skepticism*" of savvy consumers when faced with idiosyncratic offers. This measures the extent to which savvy consumers dislike offers that are difficult to compare. In Crosetto and Gaudeul (2016), we find that consumers perceive a product presented in an idiosyncratic way as if it was on average up to 15% more expensive than a product presented in a way that is comparable with another product on the market.

Our model of consumer behavior allows us to manipulate not only *how many* consumers compare products based on prices when the products are comparable ($\mu$), but also their *level* of skepticism when faced with idiosyncratic offers ($\lambda$). We are therefore able to finely manipulate how consumers are sensitive to frames (Spiegler, 2014).

## 3 | THEORETICAL ANALYSIS

We establish in this section our main hypotheses. We assert that a higher share of savvy consumers ($\mu$), higher levels of skepticism against idiosyncratic ways to present products ($\lambda$), and more information about competitors, will lead to a higher likelihood that firms will be able to maintain high prices and idiosyncratic ways to present their products. We first ground this hypothesis and then make further hypotheses about the dynamics of prices and formats.

Firms in our experiment play a repeated game that may be likened to an indefinitely repeated prisoner's dilemma. In each period, firms decide whether to cooperate ($C$) or defect ($D$). In our context, cooperation involves setting a high price, $\overline{p}$, and differentiating from other firms by adopting an idiosyncratic format. Defection involves adopting a low price, $\underline{p}$, and adopting the format of another firm. When deciding whether to cooperate or defect, firms react to the behavior adopted by other firms in the previous period. If all other firms cooperated, then they cooperate. If a firm defected, then they defect.

Let us consider whether such strategies can maintain cooperation in the market. We denote $\pi_{CC}$ the profit attained if all firms cooperate. If all firms cooperate, then they all sell at price $\overline{p}$ to mass 1 of consumers of their own type. Therefore, $\pi_{CC}$ is equal to $\overline{p}$. Now, suppose that one firm defects whereas others cooperate. We denote $\pi_{DC}$ the profit for that firm. We have $\pi_{DC} > \pi_{CC}$ because a firm can for example set $\overline{p} - \epsilon$ with $\epsilon$ small, adopt common format $A$, and gain the savvy consumers of firm $A$. If this happens however, other firms will also defect in the next period and forever thereafter. We denote $\pi_{DD}$ the profits made in that stage where other firms retaliate and compete for savvy consumers. There are many ways in which firms may compete in that stage, and we will explore a few of them. What is important is that $\pi_{DD} < \pi_{CC}$, which is true as long as $\overline{p}$ is sufficiently high. If we denote $\delta$ the per-period discount rate, and if we suppose that firms play the game forever, then cooperation will be sustained if

$$\frac{\pi_{CC}}{1-\delta} \geq \pi_{DC} + \delta \cdot \frac{\pi_{DD}}{1-\delta} \tag{1}$$

Discount factor $\delta$ reflects the level of patience of firms or the probability with which they expect to survive into the next period. Cooperation will be sustained as long as $\delta > \frac{\pi_{DC}-\pi_{CC}}{\pi_{DC}-\pi_{DD}}$. This translates into a threshold $\delta^* = \frac{\pi_{DC}-\pi_{CC}}{\pi_{DC}-\pi_{DD}}$ over which cooperation will be maintained. Taking the distribution of $\delta$ in the population as fixed, changes in the threshold $\delta^*$ translate in changes in the likelihood that all participants in a given group will be patient enough to be willing to sustain cooperation. The lower is $\delta^*$, the more likely it is that firms will cooperate. Let us now consider how $\mu$, $\lambda$, and the amount of information about competitors affect the likelihood that firms can maintain high prices and idiosyncratic ways to present products.

### 3.1 | The impact of the share of savvy consumers

A high share $\mu$ of savvy consumers, and higher skepticism $\lambda$ toward idiosyncratic ways to present products, make demand more elastic when firms adopt common ways to present their products. This means that profit $\pi_{DD}$ decreases with $\mu$ and with $\lambda$ under various assumptions about the way firms will compete. This holds whether competition involves playing the static Nash equilibrium of the game, making myopic price adjustments, imitating each other, or performing adaptive reinforcement learning (Online Appendix B). Lower $\pi_{DD}$ helps maintain cooperation in the repeated game because firms then have more to lose by competing (Abreu, 1988; Aumann & Shapley, 1994; Friedman, 1971; Fudenberg & Maskin, 1986; Møllgaard & Overgaard, 2001).

However, whereas $\pi_{DD}$ decreases in $\mu$ and $\lambda$, $\pi_{DC}$ is weakly increasing in $\mu$ (Online Appendix B.5). Indeed, defection takes the form of adopting a common format and undercutting the prices set by other firms so as to pick up their savvy consumers. The net effect is that $\delta^*$ first decreases as $\mu$ increases, and then increases as $\mu$ increases. In other words, adding savvy consumers first makes cooperation easier to sustain, and then makes it more difficult. This result is similar to a result in Petrikaitė (2016). In our experiment, we consider only levels of $\mu$ in the lower range. In that range, higher $\mu$ makes cooperation easier to sustain. This leads us to our first hypothesis:

**Hypothesis 1.** *As long as $\mu$ is not too high, then the frequency of cooperation will increase with $\mu$ and with $\lambda$. Average profits may thus increase with $\mu$ and $\lambda$.*

Note that we refrain from saying that average profit *will* increase with $\mu$ and $\lambda$. Indeed, this depends on the frequency of cooperation over the whole timeline of competition in a market. If we denote $f(\mu, \lambda)$ the frequency with which cooperation is maintained in a market over time, then average lifetime profit *will* be higher in treatments with higher $\mu$ and $\lambda$ only if $f(\mu, \lambda)\pi_{CC} + (1 - f(\mu, \lambda))\pi_{DD}$ increases in $\mu$ and $\lambda$. $f(\mu, \lambda)$ must increase sufficiently fast with $\mu$ and $\lambda$ to compensate for how $\pi_{DD}$ decreases with $\mu$ and $\lambda$. If we observe that profits increase in $\mu$ and $\lambda$, then this is a sure sign that cooperation is a significant factor in our setting. If we observe that profits decrease with $\mu$ and $\lambda$, then this does not mean that there is no cooperation between firms, only that this cooperation is not established frequently enough. Our hypothesis contrasts with what occurs under alternative hypotheses about how firms behave. If firms play the static Nash equilibrium of the game, imitate each other, follow best-response dynamics, or learn over time, then profits is lower on average in treatments with high $\mu$ and $\lambda$.

## 3.2 | The impact of information conditions

Even though cooperation can be sustained in markets in which firms can only imperfectly monitor each other (Abreu, Pearce, & Stacchetti, 1986; Green & Porter, 1984; Stigler, 1964), experimental research generally supports the hypothesis that better information about competitors leads to higher prices (Aoyagi & Fréchette, 2009; Dolbear et al., 1968; Feinberg & Snyder, 2002; Fonseca & Normann, 2012). In an environment with limited information, where firms only know their own decisions, breaks in cooperation have to be inferred from one's own sales. Because ones own sales are an imperfect signal of the actions of others, punishment may come too early or too late. Both breaking cooperation too early or inflicting penalties too late make cooperation less likely to be established or to be maintained.

We therefore express our second hypothesis as follows:

**Hypothesis 2.** *Cooperation will occur more frequently and profits will thus be higher in treatments with full information than in treatments with limited information.*

Alternative assumptions about the behavioral dynamics of competition do not predict differences across information treatments. Indeed, mixed strategies in the static Nash equilibrium and under reinforcement learning do not rely on information about other firms. Imitation strategies do not apply to a setting with limited information as they rely on information about the behavior of competitors. Finally, adapting myopic best-response dynamics to a context with imperfect information does not affect the level of profits attained by firms (Online Appendix B.2).

## 3.3 | Price dynamics and changes in formats

We now consider price dynamics under cooperation and how those correlate with the choice of format. We contrast those dynamics with the dynamics under other assumptions about how firms may behave. We will show that the dynamics of prices and formats in our experiment correspond to the dynamics of cooperation. This will allow us to further establish that our results, —which support Hypotheses 1 and 2, —are the result of cooperation between firms.

Cooperation between firms may not be established right from the beginning of a market. Firms have to gradually learn not to compete. How will that process take place? A firm that wants to cooperate could indicate this by setting the maximum price allowable, $v$. However, this is risky, as other firms may not follow. Firms may therefore prefer to increase prices progressively while maintaining their own idiosyncratic ways to present products. In that way, they reduce the risk of making no sales. Consider, for example, price profile $(p_A, p_B, p_C)$ whereby all firms adopt their own idiosyncratic way to present products (format) and prices do not differ by much: $\max(p_A, p_B, p_C) - \min(p_A, p_B, p_C) \leq e$. Each firm is then selling to consumers of its own type and not to others. Suppose, without loss of generality, that firm $A$ is the lowest priced. Firm $A$ can then increase its price up to $\min(p_B, p_C) + e$ and still sell to all consumers of type $A$. It sells as much as previously, but at a higher price, and thus increases its own profits. This change in price does not lower profits for other firms. Other firms have therefore no reason to resent that move. Rather, they may follow such a move in the next period by increasing their prices as well. As long as no firm decreases its price and no firm increases prices by more than $e$ over the minimum price of competing firms last period, then none runs any risk of making zero sales. Prices can thus easily converge to the maximum, $v$. A similar argument is made in Mouraviev and Rey (2011) and Dijkstra (2015).

Firms will maintain idiosyncratic formats when increasing prices, but also after cooperation is established at a high price. This is because maintaining an idiosyncratic format allows a firm to keep its naive consumers even if another firm lowers its price, as long as that other firm only decreases its price by a small margin. It is therefore safer to keep an idiosyncratic format.

