Spatial competition with demand uncertainty: A laboratory experiment

Aurélie Bonein, Stéphane Turolla

Spatial Competition with Demand Uncertainty: A Laboratory Experiment*

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Abstract

Motivated by recent research on product differentiation, we conduct laboratory experiments to study how demand uncertainty influences firms' incentives to differentiate. We ground our experiment on a discrete version of the standard location-then-price game introduced by Hotelling (1929), and we consider different levels of demand uncertainty. We first derive the game equilibrium assuming risk-neutral firms, and obtain the standard prediction that a high level of demand uncertainty generates more differentiation. Second, we extend the analysis to consider non risk-neutral firms and markets with asymmetric risk profiles. We show that the game equilibrium can differ substantially according to the attitude to risk. Third, we compare our predictions with the experimental data and find that demand uncertainty acts as a differentiation force in the context of both symmetric markets composed of risk-neutral or risk-lover subjects and asymmetric markets. We find support also for the agglomeration effect arising from demand uncertainty for sufficiently risk-averse subjects. Overall, these results might explain the opposite product differentiation strategies frequently observed in markets with fast-evolving tastes (i.e. minimum or maximum differentiation). Finally, the data confirm that subjects differentiate to relax price competition and provide evidence of a strong positive relationship between differentiation and prices.

Keywords: Product differentiation, Demand uncertainty, Risk attitudes, Laboratory experiment.

JEL Classification: C72; C91; D43; L13; R30.

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†Univ Rennes, CNRS, CREM, UMR6211, Rennes, France; email: aurelie.bonein@univ-rennes.fr.

‡Corresponding author, INRAE, Institut Agro, SMART, 4 Allée Adolphe Bobierre, 35000 Rennes Cedex, France; email: stephane.turolla@inrae.fr.

1 Introduction

Product success hinges principally on the firm's ability to meet demand. Despite this simple statement, firms encounter considerable practical difficulties in relation to envisioning how consumers will appreciate a brand new product. This could be due to financial constraints which prevent the firm from conducting in-depth market studies and to the difficulties involved in predicting rapidly evolving consumer tastes. Opening a restaurant, or launching a new line of apparel, a new version of an electronic device (smartphone, camera) or a new mineral water flavor are a few examples of initiatives where firms are uncertain about consumer tastes for product characteristics. This uncertainty is accentuated by the current rapid evolution of consumer tastes. There are several factors such as the growing integration of economies, the existence of social networks that favor fads and their dissemination, and the occurrence of global shocks (e.g. recessions, climate events, covid-19 crisis) that give rise to new lifestyle aspirations which seem to have accelerated renewal of consumer tastes, and by extension demand uncertainty.[1] Thus, firms cite demand uncertainty as one of the main challenges on the road to success (see Capgemini Consulting, 2012, for instance).

Launching a new product is complicated since the firm must both decide about which bundle of characteristics will best suit consumer preferences and anticipate rivals' reactions. Imperfect information about demand increases these difficulties and affects the firm's differentiation strategy. For instance, the firm might decide to propose a highly differentiated product which responds to demand from a small group of consumers, or to offer a generic product that will appeal to the mass of consumers. Both strategies produce different effects on competition intensity. Intuitively, the decision to differentiate or not should depend on both the extent of the uncertainty and how the firm reacts to uncertainty. An owner (or manager) who is a risk-lover will prefer a more risky but also more profitable strategy and will be more inclined to differentiate while a risk-averse owner will favor less differentiation in order to ensure a safer and smaller amount of profit.

There is a recent strand of work that analyzes the theoretical effect of demand uncertainty on product differentiation (see e.g. Harter, 1996; Casado-Izaga, 2000; Meagher and Zauner, 2004, 2005). Basically, these studies revisit the standard result of Hotelling (1929)'s location-then-price game model by introducing (aggregate) demand uncertainty through a random location of demand. These authors show that risk-neutral firms faced with demand uncertainty differentiate more than if they are perfectly informed.[2] Addi-

[1]For instance, it has been reported in the press that McDonald's has been under pressure to respond to growing demand for food originating from healthy and sustainable food systems. These new consumption patterns are at the root of substantial changes in the attributes of products being offered in stores (see, *Financial Times*, 2019/01/30). Beyond the food and beverage industry, there are several other sectors (such as the apparel, automotive, and tech industries all victims of the phenomenon of "fast fashion") which are facing major challenges induced by the evolution of consumer tastes.

[2]The result is similar to Cheng (2014) for the case of firms that are vertically differentiated and

tionally, they show that the differentiation force is increasing with the level of uncertainty.

Our aim in this article is to provide empirical validation of these results. First, we ground our analysis on a discrete version of Hotelling (1929)'s model and extend the previous findings by showing that when demand is uncertain the choice to differentiate depends critically on the risk preferences of both decision-makers. Second, we conduct laboratory experiments to empirically test these new predictions. Our study provides new insights on how demand uncertainty influences the firm's product positioning (in the geographical or characteristics space), and to what extent risk preferences can distort the differentiation effect of demand uncertainty. This is of particular interest because demand uncertainty can lead to market outcomes that are far from the social optimum.

This article is linked to the vast and rich literature on how firms position themselves in the characteristics space. These studies use the Hotelling-style location models and assume that firms have perfect knowledge about demand. This stream of work teaches that under a wide range of assumptions, firms tend to differentiate along the *dominant* characteristic to soften price competition (see e.g. Irmen and Thisse, 1998).[3] However, this finding has found little empirical support. The few attempts to provide empirical validation have produced mixed evidence of clustering and dispersion which questions the validity of the "principle of maximum differentiation".[4] These inconclusive findings are not surprising since it seems problematic to obtain a correct measure of the level of differentiation of firms using real market data.[5]

To circumvent these difficulties, several authors conduct laboratory experiments to study location choices and pricing decisions in spatially differentiated markets. They exploit this controlled environment to measure changes in firms' differentiation strategies. However, most of these studies assume that either location choices or pricing decisions are exogenous. Brown-Kruse et al. (1993) and Brown-Kruse and Schenk (2000) analyze firms' location decisions in repeated spatial duopoly markets with elastic demand and a fixed price environment. Both studies show that while subjects tend to agglomerate at the center of the market (i.e. the non-cooperative equilibrium), when non-binding communication is introduced they manage to coordinate and achieve the collusive out-

uncertain about how consumers perceive product quality.

[3]Nonetheless, it has been shown that in the one-dimensional case it is possible to obtain a range of equilibrium outcomes, from minimal to maximal differentiation, depending on the model assumptions (see e.g. Brenner, 2001 for a survey of Hotelling-style models of product differentiation).

[4]These studies typically focus on markets where the geographical dimension is predominant. For instance, Schuetz (2015) shows that Big Box retailers prefer to agglomerate in desirable locations rather than cede market share to rivals (see also Eckert et al., 2013 for a study of shopping center locations), whereas Netz and Taylor (2002) find that gasoline stations increase their spatial differentiation as the intensity of competition increases (see also Seim, 2006 for a study of the video retail industry). The results in Elizalde (2013) are less extreme and suggest both location equilibria in the context of the movie theater industry.

[5]It is especially difficult to define a relevant proxy for product differentiation while controling for exogenous market constraints (e.g. geographical boundaries or demographic factors in the retail industry; see Picone et al., 2009) which could bias the measure.

come (i.e. firms locate at the quartiles of the market). Huck et al. (2002) confirm the attractiveness of central location in a quadropoly market with inelastic demand, while Collins and Sherstyuk (2000) emphasize the role in a triopoly market of attitude to risk to explain deviations from the Nash equilibrium. In another vein, Orzen and Sefton (2008) empirically analyze a spatial price competition model assuming exogenous location of firms and find persistent price dispersion in line with mixed strategy equilibria.

To our knowledge, only two works test a two-stage model of location decision and price competition in a laboratory setting. The paper by Camacho-Cuena et al. (2005) is rather specific since it also includes an endogenous consumer location choice stage, which allows the authors to revisit the issue of product differentiation in the presence of strategic buyers. The study by Barreda-Tarrazona et al. (2011) is more related to our work. Their experimental design recasts the spatial duopoly model of Hotelling (1929) in a discrete framework with linear disutility of transportation and few demand slots. They find that subjects differentiate significantly less than predicted which provides support for the principle of minimum differentiation. One of the benefits of their experiment is that it delivers closed-form solutions for the theoretical model. Therefore, we rely on their framework and extend it by introducing demand uncertainty and risk preferences.