**TABLE 1** Treatment effects and price and format dynamics under different types of competitive behavior

| Type of behavior | Profits | Frequency of use of common format A | Increases in prices | Decreases in prices |
|---|---|---|---|---|
| Cooperation (appendix B.5) | Increasing in $\mu$ and in $\lambda$ (given that $\mu$ and $\lambda$ are relatively low), lower under limited information | Decreasing in $\mu$ and in $\lambda$, higher under limited information. | Small consecutive increases in prices over long periods associated with use of idiosyncratic format. | Large consecutive decreases in prices over short periods associated with use of format A. |
| Static Nash equilibrium (appendix B.1) | Decreasing in $\mu$ and in $\lambda$, no difference across information treatments. | Decreasing in $\mu$, increasing in $\lambda$, no difference across information treatments. | No correlation in price and format use across period | No correlation in price and format use across period. |
| Myopic best response (appendix B.2) | Decreasing in $\mu$ and in $\lambda$, no difference across information treatments. | Increasing in $\mu$ and in $\lambda$, no difference across information treatments. | Large consecutive increases in prices over short periods associated with use of idiosyncratic format. | Small consecutive decreases in prices over long periods associated with use of format A. |
| Imitation of the best (appendix B.3) | Same irrespective of $\mu$ and $\lambda$, does not apply to treatments with limited information | Same irrespective of $\mu$ and $\lambda$, does not apply to treatments with limited information. | Consecutive increases in prices associated with use of idiosyncratic format. Increases of same magnitude and over same time length as decreases. | Consecutive decreases in prices associated with use of format A. |
| Adaptive reinforcement learning (appendix B.4) | Decreasing in $\mu$, decreasing and then increasing in $\lambda$, no difference across information treatments. | Decreasing in $\mu$, increasing in $\lambda$, no difference across information treatments. | No correlation in price and format use across period. | No correlation in price and format use across period. |

Conversely, a firm that breaks cooperation and lowers its prices will want to adopt common format $A$, as this allows it to more easily attract the savvy consumers of firm $A$. We therefore expect high prices to be associated with the use of idiosyncratic formats, and breaks from cooperation to be associated with the use of the common format $A$. Breaks will be followed by periods of intense competition involving the use of common formats and low prices.

Those considerations lead us to express Hypothesis 3:

**Hypothesis 3.** *Cooperation will be marked by small consecutive increases in prices and the use of different formats. Breakdowns in cooperation will be marked by large consecutive decreases in prices and the use of common formats.*

If cooperation is a factor, then the dynamics of price will thus look like *reverse* Edgeworth cycles. Prices will *rise* like feathers and *drop* like rockets (Maskin & Tirole, 1988; Tappata, 2009). This hypothesis is to be contrasted with what would be observed if firms followed myopic best-response dynamics. Those dynamics are Edgeworth cycles, with rapid increases in prices and slow decreases in prices (Online Appendix B.2). As for price dynamics under imitation, they are such that there are no differences in the speed of increases and decreases in prices (Online Appendix B.3). Finally, there should not be any correlation in prices across time if firms employ mixed strategies, as predicted under the static Nash equilibrium of the game or by adaptive reinforcement learning.

Table 1 summarizes the impact of our treatment variables if firms cooperate (first row). We contrast this with alternative hypotheses about the behavior of firms (other rows).

## 4 | EXPERIMENTAL PROCEDURE

We ran our experiment in 2013 at the laboratory of the Max Planck Institute of Economics in Jena, Germany. The experimental sessions lasted about 90 minutes. Participants earned 11.50€ on average (min = 5€, max = 42€). This included a 2.50€ base

**TABLE 2** Treatments

| | | | $\mu$ (Share of Savvy Consumers) | | |
|---|---|---|---|---|---|
| | | | **0%** | **10%** | **20%** |
| **L**imited Information | $\lambda$ (Level of Skepticism) | 10% | $L_0$ | $L_{11}$ | $L_{21}$ |
| | | 20% | | $L_{12}$ | $L_{22}$ |
| **F**ull Information | $\lambda$(Level of Skepticism) | 10% | $F_0$ | $F_{11}$ | $F_{21}$ |
| | | 20% | | $F_{12}$ | $F_{22}$ |

payment for showing up, as well as a payment proportional to individual profit in one randomly selected period of the experiment. The experiment was computerized using the Zurich Toolbox for Ready-made Economic Experiments (z-Tree; Fischbacher, 2007) and participants were recruited using the Online Recruitment System for Economic Experiments (ORSEE; Greiner, 2004). Participants were in their majority German (92%), with the rest coming mainly from Eastern Europe and countries of the former Soviet Union. Fifty-eight percent of our participants were women. Participants were 24 years old on average, with age ranging from 17 to 41. Eighty-one percent of the participants were full-time students, about half of whom studied social sciences.

The experiment was framed as a market game whereby firms could produce different models of the same good model *A*, model *B* or model *C*. Participants had to decide what price $p_i$ to set for their product. Managers of firms *B* and *C* also had to decide whether to produce their own model or produce model *A*. $\upsilon$ was set to five experimental currency units (ECUs) and $e$ was set equal to one ECU. One ECU was worth 0.05€. There were 100 virtual consumers favoring each of firms *A*, *B,* or *C* and making their choices as explained in Section 2. There were thus a total of 300 virtual consumers each buying one unit from one firm every period.

In a *first phase*, participants were assigned to a group with two other players and played the stage game (choice of price and format) over several periods within the same group. When the first groups were dissolved, participants were put into new groups of three (*second phase*), and then in another set of groups of three (*third phase*). Participants never played with the same opponents twice. Participants also changed their role (Firm *A*, *B*, or *C*) across phases. Participants were told that there was a 90% chance that the game would continue with the same group in the next period, and a 10% chance that the group would be dissolved next period. We drew the number of periods in each phase in advance: the first phase lasted 22 periods, the second phase lasted 9 periods, and the third phase lasted 16 periods.

Instructions, control questions and practice scenarios are reported in Online Appendix C. Participants had to correctly answer a set of questions about the procedure before the experiment could continue. They were also given the opportunity to practice setting prices and formats in a variety of different, predefined market situations.

We ran 10 sessions with 30 participants each, for a total of 300 participants. Each session corresponds to one of 10 treatments. Each treatment involved a different combination of $\mu$, $\lambda$ and information condition, as shown in Table 2.

We varied the *share* $\mu$ of *savvy* consumers and their *level* of *skepticism* $\lambda$ across treatments. The baseline treatment is a market with no savvy consumers ($\mu = 0$). In this baseline treatment, participants could change the format of their product but were told that consumers did not care about formats. Other combinations with $\mu = 10\%$ or $\mu = 20\%$ and $\lambda = 10\%$ or $\lambda = 20\%$ were considered in other treatments. Our choice of parameter values corresponds to markets in which many consumers are set in their ways (low $\mu$) and are not very sensitive to the asymmetric dominance effect (low $\lambda$).

We also varied information conditions. There were treatments where firms had *full information* about the prices, formats, sales, and profits of over firms in the past, and treatments where firms had only *limited information*, that is, they knew only their own past sales and profits.

## 5 | TESTING TREATMENT EFFECTS ON PRICES AND ADOPTION OF COMMON FORMAT *A*

This section tests Hypotheses 1 and 2, both of which deal with comparative statics. Experimental findings are summarized in Figure 2, which shows average profit in each treatment and the frequency with which firms *B* and *C* adopted format A. Profit is calculated at the level of the firm for every period of every phase. We have $30 \times (22 + 9 + 16) = 1,410$ observations per treatment.

Table 3 shows the results of bootstrapped linear regressions relating individual profits and format adoption in each period to the values of $\mu$ and $\lambda$, for each information treatment. Parameter estimates and their level of significance are all bootstrapped with stratification at both the individual and group level.

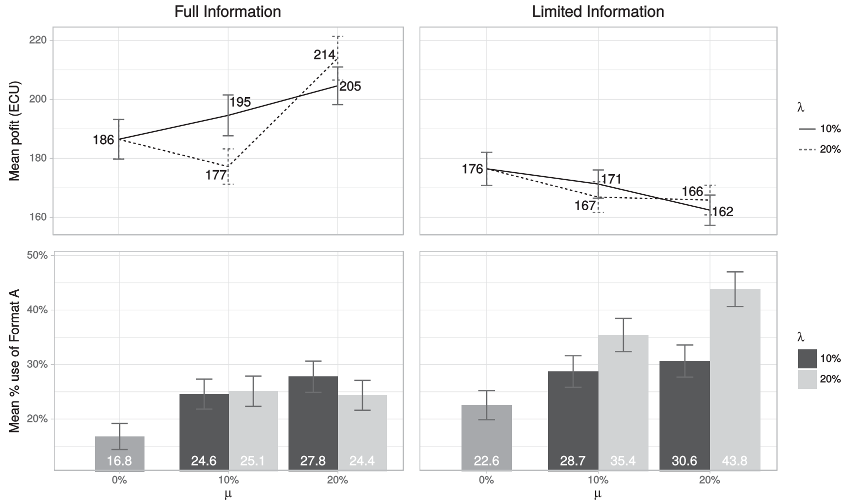


**FIGURE 2** Individual profit per period and frequency of adoption of format A. Mean and 95% confidence interval, $N = 1,410$ per treatment for profits, $N = 940$ per treatment for format adoption

**TABLE 3** Linear and logistic regressions for profit and adoption of format A, by information treatment

| | Profits | | Format A | | Format A (Marginal Effect) | |
|---|---|---|---|---|---|---|
| | Limited Info | Full Info | Limited Info | Full Info | Limited Info | Full Info |
| $\mu = 10\%$ | −7.13* | 1.44 | 0.25** | 0.53*** | 0.05** | 0.10*** |
| | [−13.45,−0.82] | [−6.42,9.30] | [0.10,0.40] | [0.37,0.69] | [0.02,0.09] | [0.07,0.12] |
| $\mu = 20\%$ | −12.06*** | 24.81*** | 0.48*** | 0.59*** | 0.10*** | 0.11*** |
| | [−18.31,−5.81] | [17.47,32.16] | [0.33,0.64] | [0.45,0.74] | [0.07,0.14] | [0.08,0.13] |
| $\lambda = 20\%$ | −0.50 | −4.01 | 0.44*** | −0.08 | 0.09*** | −0.01 |
| | [−4.93,3.92] | [−9.56,1.55] | [0.33,0.55] | [−0.20,0.05] | [0.07,0.12] | [−0.04,0.01] |
| Constant | 176.45*** | 186.45*** | −1.23*** | −1.60*** | | |
| | [171.38,181.53] | [180.73,192.17] | [−1.35,−1.12] | [−1.71,−1.49] | | |
| $\mu = 20\%$ vs. $\mu = 10\%$ | −4.93+ | 23.36*** | 0.23*** | 0.06 | 0.05*** | 0.01 |
| | [−10.36,0.50] | [16.63,30.11] | [0.10,0.36] | [−0.08,0.21] | [0.02,0.08] | [−0.02,0.04] |
| N observations | 7050.00 | 7050.00 | 4700.00 | 4700.00 | | |
| Log-likelihood | −42379.69 | −44230.97 | −2901.87 | −2557.64 | | |
| $\chi^2$ | 18.08*** | 90.78*** | 168.64*** | 68.15*** | | |

*Note*: Base categories: $\mu = 0\%$, $\lambda = 10\%$.
Bootstrapped estimations, 1,000 repetitions, stratified by group and participants.
$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. 95% confidence intervals in brackets.

## 5.1 | Effect of the share of savvy consumers and of their skepticism

In treatments with full information, average profits when $\mu = 20\%$ were significantly higher than when $\mu = 0\%$ (*+25 ECU*, $p < 1‰$), but average profits when $\mu = 10\%$ were not significantly higher than when $\mu = 0\%$ (*+1 ECU, n.s.*). Common format *A* was used more frequently when $\mu = 10\%$ than when $\mu = 0\%$ (*+10%*, $p < 1‰$), but was not used more frequently in treatments when $\mu = 20\%$ than in treatments when $\mu = 10\%$. Higher $\lambda$ did not affect either profits (*−4 ECU, n.s.*) or choice of format (*−0.01%*, *n.s.*).

In treatments with limited information, average profits was lower in treatments with higher $\mu$ (−7 *ECU* when $\mu = 10\%$, $p < 5\%$; *−12 ECU* when $\mu = 20\%$, $p < 1‰$), but profits were not influenced by the level of $\lambda$ (*−0.5 ECU, n.s.*). Common format *A* was used more frequently in treatments with higher $\mu$ (*+5%* when $\mu = 10\%$, $p < 1‰$; *+10%* when $\mu = 20\%$, $p < 1‰$), as well as in treatments with higher $\lambda$ (*+9%* when $\lambda = 20\%$, $p < 1‰$).

We summarize our findings into Result 1:

**Result 1.** *In treatments with full information, profits were higher when there was a sufficient number of savvy consumers* ($\mu = 20\%$). *In treatments with limited information, profits were lower in treatments with more savvy consumers.*

The effect of an increase in $\mu$ in treatments with full information supports Hypothesis 1, but that hypothesis is not supported in treatments with limited information. We can put this finding in relation with Hypothesis 2 whereby cooperation will occur less frequently in treatments with limited information. The frequency of cooperation increased sufficiently fast with $\mu$ and $\lambda$ in treatments with full information to translate into increasing overall profits. In treatments with limited information however, profits decreased with $\mu$. Firms competed harder when there were more savvy consumers. This is not consistent with Hypothesis 1 but rather consistent with alternative hypotheses. In particular, the more frequent use of common format A in treatments with higher $\mu$ and $\lambda$ is consistent with best-response dynamics (a variety of which allows for imperfect information about the behavior of others, see Online Appendix B.2).

We check our results for robustness by considering only the third phase of the experiment. In that phase, all participants are experienced. We also consider statistics on group profits rather than profits of individual firms.

Figure A1 and Table A1 in Appendix A show results for the third phase, in which participants were more experienced. We confirm that treatments with $\mu = 20\%$ generated higher profits in treatments with full information. Firms are also less likely to use common format *A* in treatments with $\mu = 20\%$, which is consistent with the use of idiosyncratic formats under cooperation. Profits did not vary significantly with $\mu$ in treatments with limited information.

Figure A2 and Table A2 in Appendix A show group statistics, that is, average profits made in each of our experimental markets (30 observations per treatment). We confirm that profits are higher in treatments with higher $\mu$ and full information. Profits do not vary significantly with $\mu$ in treatments with limited information.

## 5.2 | Effect of the information treatments

The effect of information treatments on profits supports the cooperation hypothesis. We indeed find that profits were significantly lower in treatments with *limited information* than in treatments with *full information* (−27 ECU, $p < 1‰$, individual profits, *t*-test bootstrapped at the individual and group level). Use of common format *A* was also more frequent in treatments with limited information (+9%, $p < 1‰$, Wald test bootstrapped at the individual and group level). Those results are robust when considering group statistics or only Phase 3 of the experiment. This allows us to express Result 2, which supports Hypothesis 2:

**Result 2.** *Profits were higher and choice of common format* A *less frequent in treatments with full information than in treatments with limited information.*

We also find that average profits in the full information treatments were higher than predicted by types of behavior other than cooperation (cf. Appendix B). This finding supports the hypothesis that participants were able to maintain cooperation in the full information treatment. Indeed, with reference to Holt (1995, p. 392), "tacit collusion"—that is, cooperation—is identified by prices that "exceed the levels determined by static non-cooperative equilibria in the market-period stage games," in situations "when subjects are not permitted to communicate directly."

# 6 | DYNAMICS OF PRICES AND OF THE CHOICE OF FORMATS

This part tests Hypothesis 3, which deals with the dynamics of prices and of the choice of formats. Online Appendix D shows the evolution of prices and of the frequency of adoption of common format *A* over time, for each 10 groups of each three phases of each 10 treatments. We identify regularities in the behavior of participants, in particular increases in price that are slower than price decreases, and an association of the use of common format *A* with price decreases, and of the use of idiosyncratic formats with price increases.

## 6.1 | Price dynamics

Figure 3 shows the distribution of the length of phases of increases and decreases in the average price paid by consumers across information treatments. The length of a phase of increases in price is indicated by a positive number, whereas the length of a phase of decreases in prices is indicated by a negative number. For example, a phase of length *0* indicates that a price did not change from one period to the next. A phase of length 1 indicates that the price increased from one period to the next but not afterward sit then dropped or stayed the same. A phase of length −1 indicates that the price decreased from one period to the next but not afterwards.

The average length of a phase was 0.55 under full information and 0.40 under limited information. Both numbers are significantly different from 0 (*t*-test, $p < 1‰$, bootstrapped standard errors). This finding indicates that the distribution of phase

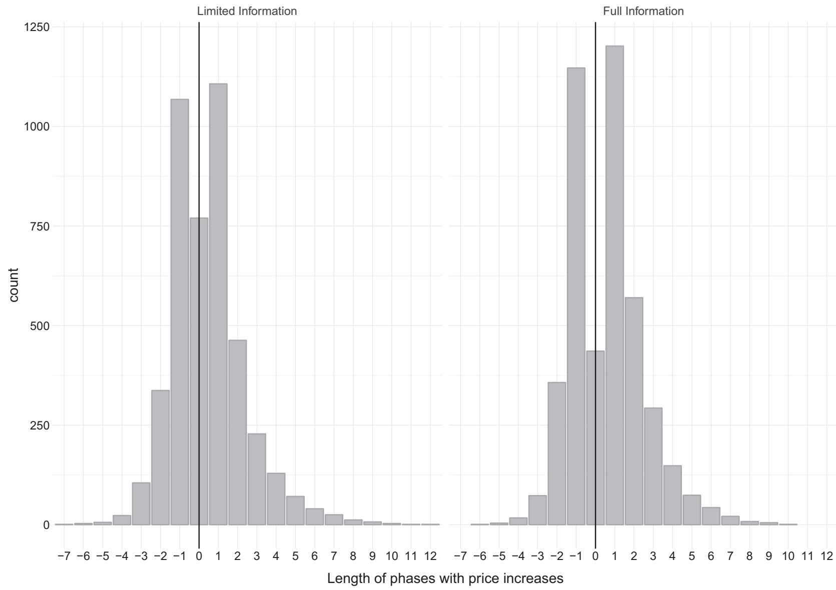


**FIGURE 3** Distribution of the length of phases of increases and decreases in prices

**TABLE 4** Average magnitude and frequency of change in prices, by direction of change (Firms B and C)

| | | Price Decreases | No Change | Price Increases |
|---|---|---|---|---|
| Limited information | Mean (*SD*) | −0.55 (0.52) | 0 (0) | 0.34 (0.37) |
| | *N* (%) | 1,543 (35%) | 770 (18%) | 2,087 (47%) |
| Full information | Mean (*SD*) | −0.68 (0.64) | 0 (0) | 0.44 (0.41) |
| | *N* (%) | 1,599 (36%) | 436 (10%) | 2,365 (54%) |

length was skewed to the right. This means that phases of increases in prices lasted longer than phases of decreases in prices in both information treatments. The length of phases of increases and of decreases in prices was on average longer under full information than under limited information. This difference in the distributions of phase length between information treatments is significant (Kolmogorov–Smirnov test, $p < 1‰$) as is the difference in average phase length (*t*-test, $p < 1‰$, bootstrapped standard errors).[6] This leads us to Result 3 in support of Hypothesis 3:

**Result 3.** *Phases with increases in prices lasted longer than phases of decreases in prices. This was particularly so in treatments with full information.*

We now consider by how much prices increased when prices increased, and by how much they decreased when they decreased (Table 4).