Specifically, we propose a discrete version of the location-then-price game in which demand uncertainty is introduced through a random shift of the support of the demand, as in Meagher and Zauner (2005). Firms choose their locations simultaneously and before the consumer location distribution is revealed, and then compete in prices with perfect knowledge about the location of demand. This location-then-price game reflects the firms long-term decision about positioning. It also implicitly assumes that once settled in a location firms can learn quickly about demand characteristics and can rapidly adjust their prices at no cost. Contrary to the literature, we develop a model for different firm risk profiles.[6] In addition to the standard case of risk neutrality, we suppose that firms can be risk-averse or risk-lover. This departs from the economics and management literatures which generally assume that faced with demand uncertainty firms are risk-averse. We are not suggesting that this hypothesis is irrelevant since it is supported by a large number of studies.[7] However these findings were generally drawn "on average", and all of those

[6]An exception is Balvers and Szerb (1996) who analyze the location choices of risk-averse firms in a spatial duopoly model featuring aggregate demand uncertainty. However, in their model prices are assumed to be exogenous which entails the standard result for firms located at the city center in the absence of uncertainty. When uncertainty arises, an increase in risk aversion drives firms to move closer to the edges of the city to secure a smaller share of demand and to avoid risky realizations of a random shock which decreases the expected payoff at the city center.

[7]Numerous empirical studies find risk-averseness among firms in the presence of uncertainty. This has been shown for large companies with hierarchical organizations operating in the financial, media, and technology sectors (see for instance, Lovallo and Kahneman, 2020) and also for entrepreneurial ventures where demand uncertainty arises mostly from heterogeneous and evolving consumer tastes (e.g. retail, motel and manufacturing industries; see Mazzeo, 2004; Wu and Knott, 2006; Sharma and Tarp, 2018). Several reasons have been proposed to explain firm risk aversion: delegation of firm control to a financially constrained manager, fear of losing job or reputation, financial distress, composition of

studies that rely on a measure of risk aversion report a fraction of non risk-averse decision-makers in both the lab and in the field (e.g., Caliendo et al., 2009; Cramer et al., 2002; Morgan et al., 2016). Therefore, we make no assumptions about the firm's risk attitude and we investigate the effect of demand uncertainty by considering different risk profiles. We also consider different market configurations depending on whether two firms have the same risk profile (i.e. symmetric market) or not (i.e. asymmetric market). Using this model, we implement three experimental treatments. In the baseline treatment, subjects have perfect information on demand location; in the other two treatments, we introduce different levels of demand uncertainty.

The model delivers clear predictions. First, we obtain the standard result that high demand uncertainty acts as a differentiation force in markets composed of risk-neutral firms (see for e.g. Meagher and Zauner, 2005). This result applies also to risk-lover firms, and we find that the differentiation effect increases with the degree of risk-loving. However, if we assume sufficiently risk-averse firms the predictions change. The differentiation force entailed by demand uncertainty is counterbalanced by the attraction of the city center which ensures a smaller but safer share of demand. Therefore, we find that for sufficiently risk-averse firms, demand uncertainty acts as an agglomeration force regardless of the size of the uncertainty. Finally, we extend the model to the case of asymmetric markets composed of a risk-averse and a non risk-averse firm.

Subjects in the lab play one of three treatments of the location-then-price game, and participate in a second experiment which allows us to elicit their risk preferences. The experimental data confirm that on average demand uncertainty acts as a differentiation force which supports the central prediction in the literature. Although subjects do not differentiate as much as predicted by the theory, we observe a significant increase in the level of differentiation as demand uncertainty rises. This result also appears robust to the way demand uncertainty is modeled. When controlling for subjects' risk attitudes, the prediction that high demand uncertainty yields a differentiation force in symmetric markets composed of risk-neutral or risk-lover subjects is confirmed and applies also to the case of asymmetric markets. In addition, we show that demand uncertainty might generate an agglomeration force for sufficiently risk-averse competing subjects together. This new finding highlights the importance of considering the risk preferences in presence of demand uncertainty and might explain some of the agglomeration patterns observed in markets featuring fast-evolving tastes (e.g. bars and restaurants) and risk-averse decisions makers . Finally, our experimental data show that when differentiation increases subjects succeed in mitigating price competition; a relationship at the heart of addressing models that is rarely verified empirically.

The remainder of the paper is organized as follows. Section 2 presents the discrete

corporate governance, non-linear corporate tax system, or particular personality traits (see for instance, Spagnolo, 1999; Asplund, 2002; Bernhardt and Rastad, 2016, and the references cited therein).

location-then-price game framework and reports the game equilibria for the different treatments. Section 3 describes the experimental procedure, and Section 4 presents the results of the experiments. Section 5 concludes the paper.

2 A Discrete Version of the Hotelling Game

Section 2.1 provides a discrete version of the standard Hotelling's model. In Section 2.2 we derive the game equilibria under the assumption of perfect knowledge about demand location and risk-neutral firms. In section 2.3 we introduce demand uncertainty and in section 2.4, we relax the hypothesis of risk-neutral firms.

2.1 Basic Settings

As a natural benchmark, we consider the standard Hotelling's model in which firms play a location-then-price game under the canonical assumptions of risk-neutral firms and perfectly known demand (hereafter the *demand certainty* (DC) case) prior to the firms' location and price decisions.[8] To conduct the laboratory experiments, we recast Hotelling (1929)'s model in a discrete framework by adopting the game proposed by Barreda-Tarrazona et al. (2011). While a discrete framework makes it difficult to derive closed-form solutions it allows us to limit both the number of locations and the number of price offers. This favors the replication of the game in the lab, and facilitates comparison with real-world situations in which the sets of actions are reduced. In the following paragraphs, we present the key features of the game proposed by Barreda-Tarrazona et al. (2011) while introducing specific notations that will be useful for introducing the case of demand uncertainty.

Let us consider two firms $i \in \{1, 2\}$ playing a location-then-price game. In the first stage, the firms with perfect information about demand choose their locations, x simultaneously. Once the locations are set, the firms compete in prices simultaneously. The solution to this game can be derived from the resolution to the firms profit maximization problem given by $\Pi_i\left(x_i, x_{-i}, p_i, p_{-i}\right) = \max\left\{p_i \cdot q_i\right\}$, where p_i is the price charged by firm i and q_i is its residual demand.

Assume there is a unit-length linear segment populated by 7 consumers $j = \{1, \ldots, 7\}$ uniformly distributed over $[M-3, M+3]$, with $M \in \Re$. Fig.1 shows that each consumer is located on one of the 7 equidistant slots denoted x_j and separated from its closest neighbors by a distance of $1/6$.[9] A consumer can either buy a maximum of 1 unit of the

[8]To remain as close as possible to the pioneering work of Hotelling (1929), we assume also that consumers are uniformly distributed along the linear city, that firm location is restricted to the inner city, that travel costs are proportional to the distance traveled, and that demand is inelastic up to a reservation price.

[9]In our study, we consider only the *Simulated Consumers Treatment* of Barreda-Tarrazona et al.

good sold by one of the two firms labeled i and located at $x_i \in \{M-3, M-2, \ldots, M+3\}$ or can abstain from buying. Without loss of generality, we assume that firm 1 is located to the left of firm 2, i.e. $x_1 \leq x_2$. The firms sell a homogeneous good produced with constant marginal costs normalized to 0. Since products are not vertically differentiated, the difference in consumer utility between two products offered at the same price will depend on the taste difference between the consumer's ideal product and the product offered. In the case of geographical differentiation, this corresponds to the difference in transportation costs. Hence, for a consumer located at x_j who visits firm i, his indirect utility function is given by:

$$V_{ji} = R - p_i - tx_{ji} \tag{1}$$

where R is the basic reservation utility which is assumed to be positive, p_i is the price charged by firm i, x_{ji} is the distance between consumer j and firm i (i.e. $x_{ji} = |x_j - x_i|$), and t is the transportation cost per unit distance. According to the highest utility rule, consumer j purchases the product from firm i if $V_{ji} > V_{jk}$ with $k \neq i$. In other words, as long as his payment does not exceed his reservation utility R consumer j chooses the cheapest firm (i.e. the firm minimizing mill price plus transportation cost). In the event of ties between V_{ji} and V_{jk}, consumer j is assumed to randomly choose one of the two firms with probability 1/2. Bearing in mind that the experiment should be kept as simple as possible, we adopt the same parameter values as in Barreda-Tarrazona et al. (2011), which entails clear-cut solutions for experimental subjects. Therefore, we set $R = 10$, $p_i = \{0, \ldots, 10\}$ and $t = 6$.[10]

At this point, we need to consider two hypotheses of the model. First, rather than the standard hypothesis of quadratic transportation costs we chose a linear form to model transportation costs which reduces the cognitive burden of the experimental subjects in the lab. Also, there is no economic reason for choosing a quadratic rather than a linear formulation. Use of linear transportation costs in Hotelling's location-then-price game tends to be dismissed because it leads to the non-existence of a price equilibrium in pure strategies with firms located inside the market quartiles (see D'Aspremont et al., 1979). In fact, for location configurations close to but not at the center, there is an incentive for the firm to undercut its rival in order to capture the entire demand. This implies that the profit functions are not quasi-concave and that the best response functions do not intersect due to discontinuity. Obviously, in a discrete game context, this issue does not arise since by nature the profit functions are not quasi-concave.

Second and in contrast to experiments based on spatial competition models (see e.g. Brown-Kruse and Schenk, 2000; Collins and Sherstyuk, 2000; Huck et al., 2002; Orzen and

(2011), which implies odd numbers of locations and exogenous consumers.

[10] To facilitate the exposition of the game in the lab, we fix to one the distance between two neighboring locations and set to one the transport cost per unit distance so that transportation costs are unchanged compared to those of the model.

Table 1: Equilibrium Payoffs in the Price Subgame (Demand Certainty)

	1	2	3	4	5	6	7
1	$(3.5,3.5)^e$	(1,6)	$(4.71,15.88)^\star$	$(10,22.42)^\star$	(18,28)	(21,28)	$(24.5,24.5)^e$
2	(6,1)	$(3.5,3.5)^e$	(2,5)	$(10,17)^\star$	$(20,23.65)^\star$	$(24.5,24.5)^e$	(28,21)
3	$(15.88,4.71)^\star$	(5,2)	$(3.5,3.5)^e$	(6,8)	$(18.2, 18.2)^\star$	$(23.65,20)^\star$	(28,18)
4	$(22.42,10)^\star$	$(17,10)^\star$	(8,6)	$(3.5,3.5)^e$	(8,6)	$(17,10)^\star$	$(22.42,10)^\star$
5	(28,18)	$(23.65,20)^\star$	$(18.2,18.2)^\star$	(6,8)	$(3.5,3.5)^e$	(5,2)	$(15.88,4.71)^\star$
6	(28,21)	$(24.5,24.5)^e$	$(20,23.65)^\star$	$(10,17)^\star$	(2,5)	$(3.5,3.5)^e$	(6,1)
7	$(24.5,24.5)^e$	(21,28)	(18,28)	$(10,22.42)^\star$	$(4.71,15.88)^\star$	(1,6)	$(3.5,3.5)^e$

Notes: $(\star)$ and (e) denote respectively the mixed strategy equilibrium and the expected payoffs due to indifferent consumers.

Sefton, 2008), the resolution of the game yields possible outcomes in which the market is not fully covered. This particularity originates from the model parametrization which allows the firms to set delivered prices that exceed the consumer's reservation utility. Therefore, for those particular prices, consumers are better off not buying the good which results in an uncovered market. Thus, in the particular case where non-buying consumers are located between the two firms, the firms do not compete directly with one another but instead behave like local monopolists.

2.2 Location-then-Price Game Equilibria

Throughout the paper, we study the non-cooperative game equilibrium and consider the subgame perfect Nash equilibrium (SPE) as the equilibrium concept.[11]

We first consider risk-neutral firms, and determine the price equilibrium for each pair of locations (x_1, x_2). Whenever a consumer is indifferent between firms 1 and 2, we adopt an arbitrary sharing rule such that the marginal consumer chooses one of the two firms with the probability 1/2.[12] In the case of a multiplicity of price equilibria, we assume that firms choose the riskless option, meaning the price equilibrium which ensures an equivalent level of profit with a larger number of safe consumers. If the multiplicity of equilibria persists, we consider the strict Nash equilibrium. However, if there is no strict Nash equilibrium, we assume that firms choose the Pareto superior equilibrium and otherwise the joint profit-maximizing solution. Assuming that firms are risk-neutral and perfectly informed about demand location, the payoffs in Table 1 are derived from the price equilibrium for each pair of locations.[13] Given this matrix of payoffs, it is now easy to determine the unique SPE of the location-then-price game under demand certainty.

[11] In the Online Appendix, we discuss another strategy which allows firms to reach the collusive outcome.

[12] In the case of multiple indifferent consumers, we consider the polar cases of none or all indifferent consumers visiting a firm. We would stress that location and price equilibria do not depend on this sharing rule. For instance, assuming that half of the indifferent consumers visit a firm leads to the same equilibria.

[13] The multiplicity of equilibria exists in only 15.69% of the price combinations and the equilibrium of the location-then-price game is insensitive to this selection rule. In Appendix A we explain how we determined the unique price equilibrium for each pair of locations, and report the corresponding equilibrium prices.

Proposition 1 *The unique SPE for the location-then-price game under demand certainty and risk neutrality is* $(x_1^\star, x_2^\star) = (2, 6)$ *with equilibrium prices* $(p_1^\star, p_2^\star) = (7, 7)$.

This result first established by Barreda-Tarrazona et al. (2011), implies a degree of differentiation equal to $\Delta^{DC} \equiv x_2^\star - x_1^\star = 4$.

2.3 Demand Uncertainty

We now introduce demand uncertainty into the location-then-price game under the assumption that firms are risk-neutral. This extension corresponds to the central issue which we examine experimentally in this paper. The introduction of demand uncertainty resonates with a stream of research that investigates to what extent uncertainty over (aggregate) demand location mitigates the firm's positioning in geographical space. In brief, this literature considers a modified version of the (continuous) Hotelling game in which uncertainty applies to consumer locations through a random shift of the linear city.[14] For instance, Casado-Izaga (2000) uses the standard location-then-price game with quadratic transportation costs, and models demand uncertainty as a common draw for the mean of the consumers' distribution which is assumed to be uniformly distributed.[15] For simplicity, the center of the linear city is assumed to be drawn from a uniform distribution on the closed unit interval $[0, 1]$ and revealed to firms once the simultaneous location game has ended. Meagher and Zauner (2005) generalize this setting by extending the support of the distribution of the city center to $\left[-\frac{L}{2}, \frac{L}{2}\right]$, where L represents the size of the uncertainty. They show that a unique pure strategy SPE exists which leads to higher differentiation, higher expected prices, and higher expected profits as L increases.

The intuition for this result is simple. Under demand certainty, the location equilibrium in the Hotelling game is shaped by the basic tradeoff firms face between securing a larger fraction of the demand by locating closer to the center (*demand effect*) or relaxing the price competition by moving farther away from competitors (*strategic effect*). Because demand uncertainty reduces the magnitude of the *demand effect* but does not affect the *strategic effect*, firms choose to differentiate more compared to the certainty case. More precisely, with a uniform distribution of the demand center, extreme realizations of demand are equally likely as central realizations to occur. This implies that firms are no longer certain to lose consumers if located far from the city center. Consequently, the *demand effect* is weakened and firms choose to differentiate to reduce price competition. This result becomes more pronounced with greater levels of uncertainty.

Although established for a given set of assumptions, the differentiation force entailed by demand uncertainty remains valid under alternative assumptions: a non-uniform dis-

[14] Throughout the paper, we use the terms linear city and demand interchangeably.

[15] Readers interested in a more general setting where uncertainty applies at the distributional level and does not only rely on the first moment of the distribution should consult Meagher and Zauner (2004, 2008).

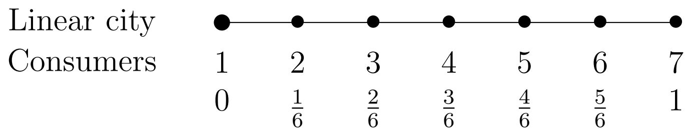


Figure 1: Demand Certainty Treatment ($L = 0$): Linear City with 7 Consumers and 7 Potential Locations.

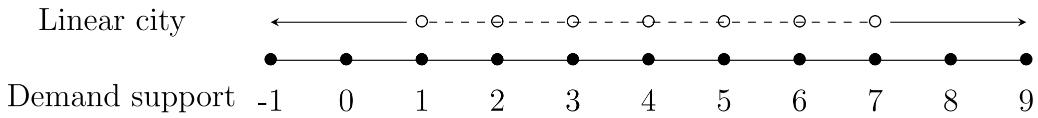


Figure 2: Low Demand Uncertainty Treatment ($L = 4$): Linear City with 7 Consumers and 11 Potential Locations.