Table 4 shows that price increases were more frequent than price decreases in both information treatments (47% of periods displayed price increases vs. 35% price decreases under limited information, 54% vs. 36% under full information, differences $p < 1‰$, b.s.e.). We also find that price decreases were larger on average than price increases in both information treatments ($p < 1‰$, b.s.e.).[7] Those findings are consistent with our observation that phases of increases in prices lasted longer than phases of decreases in prices. This leads us to Result 4, also in support of Hypothesis 3:

**Result 4.** *Increases in prices were more frequent and smaller in magnitude than declines in prices.*

Those two findings are not consistent with myopic best-response strategies, whereby gradual price decreases are followed by abrupt increases in prices. They are not consistent either with imitation strategies, whereby phases of increases in prices would be of the same length and with the same step size as phases of decreases in prices. They are, however, consistent with cooperation, whereby firms build trust by slowly increasing prices, until one or more firms decide to undercut others, which prompts quick retaliation by other firms who also lower prices.

**TABLE 5** Average magnitude and frequency of change in prices, by choice of format (Firms B and C)

| | | Δprice | |
|---|---|---|---|
| | | Own Format | Format A |
| Limited information | Mean (*SD*) | 0.05 (0.53) | −0.21 (0.61) |
| | *N* (%) | 2,999 (68%) | 1,401 (32%) |
| Full information | Mean (*SD*) | 0.09 (0.65) | −0.33 (0.79) |
| | *N* (%) | 3,335 (76%) | 1,045 (24%) |

## 6.2 | Choice of format over time

We finally consider the association between choice of format and price changes. Table 5 shows average price change under one's own idiosyncratic format and under common format A.

We find that price changes were on average positive when a firm used idiosyncratic formats, whereas they were negative when a firm used common format *A*. All means in the table are significantly different from 0 ($t$-tests, $p < 1‰$, bootstrapped standard errors). We also find that price decreased by more on average under common format *A* than they increased under idiosyncratic formats.[8]

If we now consider how changes in formats were associated with changes in price (statistics not shown), we find that switching to a common format was associated with price decreases. Switching to an idiosyncratic format, on the other hand, was associated with price increases. Differences in the distribution of price changes when switching to common format A and when switching to ones own idiosyncratic formats are significant according to Kolmogorov–Smirnov tests for differences in distributions and t-tests for differences in means ($p$-values $< 1‰$).

This leads us to Result 5, which completes the verification of Hypothesis 3:

**Result 5.** *Use of idiosyncratic formats was associated with small increases in prices, whereas use of common format A was associated with large declines in prices.*

This finding suggests that firms adopted idiosyncratic formats when increasing prices so as to soften competition. They adopted common format *A* when initiating or following decreases in prices. This pattern is consistent with strategies sustaining cooperation. It is not consistent with the hypothesis that participants adopted best responses. Indeed, myopic best-response dynamics imply an association between infrequent and large increases in price under ones own idiosyncratic format, and frequent small decreases in prices under common format *A*. This pattern does not fit with imitation strategies either, as those imply equally frequent upward or downward changes in price in steps of equal size. Overall, this pattern is consistent with the establishment of cooperation, whereby progressive increases in prices are facilitated by the use of idiosyncratic format. Breakdowns in cooperation are associated with the use of common format *A* and large decreases in prices.

# 7 | CONCLUSION

We analyzed competition in an experimental market. Firms chose how to present their product (their "format") in addition to their price. The way they presented their product could make it either hard or easy for consumers to compare their product with the competition.

We found that firms cooperated if they could observe the prices and formats chosen by other firms in previous periods. Cooperation was such that firms maintained different formats so as to avoid challenging other firms on price. Artificial differentiation in the way to present products allowed them to maintain high prices. Cooperation was maintained with the threat to retaliate quickly if any firm chose to make its offers comparable with others. Retaliation took the form of low prices and helping consumers compare products in the market. Firms used this threat to sustain cooperation. Rather counter-intuitively, firms were especially likely to maintain such artificial differentiation in markets where many consumers would actually be indifferent between competing products if they were all presented the same way. This is because the threat of competition without artificial differentiation is then all the more powerful.

We also found that prices remained low, and firms were more likely to adopt common ways to present their product, if they could not observe the prices and formats used by other firms in previous periods. In that case, an increase in the number of savvy consumers—who are indifferent between competing products if they are presented the same way—led to lower prices and less use of artificial product differentiation.

This experiment shows that firms can sustain high prices even when their products are actually very similar. Firms do this by presenting their products in different ways. They choose different ways to market their product, different distribution channels, different pricing schemes, different marketing message, etc. Price competition is discouraged, and consumers remain confused.

Our findings provide a potential explanation for how Coca-Cola and Pepsi are able to maintain profits. Those two firms have been able to maintain a high degree of perceived differentiation and have avoided downward spirals in the price of their concentrate. This is especially noteworthy as both firms sell essentially the same product. They are so much alike indeed that most people cannot identify which is which when tasting them blindfolded. Both firms avoid competition most of the time by focusing on different consumers, sponsoring different sports, differentiating their logos, choosing different colors for their packaging, and building different images for their brand. They devote most of their efforts to maintaining the illusion of a difference between their two products. This type of cooperation has been interrupted however by short periods of intense competition. In those periods, one firm—most of the time Pepsi—challenged the other by asserting superiority on one specific aspect of their products. This led to direct competition and changes in market shares or in prices. For example, Pepsi marketed bigger bottles for the same price as Coca-Cola during the Great Depression in the 1930s. Pepsi advertised a better taste during the Cola Wars, with the Pepsi Challenge in the 1970s. The memory of such periods of frontal competition may help both firms maintain the more profitable status quo. Both firms prefer not to compete on real product differences, such as price or taste, because this offers only short-term opportunities for additional profit.

We showed that artificial product differentiation and high prices were more likely to be maintained if firms could observe the strategies chosen by other firms. From the point of view of consumer welfare, therefore, one would want to prevent firms from observing the prices and formats chosen by other firms. This would prevent them from establishing cooperation. However, this is difficult in consumer markets. Indeed, sales are often handled by intermediaries in such markets, and there is therefore generally no one-to-one negotiation of the terms of trade with the end-consumer. This makes it easy for competing firms to check that other firms are not helping consumers compare products. Firms are therefore discouraged from making their product comparable with others or otherwise help consumers compare products, as this would be noticed very fast and retaliated against.

Other types of procompetitive policies are therefore needed. This involves promoting the use of common ways to present products. This goes along with promoting more precise specifications of how products should be described and presented. Better labeling for consumer goods would also help (Agnew, 1934). Such policies are already implemented in some markets for some aspects of product information. For example, unit price information is generally available or even mandated in supermarkets. There is also some standardization in banking, whereby lending rates must be presented in terms of annual percentage rate of charge. Much progress still needs to be made to elaborate common ways to measure the performance and prices of competing products. It is best to limit the promotion of such standards for industries where products already have well-understood and stable characteristics. Those are markets where innovations in marketing, pricing schemes and ways to present products are unlikely to be of much use to the consumer. Firms should remain otherwise free to develop different ways to present their products when there is no clear best way to do so.

## ENDNOTES

[1] The practice and ethics of "confusion marketing" is also a topic in the marketing literature (Kasabov, 2015). Some marketers have called for greater simplicity in offerings (Cristol & Sealey, 2000; Spenner & Freeman, 2012).

[2] Suppose for example that a product is worth $v$ to consumers and that the alternative is worth $w < v$. You can sell that product at price $v - w$ and make profit $v - w$. Or you can encourage mistakes in the evaluation by consumers such that half of them think it is worth $v + e$ and another half think it is worth $v - e$. By setting your price equal to $v - w + e$, you make profit $^{(v-w+e)}/_{2}$. This is more than $v - w$ if $v - w \leq e$.

[3] We call those consumers naive in this paper, but those consumers may actually be the ones who are the most sensitive to differences between products. For example, they may be the ones who can actually tell the difference between a Pepsi and a Coca-Cola even when those are presented in neutral containers. By contrast, savvy consumers may be the ones who do not taste the difference. They buy one product rather than the other only when differences in marketing lead them to believe that they are different. The way we label consumers does not therefore imply a value judgment: both savvy and naive consumers are not perfectly rational.

[4] We force firm $A$ to keep format $A$ in order to avoid cycles of mutual imitation. This guarantees to firm $B$ that adopting format $A$ will make its product fully comparable with that of firm $A$.

[5] If consumers are indifferent between firm $A$ or firm $B$, then we assume they divide equally between firms.

[6] Differences across treatments with different levels of $\mu$ and $\lambda$ are not significant.

[7] Differences across treatments with different levels of $\mu$ and $\lambda$ are not significant.

[8] Statistics in treatments with $\mu = 0\%$ have significantly lower absolute value than in other treatments. Differences across other treatments are not significant.

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## SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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## APPENDIX A: ADDITIONAL STATISTICS AND REGRESSIONS

### A.1 Last phase

In Figure A1, profit is calculated at the firm level for every period of the last phase, resulting in $30 \times 16 = 480$ observations per treatment.