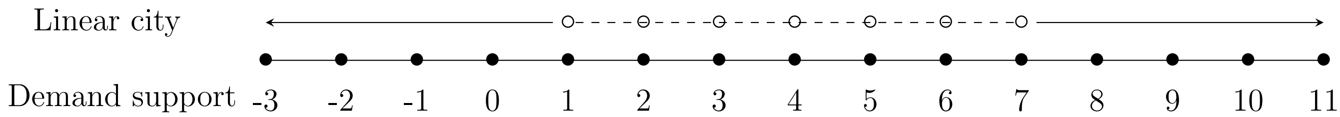


Figure 3: High Demand Uncertainty Treatment ($L = 8$): Linear City with 7 Consumers and 15 Potential Locations.

tribution of the random shock (Meagher and Zauner, 2004, 2008, 2011), sequential location choices (Harter, 1996; Casado-Izaga, 2000; Bonein and Turolla, 2009), and pricing decisions under demand uncertainty (Meagher and Zauner, 2004, 2005).[16]

To test the effect of demand uncertainty on firm differentiation experimentally, we extend the baseline model by assuming that firms are uncertain about consumer locations. The timing of the game is as follows. First, firms simultaneously choose their location in the absence of knowledge about the location of demand. Then the location of demand is revealed, and firms' locations are announced publicly. Finally, firms simultaneously set their prices. This timing corresponds to the ex-post pricing timing in Meagher and Zauner (2004, 2005). It suggests that firms can learn rapidly about demand characteristics and that it is easier for firms to change their prices than their locations (or any other product characteristic). Implicitly the chosen price is not the introductory price but rather a short-term price. We also follow Meagher and Zauner (2005) by assuming that firms are uncertain about realization of the first moment of the consumer distribution while they are perfectly informed about the higher-order moments of the distribution and the definition of its support. Formally, let us assume that the demand center M is distributed according to a discrete uniform distribution on $\left\{-\frac{L}{2}+4,\ldots,4,\ldots,\frac{L}{2}+4\right\}$, with $L>0$. Implicitly, this means that firms' beliefs can be represented by a common prior.[17] To facilitate comparison among treatments, we impose that the city center is always the integer 4 regardless of the level of uncertainty. The expected profits of firm i for a given pair of locations (x_i, x_{-i}) and prices (p_i, p_{-i}) are now given by:

$$\mathbb{E}\left[\Pi_i\left(x_i, x_{-i}, p_i, p_{-i}|M\right)\right] = p_i \times \left[\frac{1}{M_C} \times \sum_c q_{ic}\left(x_i, x_{-i}, p_i, p_{-i}|M\right)\right] \tag{2}$$

where c is a realization of the random variable M, M_C is the number of possible realizations of M, and $q_{ic}(\cdot)$is the number of consumers i attracts for realization c of the demand center. Note that since the demand center M is distributed uniformly, the formulation of the expected profits gives equal weight to each realization of M in the computation of the firm's demand.

In the experiment, we consider two treatments that embody demand uncertainty and differ in the level of uncertainty. In the first treatment, we study firm decisions under a high level of uncertainty about consumer locations by setting $L = 8$. This treatment,

[16]Recently, Meagher et al. (2020) use a Salop-style model to study firms' entry/exit decision over an industry life cycle and confirm the differentiation force of demand uncertainty.

[17]Król (2012) examines the case where firms do not know the exact probability distribution of the mean of the consumer distribution which results in *ambiguous* consumer demand. Because firms are no longer able to compute the expected profits in the location subgame, Król (2012) analyzes product differentiation decisions when firms adopt pessimistic decision criteria. The resolution of the game reveals that the optimal strategy consists of adopting an extreme form of pessimism which when demand location is uncertain leads firms to agglomerate at the city center, a result similar to our theoretical prediction for the case of high risk aversion.

labeled *High Demand Uncertainty* (HDU), increases the support of the distribution of consumers, thus offering 9 possible realizations for the demand center M.[18] Fig.3 shows that this treatment extends the set of potential firm locations to 15 slots while holding the number of consumers populating the linear city at 7. In other words, demand is unchanged (i.e. 7 consumers), but prior to locating, firms now are uncertain about the location of demand, which could be between sites -3 and 11.

In the second treatment, we choose a lower level of uncertainty such that we obtain an identical location equilibrium with respect to the DC treatment. The rationale for this treatment is that it allows us to analyze whether the introduction of a low level of demand uncertainty leads risk-neutral subjects to adopt different decisions compared to the DC treatment while the theoretical predictions are unchanged. This treatment, which is labeled *Low Demand Uncertainty* (LDU) involves the assumption that $L = 4$, which offers 11 potential firm locations (see Fig.2; the locations are labeled from -1 to 9).

Similar to the baseline case, a unique SPE in a pure strategy can be characterized by solving these two variants of the game by backward induction. As before, we first determine the price equilibrium for each pair of locations. Then, given the matrix of payoffs for each pair of locations, we derive the unique location equilibrium in a pure strategy.[19] As noted above, the location and price equilibria obtained in the LDU treatment are similar to those derived under perfect knowledge about the location of demand.

Proposition 2 *The unique SPE for the location-then-price game under low demand uncertainty and risk neutrality is* $(x^\star_{L1}, x^\star_{L2}) = (2, 6)$ *with equilibrium prices* $(p^\star_{L1}, p^\star_{L2}) = (7, 7)$.

In contrast, the resolution of the game in the HDU treatment leads to a different location equilibrium.

Proposition 3 *The unique SPE for the location-then-price game under high demand uncertainty and risk neutrality is* $(x^\star_{H1}, x^\star_{H2}) = (1, 7)$ *with equilibrium prices* $(p^\star_{H1}, p^\star_{H2}) = (7, 7)$.

When firms face a high level of demand uncertainty, they choose to locate at a greater distance from one another relative to the DC and LDU treatments. We obtain the central result in Meagher and Zauner (2005), which stresses that demand uncertainty

[18] Although Meagher and Zauner (2005) examine higher levels of uncertainty, the choice of $L = 8$ is the result of a delicate tradeoff between adopting a sufficiently high level of uncertainty to observe a change in the equilibrium outcome and limiting the support of the consumer distribution (i.e. reducing L) to avoid an excessive number of equilibria with a large share of non-buying consumers. A disadvantage when increasing the size of the uncertainty is that we significantly increase the choice set of locations, thereby complicating the subjects' task and encouraging them to behave as local monopolists.

[19] The price equilibrium payoffs and the equilibrium prices for each pair of locations are provided in the Online Appendix.

acts as a differentiation force. Above a certain threshold of demand uncertainty, firms are no longer sure to capturing a larger share of demand than when located close to the center. Consequently, the firm's best response consists of reducing the intensity of the price competition by locating farther away from its rival and thereby maximizing its expected profit. However, unlike Meagher and Zauner (2005), we do not predict that firms raise their prices if demand uncertainty increases. This is due to a combination of three factors which make deviation from the initial price equilibrium unprofitable: (i) adoption of a linear transportation cost which strengthens price competition compared to the case with quadratic transportation costs, (ii) a discrete framework which introduces threshold effects in firms' actions, and (iii) a level of demand uncertainty sufficient to increase differentiation but not enough to induce softer price competition.

Following the resolution of the games, the following theoretical prediction can be brought to the data:

Prediction 1 *A high level of demand uncertainty acts as a differentiation force.*

2.4 Behavioral Hypotheses

So far our theoretical predictions have been derived under the assumption of risk-neutral firms. However, in our model two sources of uncertainty combine, and decision-makers in both the lab and the firms are not necessarily risk-neutral.

The first source of uncertainty stems naturally from the existence of indifferent consumers. With a sharing rule of 1/2, a firm is not certain to be chosen by an indifferent consumer, and thus has to form expectations about the total number of consumers it will attract. We can illustrate the importance of risk preferences when some consumers are indifferent between two firms and demand is certain.

We employ an expected utility theory framework and a standard isoelastic utility function characterized by constant relative risk aversion (CRRA).[20] The expected utility of the firm i's profit can be written as:

$$U(\Pi_i) = \frac{(p_i q_i)^{1-r}}{1-r} \tag{3}$$

where r is the coefficient of relative risk aversion. If $r = 0$, we return to the situation with risk-neutral firms; $r > 0$ and $r < 0$ denote risk-averse and risk-loving behaviors respectively.[21]

[20] The power functions family has been used frequently to model risk aversion in the fields of economics (Holt and Laury, 2002; Palacios-Huerta and Serrano, 2006), psychology (Luce and Krumhansl, 1988) and health (Bleichrodt et al., 1999). In our experiment, the domain of interest involves only positive outcomes. In this case, this specification of the utility curvature has been shown typically to better fit the experimental data than alternative families (see Camerer and Ho, 1994; Wakker, 2008; Holzmeister and Stefan, 2021, for instance).

[21] When $r = 1$, $\Pi_i(\cdot) = ln(\cdot)$.

In the presence of indifferent consumers, the expected utility of the profit is:

$$U(\Pi_i) = \frac{1}{2}\frac{[p_i\overline{q}_i]^{1-r} + [p_i(\overline{q}_i + \widetilde{q}_i)]^{1-r}}{1-r} \tag{4}$$

where $\overline{q}$ is the sure demand and $\widetilde{q}$ is the number of indifferent consumers. Assume that firms are located in $(x_1, x_2) = (3, 5)$ and that they choose to set identical prices equal to 8. These symmetric outcomes lead to each firm being visited by 3 consumers, with 1 consumer remaining indifferent. It follows that firm 1 can either obtain a profit of 24 or 32 with a probability of 1/2 for each outcome. Conversely, if firm 1 chooses to deviate and sets a price equal to 7, it will attract 4 consumers with certainty and will obtain a profit of 28. Therefore, a risk-averse firm will always prefer to secure a profit of 28 and will set a price of 7, while a risk-lover firm will prefer to take the risk of an indifferent consumer and will set a price of 8.

The second source of uncertainty emerges from the random allocation of the demand center in the LDU and HDU treatments. Both sources of uncertainty could lead the adoption by the firms of different location choices and price decisions depending on their risk preferences.

If the economic environment is uncertain, a standard approach might consist of considering risk-averse rather than risk-neutral firms (see for e.g. Sandmo, 1971; Leland, 1972; Asplund, 2002; Gervais, 2018). Although there is a large body of anecdotal evidence which tends to confirm that in general firms are risk-averse, the empirical evidence based on a measure of risk aversion also shows the presence of a non-negligible fraction of non risk-averse decision makers. We account for this diversity of risk profiles and assume that the firm might be a risk-lover, be risk-neutral, or risk-averse. Since this generates a high number of market configurations, in the first step we restrict the analysis to markets where both firms have the same risk profile (hereafter symmetric markets).[22] We assume also that the firms risk preferences are common knowledge. This can be justified by the existence of exogenous market features which force firms to behave in certain ways (corporate tax systems, failure rate, other market-specific regulations, or economic shocks, for instance).

Again, we solve the game by backward induction to derive the game's theoretical predictions. Given the size of the game's monetary stakes, the behaviors obtained may be close to those obtained for the risk neutral case due to the concavity of the utility function. To examine how risk-aversion can affect the game equilibrium, we use an extremely-concave expected utility function to model risk aversion (assuming $r = 0.9$; see Rabin, 2000 for a discussion of this issue). For risk-loving behavior, we use a CRRA parameter of -0.2, a value that is sufficient to observe an effect that differs from the risk-

[22]In Section 4.2 we relax the assumption of symmetric markets which allows us to extend our conclusions to a larger set of real-world situations.

neutral case. In the main text we report the location and price equilibria by treatment for these particular values. We also examine the relationship between the degree of risk aversion and the firm's decisions. For space reasons, the location and price equilibria derived under other values of the CRRA parameter are reported in Appendix B.

DC treatment As a natural benchmark, we examine the SPE of the game where firms have perfect information about consumer locations. We find that firms' risk preferences do not affect the location equilibrium (i.e., $(x_1^\star, x_2^\star) = (2, 6)$), and therefore do not affect the level of differentiation regardless of the degree of risk aversion. Only the price equilibrium differs according to the firm's risk preferences. For risk-neutral and risk-averse firms, and even if the price strategy $(p_1, p_2) = (8, 8)$ Pareto dominates the outcome $(p_1, p_2) = (7, 7)$, they will always be better off by deviating unilaterally and choosing a price equal to 7 to secure safe demand. The unique price equilibrium then is $(p_1^\star, p_2^\star) = (7, 7)$ for all risk-neutral and risk-averse subjects. Conversely, for risk-lover firms, a unilateral deviation from a price equal to 8 is never profitable, resulting in a price equilibrium equal to $(p_1^\star, p_2^\star) = (8, 8)$. At equilibrium, firms that enjoy risk charge the highest possible price that ensures market coverage and the price competition then softens for these risk-lover firms.[23]

LDU and HDU Treatments Let us first consider the case of risk-lover firms. Intuitively, we might expect risk-lover firms faced with uncertainty to be more inclined to differentiate compared to the DC treatment for two reasons. First, we have seen that demand uncertainty weakens the *demand effect* and pushes (risk-neutral) firms to differentiate more compared to the DC treatment. Second, we have demonstrated that risk-loving preferences favor the adoption of riskier but potentially more profitable choices. Even though expected demand is lowest at the edges of the city, the profits obtained in these locations might be the highest depending on realization of the demand center and the location of the rival. In other words, risk-lover preferences may induce firms to differentiate more. This intuition is confirmed by computation of the SPE under different values of the CRRA parameter. It appears that high demand uncertainty acts as a differentiation force for risk-lover firms. For example, with a CRRA parameter of $r = -0.2$, we obtain a location equilibrium of $(x_{H1}^\star, x_{H2}^\star) = (1, 6)$ in the HDU treatment (see Table 2).[24] This location equilibrium leads to a higher level of differentiation than in the DC treatment. More generally, varying the value of the CRRA parameter reveals that the differentiation force yielded by a high demand uncertainty is even stronger for highly risk-lover firms (see Appendix B). We observe also that similar to risk-neutral firms, a

[23]The price equilibrium payoffs and the equilibrium prices are reported in the Online Appendix for each pair of locations and different values of the CRRA parameter.

[24]And its symmetric $(x_{H1}^\star, x_{H2}^\star) = (2, 7)$.

Table 2: Location and Price Equilibria by Treatment and Risk Preferences

Treatment	Locations	Prices	Demands	Profits
Panel A: Risk-neutral firms				
DC	(2,6)	(7,7)	(3.5,3.5)	(24.5,24.5)
LDU	(2,6)	(7,7)	(3.5,3.5)	(24.5,24.5)
HDU	(1,7)	(7,7)	(3.4,3.4)	(23.7,23.7)
Panel B: Risk-averse firms with $r = 0.9$				
DC	(2,6)	(7,7)	(3.5,3.5)	(13.8,13.8)
LDU	(2,5)	(6,6)	(4.0,3.0)	(13.6,13.2)
HDU	(3,5)	(2,2)	(3.5,3.5)	(10.2,10.2)
Panel C: Risk-lover firms with $r = -0.2$				
DC	(2,6)	(8,8)	(3.5,3.5)	(45.5,45.5)
LDU	(2,6)	(7,7)	(3.5,3.5)	(39.6,39.6)
HDU	(1,6)	(7,7)	(3.0,3.6)	(34.8,41.4)

Notes: This table reports location equilibrium, price equilibrium, demand and equilibrium profits by treatment and by risk preferences. To allow comparison, the outcomes for risk-neutral firms are also reported.

low level of demand uncertainty is not enough to induce a location equilibrium different from that in the DC treatment (i.e. $(x^{\star}_{L1}, x^{\star}_{L2}) = (2, 6)$).

Turning now to the price equilibria, fiercer price competition than in the DC treatment is predicted under low and high demand uncertainty. While in the DC treatment it is optimal for risk-lover firms to set high prices, the introduction of demand uncertainty mitigates this riskier strategy. Indeed, in the LDU and HDU treatments, the support of demand is increases which in turn increases the average distance between firm and consumers. For some price strategies this could result in an uncovered market. Then the price raising effect of risk-loving preferences is attenuated in the presence of demand uncertainty. This results in lower prices at the equilibrium compared to the DC treatment, regardless of the value of the CRRA parameter of risk-lover firms.

The theoretical predictions derived under the assumption of risk-lover firms suggest the following location decisions.