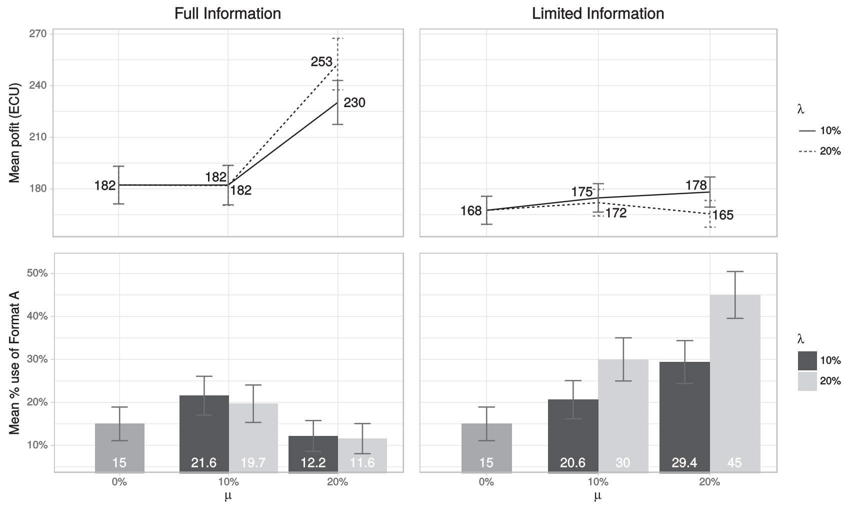


**FIGURE A1** Individual profit per period and frequency of adoption of format A, in the third phase. Mean and 95% confidence interval, $N = 480$ per treatment for profits, $N = 320$ per treatment for format adoption

**TABLE A1** Linear and logistic regressions for profit and format A adoption, phase 3, by information treatment

| | Profits | | Format A | | Format (Marginal Effect) | |
|---|---|---|---|---|---|---|
| | Limited Info | Full Info | Limited Info | Full Info | Limited Info | Full Info |
| $\mu = 10\%$ | 9.68* | −5.64 | 0.33* | 0.43** | 0.06* | 0.06** |
| | [0.33,19.04] | [−19.10,7.82] | [0.05,0.61] | [0.14,0.72] | [0.01,0.12] | [0.02,0.10] |
| $\mu = 20\%$ | 8.13+ | 53.65*** | 0.90*** | −0.22 | 0.17*** | −0.03 |
| | [−1.30,17.56] | [40.38,66.91] | [0.61,1.19] | [−0.52,0.07] | [0.12,0.22] | [−0.07,0.01] |
| $\lambda = 20\%$ | −7.73* | 11.03* | 0.60*** | −0.09 | 0.11*** | −0.01 |
| | [−14.59,−0.88] | [0.26,21.80] | [0.41,0.78] | [−0.35,0.16] | [0.08,0.15] | [−0.05,0.02] |
| Constant | 167.55*** | 182.21*** | −1.73*** | −1.73*** | | |
| | [160.38,174.72] | [172.55,191.87] | [−1.97,−1.50] | [−1.92,−1.55] | | |
| $\mu = 20\%$ vs. $\mu = 10\%$ | −1.55 | 59.28*** | 0.57*** | −0.66*** | 0.12*** | −0.09*** |
| | [−9.83,6.72] | [46.72,71.85] | [0.35,0.79] | [−1.00,−0.31] | [0.07,0.16] | [−0.13,−0.05] |
| N observations | 2400 | 2400 | 1600 | 1600 | | |
| Log-likelihood | −14232.91 | −15246.54 | −907.81 | −694.04 | | |
| $\chi^2$ | 6.60+ | 146.44*** | 136.43*** | 22.50*** | | |

*Note*: Base categories: $\mu = 0\%$, $\lambda = 10\%$

Bootstrapped estimations, 1,000 repetitions, stratified by group and subjects

$^+p < 0.10$, $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. 95% confidence intervals in brackets.

### A.2 Group statistics

In Figure A2, profit is calculated at the group level, resulting in 30 observations per treatment.

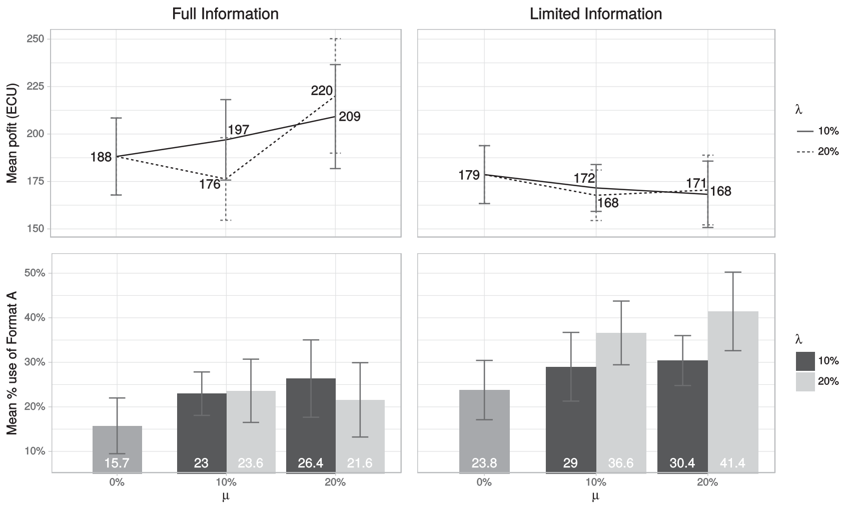


**FIGURE A2** Group profit and frequency of adoption of format A. Mean and 95% confidence interval, $N = 30$ per treatment for profits and for format adoption

**TABLE A2** Linear regressions, group profit and format A adoption, by information treatment

| | Profits | | Format A | |
|---|---|---|---|---|
| | Limited Info | Full Info | Limited Info | Full Info |
| $\mu = 10\%$ | −8.56 | 0.90 | 0.04 | 0.09* |
| | [−27.96,10.84] | [−28.27,30.07] | [−0.05,0.14] | [0.01,0.16] |
| $\mu = 20\%$ | −8.85 | 28.91+ | 0.07+ | 0.09+ |
| | [−30.09,12.40] | [−2.13,59.95] | [−0.01,0.16] | [−0.01,0.19] |
| $\lambda = 20\%$ | −0.79 | −4.86 | 0.09* | −0.02 |
| | [−16.25,14.68] | [−29.89,20.17] | [0.02,0.17] | [−0.09,0.05] |
| Constant | 178.62*** | 188.16*** | 0.24*** | 0.16*** |
| | [162.92,194.32] | [166.88,209.43] | [0.17,0.30] | [0.10,0.22] |
| $\mu = 20\%$ vs. $\mu = 10\%$ | −0.28 | 28.01+ | 0.03 | 0.01 |
| | [−18.76,18.20] | [−4.06,60.08] | [−0.06,0.12] | [−0.08,0.10] |
| N observations | 150.00 | 150.00 | 150.00 | 150.00 |
| Log-likelihood | −775.89 | −844.88 | 28.69 | 30.16 |
| $\chi^2$ | 1.04 | 5.23 | 13.38** | 4.94 |

*Note*: Base categories: $\mu = 0\%$, $\lambda = 10\%$
Bootstrapped estimations, 1,000 repetitions, 95% confidence intervals in brackets.
$^+p < 0.10$, $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

## APPENDIX B: MODELS OF COMPETITIVE BEHAVIOR

### B.1 Nash equilibrium

Figure B1 shows the best response function ("BRF") of firm $B$ in a duopoly as a function of the level of the price of firm $A$. There are two dimensions to the choices by firm $B$, $format_B$, the choice of format, and $p_B$, the price chosen. We assume $\mu = 40\%$.

For low prices of firm $A$ then firm $B$ chooses to target naive consumers by setting price $p_A + e-$¢ (with ¢ the smallest allowable price unit, 0.01 ECU in the experiment), and sets its own idiosyncratic format $B$. It then sell to mass 1 of consumers. For medium prices of firm $A$ then firm $B$ chooses to target savvy consumers of firm $A$ by adopting format $A$ and pricing at $p_A-$¢.

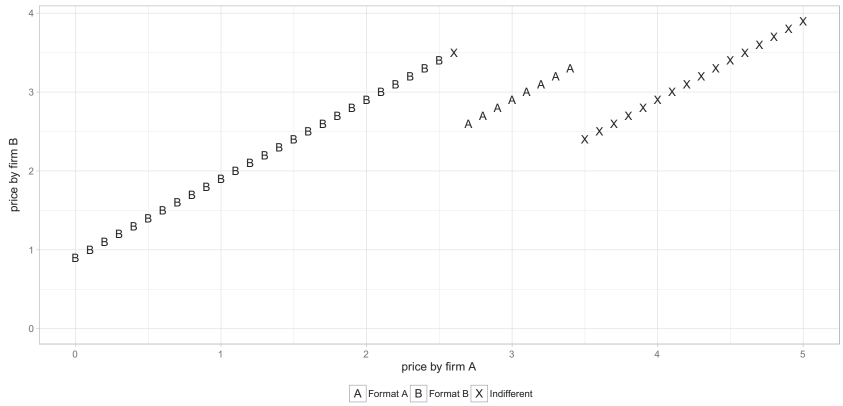


**FIGURE B1** Best response function of firm $B$ in a duopoly

It then sells to mass $1 + \mu$ of consumers. Finally, for high prices of firm $A$ then firm $B$ takes all demand from the market by setting price $p_A - e-$ ¢ and selling to mass 2 of consumers. In this case, it is indifferent between setting format $A$ or $B$ because both naive and savvy consumers buy from it anyway.

The BRF of firm $A$ can be drawn as well and depends on whether firm $B$ chose format $A$ or format $B$.

From an examination of those best response functions, we can show that there is no Nash equilibrium in pure strategies. Suppose indeed that an equilibrium exists with price $p_A$ set by firm $A$. Then firm $B$ either sets price $p_B = p_A + e-$ ¢ under its own format, or price $p_B = p_A-$ ¢ under format $A$, or price $p_B = p_A - e-$ ¢, where the choice of format is indifferent. The best response by firm $A$ to such prices by $B$ is either to undercut $B$ by $e +$ ¢ or by $e +$ ¢ or to increase prices by $e-$ ¢. The best response by firm $A$ to the best response by firm $B$ to a given price $p_A$ of firm $A$ is therefore never $p_A$. This implies that Nash equilibria are in mixed strategies.

The best response function of firms are very similar in the triopoly. We used Gambit, a software tool for game theory (McKelvey, McLennan, & Turocy, 2014), to find the distribution of prices in Nash equilibria in the triopoly (Figure B2).

We see that firms set prices in a range from 0.2 to 2.7 ECU and prices when they choose format $A$ are generally lower than prices without a common format—setting a common format is thus anologous to having sales in Varian (1980). The distribution of prices moves to the left (lower prices) as $\mu$ increases.

Table B1 gives us expected profits in each treatment as well as the frequency with which format $A$ is chosen by firms $B$ and $C$. $\mu$ and $\lambda$ in the table cover a range of conditions. $\lambda = 0$ indicates that savvy consumers adopt dominance editing and $\lambda = 100$ guarantees that savvy consumer never choose firms that adopt idiosyncratic formats. Higher $\mu$ and $\lambda$ decrease profits. Higher $\lambda$ encourages the use of format A, whereas higher $\mu$ discourages it.

To summarize, if firms play Nash, then profits are lower with higher $\mu$ and $\lambda$, and use of format A decreases with higher $\mu$ and increases with higher $\lambda$. Prices when a firm adopt format $A$ are lower on average than when it adopts its own format. Prices and format do not depend on decisions of others or of oneself last period. There is no prolonged trends in prices over time, and changes in prices are not correlated with changes in formats.

### B.2 Myopic best response dynamics

Suppose that firms best respond to the strategies other firms adopted last period (Fonseca & Normann, 2013; Fudenberg & Kreps, 1993; Matsui, 1992; Mäs & Nax, 2016). If there is no differentiation ($e = 0$), then firms lower prices until prices equal zero. If $e > 0$ however, then prices do not converge to zero as a firm can always set its price at the level of the minimum price in the market *plus* differentiation parameter $e$. It then sells to consumers of its own type only but makes positive profits. There is then a constant cycle of price wars leading to low prices, which are followed by abrupt unilateral increases in prices. Prices rise like a rocket but fall like feathers (Tappata, 2009), as happens in Edgeworth price cycles (Doyle, Muehlegger, & Samphantharak, 2010; Fonseca & Normann, 2013; Kruse, Rassenti, Reynolds, & Smith, 1994; Maskin & Tirole, 1988; Noel, 2015, 2008). Figure B3 shows an example of such best response dynamics in the triopoly when $\mu = 50\%$ and $\lambda = 20\%$.

We see that if prices are high, then firms adopt format $A$ and undercut each other by small amounts ¢. Those downward price spirals are broken when a firm decides to raise its price by a large amount, adopt its own format and focus on its own customer types. This is followed by other firms until prices reach such a high level that it is again more profitable to adopt format $A$ and undercut other firms, thus completing the cycle.

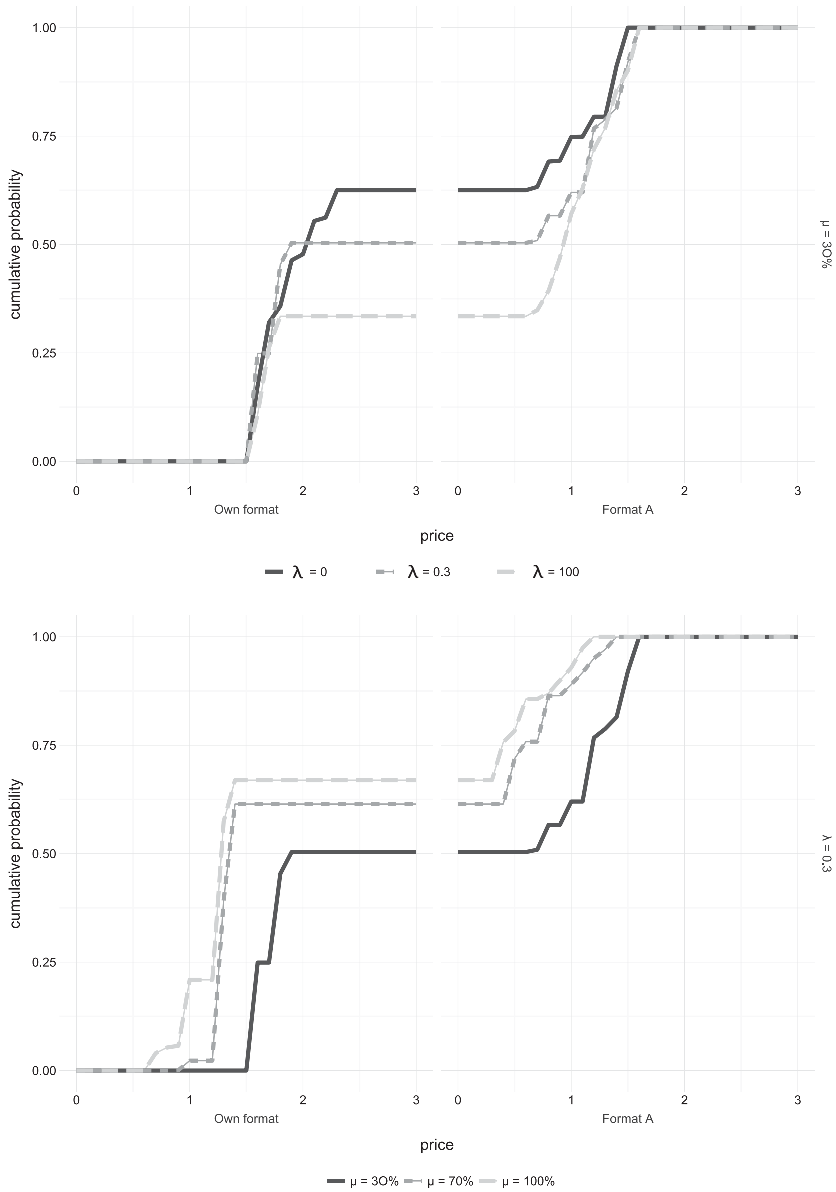


**FIGURE B2** Cumulative probability distribution function of prices under mixed strategies. We show both the cdf of prices when a firm chooses not to adopt format A, starting from the origin, and the cdf of prices when a firm chooses to adopt format A, starting from the probability that the firm does not adopt format A. The maximum value of the first cdf is therefore the cumulative probability that the firm does not adopt format A

**TABLE B1** Profits and choice of common formats in MSNE

| *Average Profits (in ECU)* | | | | | | *Adoption of Format A (firms B and C)* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $\mu$ | | | | | | $\mu$ | | | |
| | | **0%** | **30%** | **70%** | **100%** | | | **0%** | **30%** | **70%** | **100%** |
| | 0 | | 149 | 131 | 131 | | 0 | | 37% | 26% | 18% |
| $\lambda$ | 0.3 | 161 | 146 | 102 | 91 | $\lambda$ | 0.3 | indifferent | 50% | 39% | 33% |
| | 100 | | 124 | 84 | 57 | | 100 | | 67% | 48% | 43% |

Simulations were performed to obtain the average profits in each treatment if firms follow myopic best response, as well as the frequency with which firms $B$ and $C$ adopt format $A$. Results are shown in Table B2. The code for the simulations of best response dynamics, performed in R, is available at http://github.com/alescia/CS2-Simulations/blob/master/simulations.R. Firms take turn to revise their strategies according to a random process (Blume, 1995) and starting prices are randomized as well.

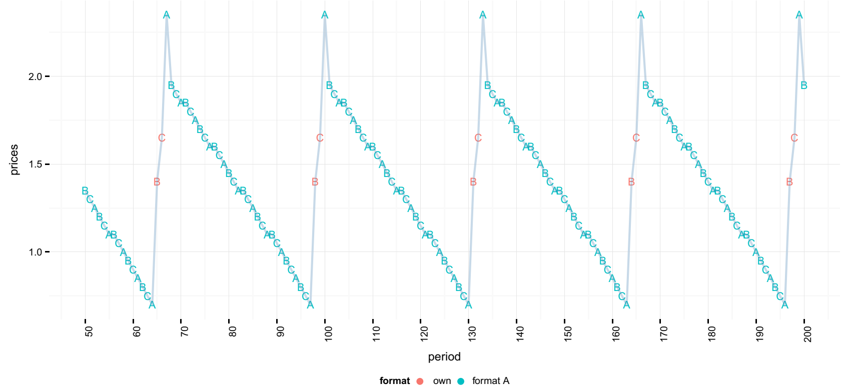


**FIGURE B3** Simulated evolution of prices and choice of format in the triopoly under myopic best response dynamics when $\mu = 50\%$ and $\lambda = 20\%$. The figure shows the price and format chosen by each firm over time. Firms are indicated by their letter, colors indicate the format chosen (blue means the firm chose format A, red means the firm chose its own format) [Color figure can be viewed at wileyonlinelibrary.com]

**TABLE B2** Results of the myopic best response simulations

| *Average Profits (in ECU)* | | | | | | *Adoption of Format A (firms B and C)* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $\mu$ | | | | | | $\mu$ | | | |
| | | 0% | 30% | 70% | 100% | | | 0% | 30% | 70% | 100% |
| | 0 | | 144 | 138 | 113 | | | | 31% | 43% | 50% |
| $\lambda$ | 0.3 | 166 | 142 | 110 | 91 | $\lambda$ | 0.3 | indifferent | 55% | 72% | 73% |
| | 100 | | 122 | 80 | 10 | | 100 | | 78% | 87% | 100% |

*Note*: We assume that firms adopt their own format or format A at random if indifferent. Prices are changed in increments of 0.1 ECU.