Prediction 2 *A high level of demand uncertainty acts as a differentiation force for risk-lover firms and this effect increases with the degree of risk-taking.*

We now turn to the case of risk-averse firms. As previously shown, risk-averse firms prefer safer outcomes. Demand support increases with the introduction of demand uncertainty, which should induce firms to locate closer to the city center to maximize their expected number of consumers. Such an agglomeration force entailed by risk aversion could offset (or even reverse) the differentiation force of demand uncertainty. Consequently, the SPE of the game will depend on the magnitude of each force. To examine this issue, we compute the game equilibrium for several values of the CRRA parameters (see Appendix B).

Following the terminology in Holt and Laury (2002), we find that the agglomeration force predominates for highly risk-averse firms ($0.97 < r < 1.37$), very risk-averse firms ($0.68 < r < 0.97$) and part of risk-averse firms ($0.41 < r < 0.68$). In the context of demand uncertainty, these firms are better off from locating closer to the city center, which reduces the level of differentiation. For these firm categories the location equilibrium is unchanged in the case of low demand uncertainty ($(x^{\star}_{L1}, x^{\star}_{L2}) = (2, 5)$ for $r = 0.9$, for instance).[25] However, in the HDU treatment the agglomeration effect is more pronounced for the most risk-averse categories ($(x^{\star}_{H1}, x^{\star}_{H2}) = (3, 5)$ for $r = 0.9$). In both treatments, the decrease in differentiation leads logically to fiercer price competition relative to the DC treatment. This finding is consistent with the prediction in Asplund (2002), who shows that risk aversion increases the price competition in the presence of demand uncertainty.

For lower degrees of risk aversion (i.e., $0.3 \leq r < 0.45$), the marginal utility of small stakes decreases so that the forces cancel out, regardless of the size of uncertainty. We return then to the location equilibrium obtained in the DC treatment (i.e. $(x^{\star}_1, x^{\star}_2) = (2, 6)$). Also, for slightly risk-averse firms (i.e., $0.18 \leq r < 0.3$), the incentive to secure safer demand is so low that a high demand uncertainty is sufficient to generate a differentiation effect (see Appendix B).

The theoretical predictions derived assuming risk-averse firms lead to the following location decisions.

Prediction 3 *Demand uncertainty acts as an agglomeration force for sufficiently risk-averse firms, regardless of the size of the uncertainty. For lower degrees of risk aversion, the incentive to agglomerate diminishes such that firms do not react to demand uncertainty. In case of high demand uncertainty and slightly risk-averse firms the agglomeration force is even greater than the differentiation force.*

3 Experimental Procedure

Our experimental design is intended to test the differentiation force of demand uncertainty while controlling for subjects' risk attitudes. Each experimental session consists of two experiments, in which all subjects are required to participate. To avoid any order effects the order of the two experiments was reversed in half of the sessions. The main experiment refers to the discrete location-then-price game presented above, while the second experiment measures subjects' risk preferences using the design proposed by Drichoutis and Lusk (2016).[26]

[25] And its symmetric $(x^{\star}_{L1}, x^{\star}_{L2}) = (3, 6)$.

[26] There are numerous methods that can be used to elicit individual risk preferences. The advantage of the method proposed by Drichoutis and Lusk (2016) is that it removes non-linear probability weighting as the explanation for switching.

In the location-then-price game, each subject interacts with rival subjects over 30 periods, $t = 1, 2, \ldots, 30$. Specifically, the experiment simulates 6 markets of 5 periods each, with a subject matched with the same rival during the 5 periods of the same market but is paired with a new rival at the beginning of each new market. In our design, we introduce a series of periods where the location decisions are given and during which subjects can modify only their prices. This means that in the first period of each market, the subject chooses both his location and price but, in the remaining 4 periods of the market, the subject competes only in prices. This setup has the advantage of reflecting the long-term real life location decision whereas price changes are deemed less costly and can be realized more frequently. Thus in the experimental design we assume that location decisions are more rigid than pricing decisions. Note that repetition of the price subgame is not included in the theoretical model but that does not change the model predictions.[27] Specifically, the timing of the decisions in the first period of each market (i.e., $t = 1, 6, 11, 16, 21, 26$) is as follows. First, the two subjects simultaneously choose their locations, then the rival's location is revealed, and, the subjects compete simultaneously in prices; finally, each simulated consumer decides whether to buy from the cheapest firm. At the end of the period, each subject learns (i) his demand level, (ii) his profit, and (iii) the price of his rival. Then 4 periods of price competition follow. Once the 5 periods have elapsed, a new market begins and subjects are randomly reshuffled, under the constraint that each subject is matched exactly once with the same rival. This stranger matching protocol is common information. To achieve this, we form random groups of subjects, and the rematching is conducted within each group. This stranger design limits end-game effects on both location and price strategies, which enables us to end the experiment with the last period of price competition in the market. Of course, consumer locations remain unchanged during the 5 periods of a market but in the LDU and HDU treatments, can vary from one market to another according to the random draw of the demand center. The draws of the demand center were made for the first session and replicated in all other experimental sessions.

Experimental sessions were conducted at the University Rennes 1 LABEX-EM (CREM-CNRS) Institute. The subjects were students with different backgrounds. The experiment was programmed and conducted using the Z-tree software (Fischbacher, 2007). Participants were invited using Orsee (Greiner, 2015). Prior to the start of the game, subjects were informed that (i) there would be two independent experiments, (ii) money earned in the experiments would depend on their decisions and the decisions of their rivals, and (iii)

[27] The repetition of the price subgame over a finite number of periods does not change the theoretical predictions of the game in game-theoretic terms. However, in a given market, the repetition of the price subgame may lead to lower (or higher) prices in the last period compared to the first period, perhaps reflecting the existence of some learning effects or collusive behaviors (see Camacho-Cuena et al., 2005 for a discussion of this issue). However, it is important to stress that thanks to our stranger matching protocol it cannot affect firms' decisions in the subsequent location-then-price game. Readers interested in the evolution of the price decisions over time should refer to the Online Appendix.

they would be paid the earnings they accrue in the two experiments. It was made clear that information about the earnings obtained in each experiment would be given only at the end of the experimental session. We set this condition to reduce potential earnings spillover effects from one experiment to the next. A total of 6 sessions were conducted for each treatment, with 18 subjects per session. No subject had previously participated in a similar experiment, and none of them participated in more than one session, which results in 324 subjects.

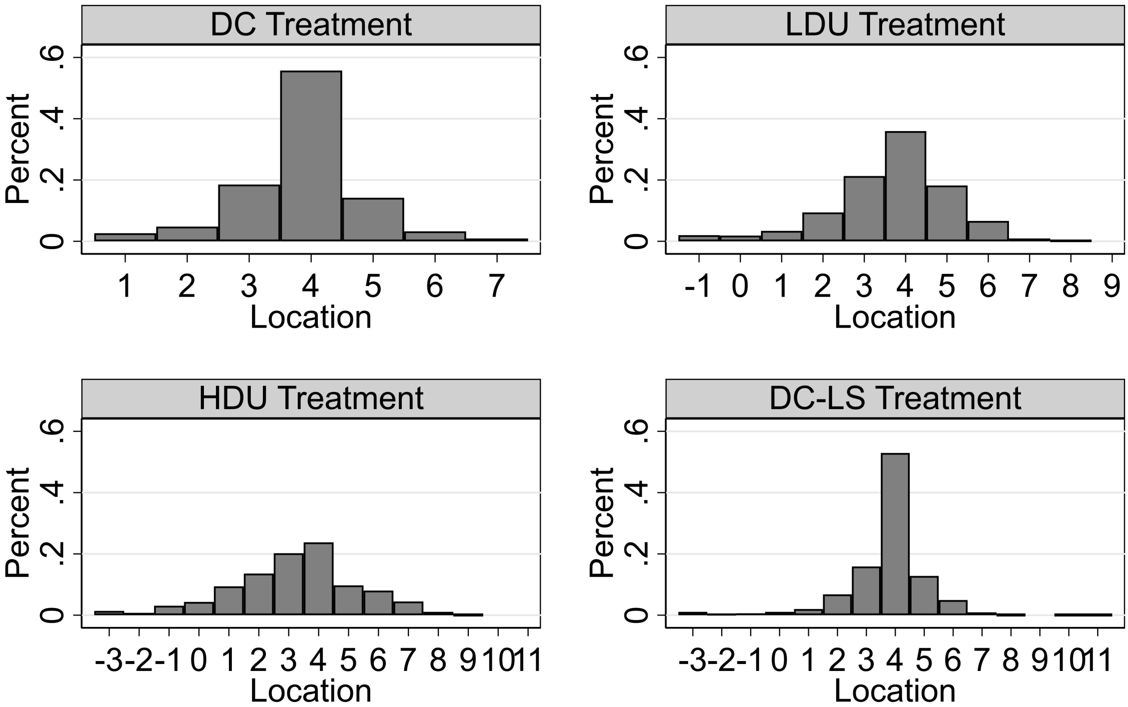
To ensure comparability across sessions and treatments, prior to the first session we randomly formed pairings within each matching group and used the same pairings for the all sessions. Upon arrival, the subjects were randomly allocated to visually separated cubicles so that neither during nor after the experiment were subjects informed about the identities of the other subjects with whom they were matched. The subjects were provided with written instructions which were read aloud by the experimenter (see the Online Appendix).[28] To ensure that all subjects completely understood the instructions, they were required to calculate firm profits in hypothetical exercises. Although this may have introduced some bias, this risk was limited by the fact that the exercises reflected representative contingencies. The responses to these exercises were checked privately before the experiment began to ensure that all the subjects understood the experiment. As a further check, we ran a practice round representing 1 market (i.e. 1 period of location then price decisions followed by 4 periods of price decisions) before the experiment began.

At the end of the two experiments (i.e. the location-then-price game and the risk experiment), the subjects were informed about their earnings and were asked to complete a brief post-experimental questionnaire which asked about personal characteristics (e.g. age, gender, field of study; see Appendix D). From the outset, it was made clear that the subjects' payoffs could be equal to their earnings in the two experiments. For the location-then-price game, subjects' earnings were proportional to the sum of their profits over the 30 periods. Subjects were paid based on the following conversion rate: 25 Experimental Currency Units = 1 euro. The conversion rate was chosen such that at equilibrium, a risk-neutral subject earned 29.40 euros for the 30 periods in the DC and LDU treatments and 28.47 euros in the HDU treatment and could obtain only 4.20 euros for the 30 periods in the DC treatment in the case of no differentiation and non-cooperative prices.

In the risk experiment, the subjects completed 10 decision tasks. At the end of the experimental session, a decision task was randomly selected for payment, and subjects were paid according to their choice (lottery A or lottery B). The selected decision task was the same for all subjects. Subjects knew that at the end of the experimental session, a random device would determine whether they were actually paid. Each subject was given a 1/9 chance of receiving the payment associated with his decision. This procedure

[28] Note that for simplicity and to facilitate subjects' understanding, the demand support is only expressed in positive integers in the instructions.

Figure 4: Location Choices by Treatment



Notes: Each of the panels displays the distribution of the location choices for a given treatment.

provided the subjects with an incentive in each decision task to choose according to their true preferences and is thus incentive compatible. Moreover, as Harrison et al. (2009) argue, stochastic fees allow for the generation of samples that are less risk-averse than would otherwise be observed. The exchange rate used was 0.4 Experimental Currency Units = 1 euro, with the highest earnings equal to 11.75 euros. Further details on the risk experiment are provided in Appendix C. The average length of an experimental session was 80 minutes, and the average participant earning was 17 euros.

4 Experimental Results

In Section 4.1 we examine whether subjects differentiate more in presence of demand uncertainty. In Section 4.2 we analyze how demand uncertainty impacts location decisions depending on the subject's attitude to risk. In Section 4.3 we examine the relationship between the level of differentiation and the price.

4.1 Location Choices and Demand Uncertainty

We begin our analysis of location decisions by pooling the data. During the 18 sessions a total of 1944 location decisions were recorded. The first three panels in Fig.4 plot the location choices for each treatment. It is striking that the center of the support of the

Table 3: Summary Statistics on Location Choices by Treatment

Treatment	Modal location	Most frequent pair of locations	Second most frequent pair of locations	Differentiation Mean (S.D.)
DC	4	(4,4)	(3,4)	1.01 (1.02)
LDU	4	(4,4)	(3,4)	1.54 (1.36)
HDU	4	(4,4)	(3,4)	2.10 (1.64)

Notes: Differentiation is measured as the distance between the two subjects.

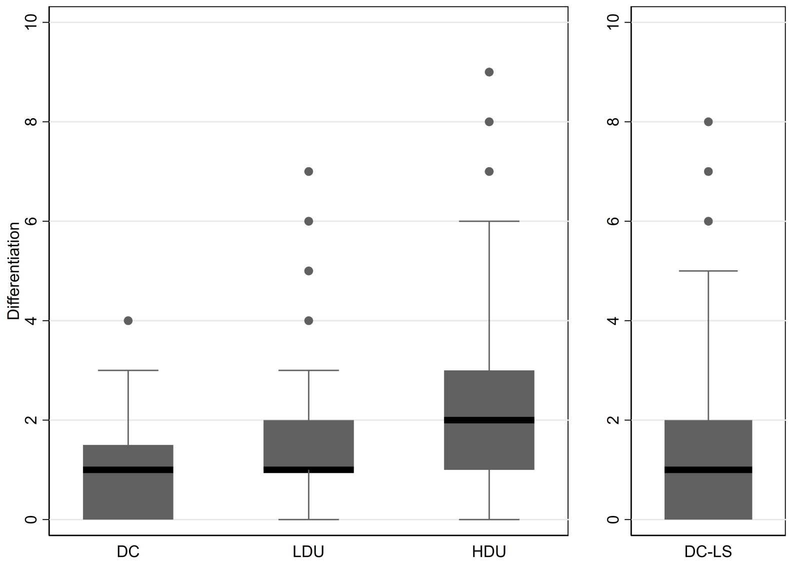
linear city is the most frequent location choice regardless of the level of uncertainty. In over 55% of all cases in the DC treatment subjects locate at the center of the demand support and the prevalence of this central position is confirmed in the LDU and HDU treatments, with respectively 36% and 24% of the location choices. Overall, few subjects decide to locate at the edges of the support of the linear city. The tendency to cluster at the center is in line with the results of past experiments on spatial duopoly markets.[29]

Table 3 report the most frequent location pairs observed for each treatment and their average level of differentiation. Differentiation is measured as the distance between the two subjects competing in a given market. We observe that the subjects' location decisions yield less differentiation than the location equilibria. This is especially clear in the DC treatment where in a given market the subjects are both located at the city center (4,4) in more than 32% of the location games, while the second-most preferred location configuration yields only a low level of differentiation. Thus the preferred pairs of locations are far away from the non-cooperative location equilibrium $(x_1^\star, x_2^\star) = (2, 6)$. Nevertheless, we find that the attractiveness of the center of the demand support decreases if demand location is uncertain (LDU and HDU). While the pair of locations (4,4) is always the most frequent choice in the LDU (12.65%) and HDU (5.56%) treatments, Fig.4 shows that subjects are more prone to locate far from the center of the demand support in these two treatments. The prevalence of central location and the resulting low level of differentiation explain why the average earnings are well below the amount the subject would obtain were they to play the equilibrium strategies.

Turning now to the main proposition of the paper, the left panel in Fig.5 shows the distribution of the levels of differentiation obtained in each treatment to verify whether a high level of demand uncertainty yields a higher differentiation. For each treatment, we construct a Box and Whisker plot that summarizes the distribution of the levels of differentiation computed on all location pairs. It is clear that subjects differentiate more in contexts of a high level of demand uncertainty. Computation of the average level of differentiation by treatment highlights that differentiation more than doubles between the DC and HDU treatments (see Table 3, column 4). The statistical significance of this

[29]For instance, Brown-Kruse et al. (1993) demonstrate that in their setting central locations are consistent with min-max behavior; risk aversion has been suggested as a possible explanation for central location (see e.g. Collins and Sherstyuk, 2000; Mangani and Patelli, 2002; Georgantzis, 2006). In Section 4.2, we explore this explanation further.

Figure 5: Levels of Differentiation by Treatment



Notes: The distribution of the levels of differentiation for each treatment is represented by means of a Box and Whisker plot. The closed boxes are constructed from the first and third quartiles and the middle bold line indicates the median. Thus, the length of the box represents the interquartile range (IQR). The whisker lines delimit all observations within the IQR 1.5 of the nearest quartile. The circles denote outliers.

difference is confirmed by comparing the average levels of differentiation among independent matching groups. Using Mann-Whitney U tests and the alternative hypothesis delivered by the model predictions, we find that the differentiation in the HDU treatment is statistically significantly higher than in the DC (one-tailed M-W test: $p<0.0001$) and the LDU treatment (one-tailed M-W test: p=0.0002).[30] In other words, subjects faced with high demand uncertainty choose to differentiate more. These findings corroborate Prediction 1 and testify to the differentiation force exerted by demand uncertainty.[31] This provides a convincing empirical test of the attractiveness of more remote locations under demand uncertainty.