We find that higher $\mu$ and $\lambda$ decrease profits. Both higher $\mu$ and higher $\lambda$ encourage the use of format $A$. Prices are on average higher in periods with no common format.

To summarize, *if firms follow myopic best response dynamics*, both higher $\mu$ and $\lambda$ decrease profits and promote the use of format $A$. Prices when a firm adopts format $A$ are lower on average than when it adopts its own format. Increases in prices occur over short periods of time with big increments, whereas declines in prices occur over longer periods of time with small increments. Finally, increases in prices are associated with the use of own formats, and decreases in prices are associated with use of format $A$.

This analysis can be extended by assuming that firms do not adapt their prices and format immediately, but rather do so slowly and generally "in the right direction." They raise their price if the best response to last period's play called for a higher price than last period, and they change format with some probability if the best response called for it (Zusai, 2013). Formally, if $A_{it} = (p_{it}, ft_{it})$ was the strategy of subject $i$ in period $t$ (with $p_{it}$ the price and $ft_{it}$ the choice of format), and $A^*_{it+1} = (p^*_{it+1}, ft^*_{it+1})$ is the best response by $i$ to the strategies adopted by other firms in period $t$, then $A_{it+1}$, the action adopted by $i$ in period $t+1$ is $ft_{it+1} = ft_{it}$ with probability $\phi$ and $ft_{it+1} = ft^*_{it+1}$ with probability $1-\phi$, while price is $p_{it+1} = \gamma \cdot p_{it} + (1-\gamma) \cdot p^*_{it+1}$. Results of simulations with this type of behavior show that the general patterns of myopic best responses are maintained: price increases occur over shorter time spans than price decreases, and the level and influence of $\mu$ and $\lambda$ on profits and use of format $A$ do not vary with $\phi$ and $\gamma$.

### B.3 Imitation dynamics

Imitation is an alternative way for participants in the experiment to play the game (Alós-Ferrer, Ania, & Schenk, 2000; Apesteguia, Huck, & Oechssler, 2007; Huck, Normann, & Oechssler, 1999; Offerman, Potters, & Sonnemans, 2002; Selten & Apesteguia, 2005). Consider the outcome of an "imitate the best" dynamic, whereby firms imitate the firm that made the highest profit last period. An equilibrium of this imitation dynamics, if it exists, has to be such that all firms make the same profit—otherwise, the low-earning firms imitate the better performing firm. This equilibrium is robust only if any small change in the decision by any one firm (an "experimentation") leads that firm to earn lower profits than other firms.

We prove first that there is no robust equilibrium under imitation dynamics and we then characterize the dynamics of price and format adoption under imitation.

### B.3.1 No robust equilibrium

Assume $\mu > 0$ and consider a candidate equilibrium with prices $P = (p_A, p_B, p_C)$.

Suppose there is no common format, $F = (A, B, C)$ (firm A adopts format A, other firms do not). In this case, equal profits means that $p_A = p_B = p_C$. This equilibrium is not robust to an arbitrarily small $\epsilon$ increase in price by one firm, for example firm B, such that $P' = (p_A, p_B + \epsilon, p_C)$. Indeed, firm B now makes higher profits than others and is therefore imitated. If such a defection occurs, firms A and C imitate firm B, overall prices increase and there is no common format.

Suppose now that $F = (A, A, C)$.

- If $p_A = p_B$ then one of the two firms A or B may experiment with a decrease in its price by $\epsilon$ and gain higher profit than the other by attracting its savvy consumers. This will be then imitated by others.
- If $p_A > p_B$ then we have two possibilities,
  - Firm B sells to all savvy consumers, in which case we must have $p_B \cdot (1 + 2\mu) = p_A \cdot (1 - \mu) = p_C \cdot (1 - \mu)$ (equality of profits). This equilibrium is not robust to an experimentation by firm B such that it increases it price by arbitrarily small $\epsilon$ and make profit $(p_B + \epsilon) \cdot (1 + 2\mu)$. If such a defection occurs indeed, firm C imitates firm B by adopting the new higher price of firm B and also adopts the format adopted by firm B (format A). Firm A also adopts the new price of firm B.
  - Firm B sells only to savvy consumers of firm A, in which case we must have $p_B \cdot (1 + \mu) = p_A \cdot (1 - \mu) = p_C$ (equality of profits). As above, firm B may increase its price by $\epsilon$ and make higher profit, so this equilibrium is not robust to experimentation.
- If $p_A < p_B$, then the same type of reasoning as above holds, i.e. firm A will benefit if it experiments by raising its price by $\epsilon$. Furthermore, firm B may gain by randomly switching to its own format B.

Suppose finally that $F = (A, A, A)$. Again, equal profits means that $p_A = p_B = p_C$. This equilibrium is not robust to an arbitrarily small $\epsilon$ decrease in price by one firm, for example firm B, such that $P' = (p_A, p_B - \epsilon, p_C)$. Indeed, firm B now makes higher profits than others by attracting all savvy consumers and will therefore be imitated. Prices thus decrease and all firms maintain format A.

### B.3.2 Dynamics

From the above, the dynamics of the imitation strategy are as follows:

- If $\mu > 0$, then:

1. Whenever $F = (A, B, C)$, then prices increase and firms maintain their own format.
2. Experimentation in terms of format may however lead one firm, for example firm B, to adopt format A, so that $F = (A, A, C)$. However, $F = (A, A, C)$ cannot lead to stable prices.
   **a)** if $F = (A, A, C)$ and $p_A < p_B$, then firm B may experiment by switching to its own format (so we go back to $F = (A, B, C)$) or by increasing its price—which is imitated by firm C if this leads to higher profits, leading to $F = (A, A, A)$. Finally, firm $A$ may experiment by raising its price (up to $p_B$). This increases its profit and is thus maintained. We are then led to the situation where:
   **b)** $F = (A, A, C)$ and $p_A > p_B$, and then firm B may experiment by increasing its prices (up to $p_A$), in which case firm B is imitated by firm C so $F = (A, A, A)$ in the next period.

   Any situation where $F = (A, A, C)$ or $F = (A, B, A)$ is therefore not robust to experimentation.
3. Finally, if $F = (A, A, A)$ then experimentation leads to price decreases while firms maintain format A. This can be broken however when one firm experiments by switching to its own format. This will raise its profit–and thus be imitated–if prices are low enough.

- If $\mu = 0$, then the choice of format is indifferent and we get the dynamics of the case where $F = (A, B, C)$. Prices gradually increase until they are equal to 5. $p = (5, 5, 5)$ is therefore a stable imitation equilibrium when $\mu = 0$.

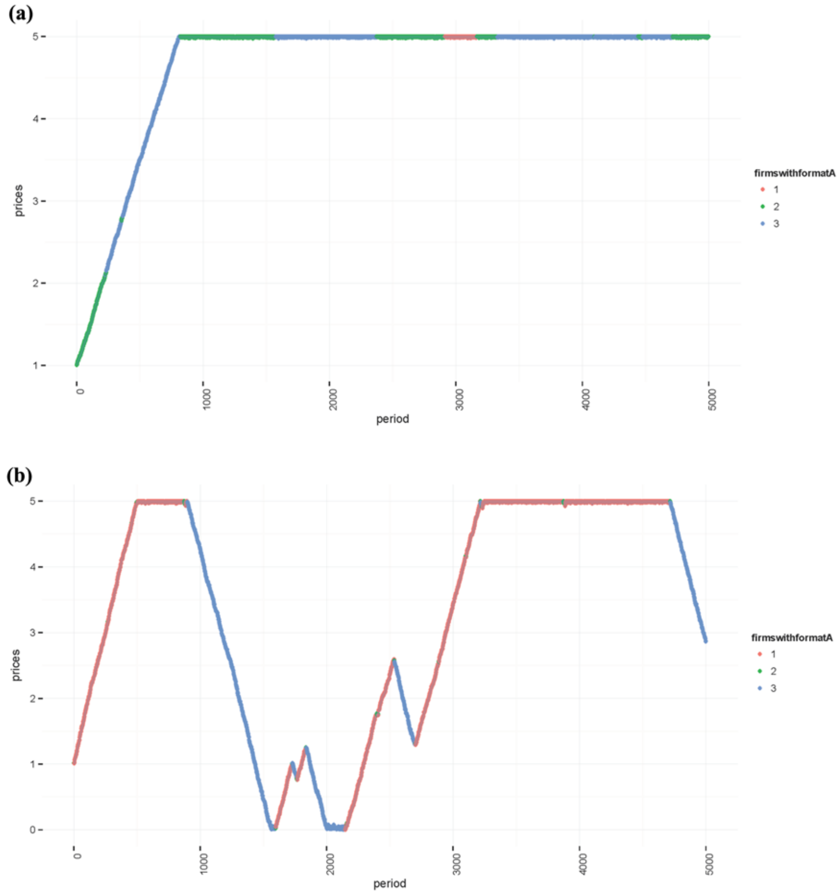


**FIGURE B4** Simulated evolution of prices and number of firms with format A in the triopoly under imitation dynamics. The figure shows the price set by firm A. This is the price set by the firm that obtained the highest profits last period, plus or minus $\epsilon \hookrightarrow U[-0.01, 0.01]$ (experimentation). Firms adopt the format of the most successful firm (other than firm A) each period, otherwise maintain their standard of the preceding period. They additionally randomly switch format with probability 1‰ each period [Color figure can be viewed at wileyonlinelibrary.com]

Figure B4 illustrates the price and format dynamics in the triopoly, whereby firms make small adjustments in prices and formats change with some small probability every period. The code for performing the simulation of imitation dynamics, written in R, is available at http://github.com/alescia/CS2-Simulations/blob/master/simulations_imitation.R

We see that periods with no common format are associated with increases in price but a firm can gain by experimenting with format $A$ and a lower price. If successful, this change in format is imitated. The lowest priced firm then makes the highest profit. Prices thus decrease until they are low enough that a firm can gain by experimenting with its own format.

To summarize, *if firms follow imitation dynamics*, then for any $\mu > 0$, profits and use of format $A$ do not depend on either $\mu$ or $\lambda$. If $\mu = 0$, then prices converge to 5. Prices set by a firm when it adopts format $A$ are on average equal to prices when it adopts its own format. Increases in prices occur over the same length of time as declines in prices, and increases are of the same magnitude as decreases in prices. Finally, increases in prices are associated with the use of own formats, and decreases in prices are associated with the use of format $A$.

### B.4 Adaptive (reinforcement) learning

Under an adaptive learning dynamic (Erev & Roth, 1998), a firm considers only its own past experience. "Players apply ex post rationality," that is, they "assess the success of their previously chosen action ex post and adapt the strategy accordingly" (Köke, Lange, & Nicklisch, 2015). Impulse balance learning (Chmura, Goerg, & Selten, 2012; Selten & Chmura, 2008) is an example of such learning where the probability to choose an action is proportional to the profit it generates on average. The probability to choose price and format ($p$, *format*) in iteration $t$ of the learning dynamic is

$$pr_t(p, format) = E(\pi_{t-1}(p, format)) / \sum_{(p,ft)} E(\pi_{t-1}(p, format))$$

**TABLE B3** Results of the reinforcement learning simulations

| *Average Profits (in ECU)* | | | | | | | *Adoption of Format A (firms B and C)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\mu$ | | | | | | $\mu$ | | | |
| | 0% | 30% | 70% | 100% | | | 0% | 30% | 70% | 100% |
| 0 | | 115 | 110 | 108 | | 0 | | 48% | 44% | 40% |
| 0.3 | 120 | 113 | 103 | 97 | $\lambda$ | 0.3 | indifferent | 50% | 49% | 48% |
| 100 | | 117 | 111 | 104 | | 100 | | 56% | 65% | 74% |

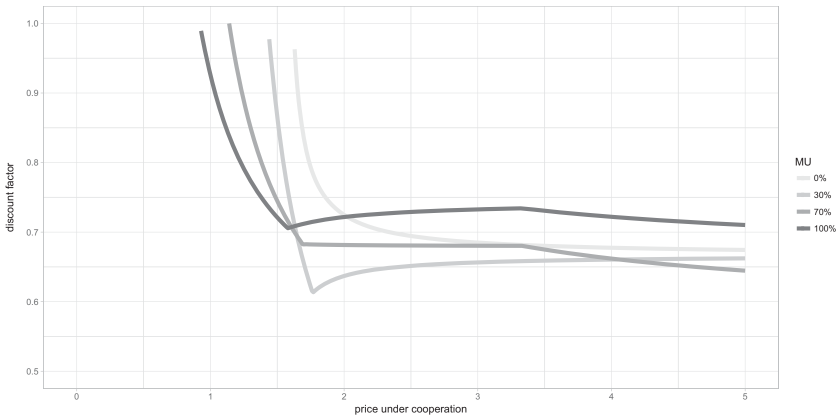


**FIGURE B5** Range $(\delta, \overline{p})$ with sustainable cooperation. $\mu \in \{0, 30\%, 70\%, 100\%\}$ and $\lambda = 30\%$

with $\pi_{t-1}(p, format)$ the profit generated in period $t-1$ of the learning dynamic. Actions that generate high profits are thus played with high probability, but any action that generates any profit is played with some positive probability. Table B3 summarizes results of the simulations of this learning dynamic in terms of average profit and frequency of choice of format $A$. The code for the simulations of reinforcement learning, performed in R, is available at http://github.com/alescia/CS2-Simulations/blob/master/simulation_reinforcement_learning.R.

We find that profits decrease with $\mu$. However, higher $\lambda$ lowers profits only up to a certain point, after which profits increase with $\lambda$. The frequency of use of common format $A$ increases with $\lambda$ and decreases with $\mu$ unless $\lambda$ is high.

To summarize, *if firms follow reinforcement learning*, higher $\mu$ decreases profits and discourages the use of format $A$ *for the range of $\lambda$ in the experiment*. For that same range, higher $\lambda$ decreases profits and promotes the use of format $A$. Prices when a firm adopts format $A$ are lower on average than when it adopts its own format and, as in the mixed strategy Nash equilibria, there are no prolonged increases and decreases in prices over time, while increases and decreases in prices are not correlated with adoption or rejection of format $A$.

### B.5 Cooperation

Higher $\mu$ and $\lambda$ make punishment harder when a firm break cooperation, but also make defections more profitable. Formally, denote $\pi_{DD}(\mu, \lambda)$ the maximum profit attainable if firms compete normally (either best responding, adopting mixed strategies or learning over time, cf. Sections B.1, B.2, B.3 and B.4), and denote $\pi_{DC}(\bar{p}, \mu, \lambda)$ the maximum profit that can be obtained by a defecting firm when cooperation was established at price $\bar{p}$. Cooperation will be sustained in a context with full information about the past action of others if

$$\frac{\overline{p}}{1-\delta} \geq \pi_{DC}(\bar{p}, \mu, \lambda) + \delta \cdot \frac{\pi_{DD}(\mu, \lambda)}{1-\delta} \tag{B1}$$

where discount factor $\delta$ reflects the level of patience of subjects or the probability with which a pairing is maintained next period in the experiment (set at 90% in our sessions).

$\pi_{DC}(\bar{p}, \mu, \lambda)$ is the maximum profit out of three options:

1. set price $p < \overline{p} - e$ in which case the deviating firm gains the whole market. Its profit can then be made arbitrarily close to $3 \cdot (\overline{p} - e)$ by setting $p$ arbitrarily close under $\bar{p} - e$.

2. adopt format $A$ set $p \in [\overline{p} - e, \min[(1 + \lambda) \cdot \overline{p} - e, \overline{p}]]$ and gain all savvy consumers. Profit of the deviating firm can then be made arbitrarily close to $(1 + 2\mu) \cdot \min[(1 + \lambda) \cdot \overline{p} - e, \overline{p}]$.
3. adopt format $A$ and set $p \in [\min[(1 + \lambda) \cdot \overline{p} - e, \overline{p}], \overline{p}]$. The deviating firm then gains savvy consumers of firm $A$ but its price is not low enough to gain savvy consumers of firm $C$ (if the deviating firm is B) or savvy consumers of firm $B$ (if the deviating firm is C). Its profit can then be made arbitrarily close to $(1 + \mu) \cdot \overline{p}$ by setting $p$ arbitrarily close under $\bar{p}$.

Of those three options, two are increasing in $\mu$ and one is weakly increasing in $\lambda$. Defection profit $\pi_{DC}(\bar{p}, \mu, \lambda)$ is therefore at least weakly increasing in $\mu$ and $\lambda$. Graph B5 shows the minimum level of $\delta$ over which cooperation will be sustained as a function of $\overline{p}$, the price when firms cooperate, for different levels of $\mu$ and given $\lambda = 30\%$. $\pi_{DD}(\mu, \lambda)$ is taken from myopic best response simulations.

We see that higher $\mu$ and $\lambda$ do not always make cooperation easier to sustain, and lower $\overline{p}$ does not necessarily make it more difficult. This is because high levels of $\mu$ make defection so profitable–one only needs to decrease price by ¢ to gain almost the whole market–that this can counteract how low competitive profits subsequently are. Consider indeed the impact of an increase in $\mu$ on threshold $\delta^*$ over which cooperation is sustainable. We have

$$\delta^*(\bar{p}, \mu, \lambda) = \frac{\pi_{DC}(\bar{p}, \mu, \lambda) - \bar{p}}{\pi_{DC}(\bar{p}, \mu, \lambda) - \pi_{DD}(\mu, \lambda)} \tag{B2}$$

1. If $\lambda \geq e/\bar{p}$, then
   - **a)** if $\mu \leq 1 - {}^{3e}/_{2\bar{p}}$, then defection profit is $3 \cdot (\bar{p} - e)$. In that case, $\delta^*$ is decreasing in $\mu$ because $\pi_{DD}(\mu, \lambda)$ is decreasing in $\mu$ and $\pi_{DC}(\bar{p}, \mu, \lambda)$ does not vary with $\mu$.
   - **b)** if $\mu \geq 1 - {}^{3e}/_{2\bar{p}}$, then defection profit is $(1 + 2\mu) \cdot \bar{p}$. In that case, $\delta^*$ is decreasing in $\mu$ only if $\bar{p} \leq \pi_{DD} - \mu \frac{\partial \pi_{DD}}{\partial \mu}$ and increasing in $\mu$ else.
2. If $\lambda \leq e/\bar{p}$, then we need to take account of the cases where defection profit is either $(1 + 2\mu) \cdot [(1 + \lambda) \cdot \bar{p} - e]$ or $(1 + \mu) \cdot \bar{p}$. As above, $\delta^*$ may be increasing or decreasing in $\mu$.