Result 1 *On average, high demand uncertainty yields higher differentiation than in the case with perfect information about demand location.*

However, the results obtained under a low level of demand uncertainty are less in line with the model predictions. As suggested by Fig.5, we find a significantly higher level of differentiation in the LDU treatment than in the DC treatment. We reject the null hypothesis of an equal level of differentiation between the LDU and DC treatments (two-tailed M-W test: p=0.0001). Although, the model predicts that a low level of

[30]Since we conduct multiple comparisons among the treatments, there is a risk of false positives. A Bonferroni correction to control for the family-wise error rate confirms that all of our results are robust.

[31]In Appendix C we show that the risk profile shares are similar among treatments which rules out composition effects as an explanation for the observed differences among treatments (Pearson chi-square test: p =0.343).

demand uncertainty does not change the level of differentiation, we observe empirically that subjects differentiate more than in the DC treatment.

Robustness analysis Because the firms are constrained to locations in the demand support, introducing demand uncertainty necessarily increases the number of location slots. It could be argued that even with perfect information about demand location, some firms might be tempted to exploit this larger differentiation space to relax the price competition.[32] Then the higher level of differentiation observed in the presence of demand uncertainty could be explained by this *longer support effect*. To test whether Result 1 is driven by this *longer support effect*, we implement an additional treatment in which the demand location is known by the firms (as in the DC treatment) but the range of the firms' possible locations is similar to the HDU treatment (i.e. 15 slots). This robustness treatment is labeled *Demand Certainty - Long Support* (DC-LS). It should be emphasized that the theoretical predictions of the DC-LS treatment are identical to those of the DC treatment, regardless of the risk preferences considered.[33]

Similar to the previous treatments, we find that most subjects are located at the center of the demand support (53% of location choices) with a few subjects choosing a location at the edges of the linear city support. The distribution of location choices is plotted in the last panel of Fig.4 and is quite close to the distribution of locations obtained in the DC treatment (Kruskal Wallis test, p=0.5144). If we compute the average level of differentiation, we find that subjects do not differentiate significantly more compared to the DC treatment: 1.01 (DC) vs 1.29 (DC-LS). Using a Mann-Whitney U test, we are not able to reject the null hypothesis of identical average levels of differentiation by matching groups between treatments at the 5% significance level (two-tailed M-W test: p=0.0667). In contrast, we observe notable differences in the levels of differentiation between the DC-LS and HDU treatments, see Fig.5, confirmed statistically by a Mann-Whitney U test (one-tailed M-W test: p <0.0001). This robustness analysis confirms that the higher level of differentiation observed in the HDU treatment is the result mainly of demand uncertainty.

4.2 The Effect of Risk Attitudes on Location Choices

Because uncertainty about demand location can have different effects on subjects' location choices depending on their attitude to risk, we next analyze how demand uncertainty af-

[32] The existence of additional location slots may encourage some subjects to choose them even if they do not correspond to the equilibrium locations. This larger choice set could lead to an adverse effect known widely as *"choice overload"* (see Chernev et al., 2015 for a recent meta-analysis).

[33] The procedure for the DC-LS treatment is similar to that implemented in the previous treatments. Overall, 6 sessions were conducted with 18 subjects per session, resulting in 108 subjects. No subject had previously participated in a similar experiment. Subjects' characteristics and risk preferences were similar to those in the previous treatments. Additional information about this treatment is available upon request from the authors.

fects location decisions by risk profile. In a preliminary step we characterize subjects' risk attitude. Using data from the risk experiment, we are able to provide an estimate of the CRRA parameter for each subject by estimating a structural model of decision-making following the modeling strategy in Harrison and Rutström (2008) and Andersen et al. (2010). We use the CRRA estimates to determine the subjects' risk profiles. Subjects are risk-lovers, risk-neutral, or risk-averse. The classification is derived by comparing the CRRA estimates with the open CRRA intervals from the risk experiment (see Appendix C for more details on the estimation method and the classification).[34] Using this classification, we first examine whether high demand uncertainty acts as a differentiation force for both risk-lovers and risk-neutral subjects as per the model predictions for the case of symmetric markets. In the next step, we compare the model predictions for symmetric markets composed of risk-averse subjects with the data. This allows us to examine how demand uncertainty affects the level of differentiation depending on the degree of subjects' risk aversion. In the last step, we study the effect of demand uncertainty on differentiation for markets in which a risk-averse subject competes with a non-risk averse subject (i.e. asymmetric markets).

In line with the model setting, these analyses use observations corresponding to either symmetric markets or asymmetric markets. This significantly reduces the size of the sample: 38.58% of the pairs of subjects (375 in a total of 972 pairs) are retained for symmetric markets and 50.21% (488 in a total of 972 pairs) are retained for asymmetric markets. It also means that we cannot compare the average level of differentiation among matching groups. We therefore conducted non-parametric tests using one observation of differentiation per pair of subjects (see Table 11 in Appendix C for detailed information on the number of pairs of subjects by risk profile).[35] This reduces the power of the statistical tests, especially when we compare the level of differentiation within a risk profile.

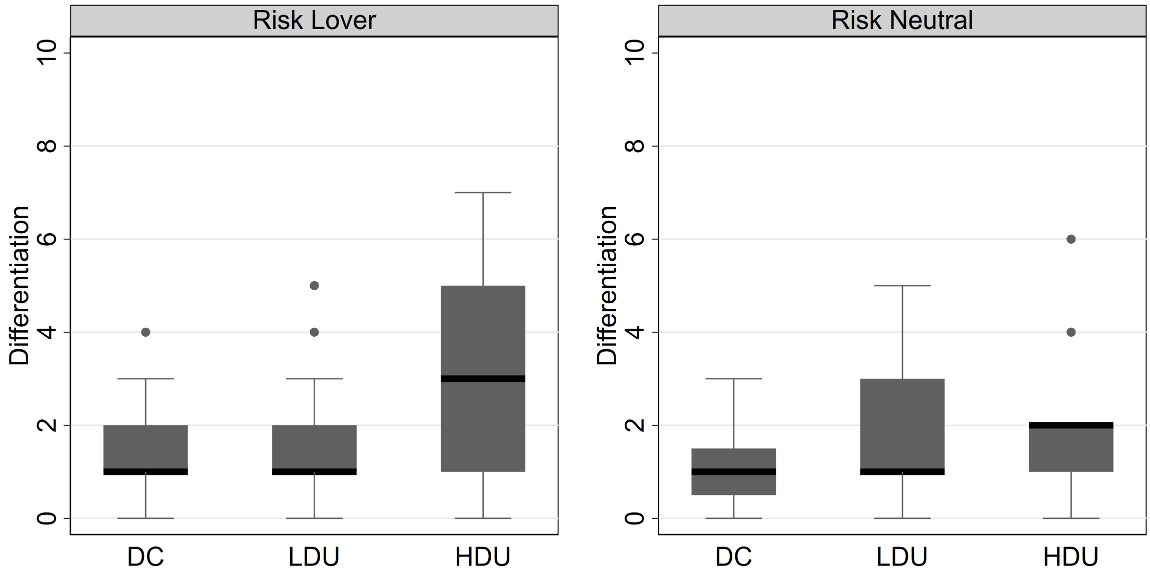
4.2.1 Demand Uncertainty and Non Risk-Averse Subjects

Fig.6 depicts the distributions for the levels of differentiation by treatment and by non risk-averse profiles. A first insight is that a high level of demand uncertainty significantly increases the level of differentiation for risk-lover and risk-neutral subjects. On average, the level of differentiation is always higher in the HDU treatment than in the DC treatment (one-tailed M-W tests: p=0.0260 for risk-lover subjects and p=0.0276 for risk-neutral subjects). Also, we observe that, on average, the introduction of a low level of demand uncertainty does not allow risk-lover and risk-neutral subjects to differentiate

[34]Note that the classification holds if we use the first switching point to determine subjects risk profiles but this method removes the heterogeneity of individual risk parameters which is needed for the subsequent analysis. Nonetheless, it should be remembered that the measure of risk preferences we obtained is only a proxy for the subjects true risk preferences which are not observable.

[35]To further check the robustness of the findings from our non-parametric tests, we also ran Tobit regression analyses at the individual level controlling for subjects' characteristics (see Appendix E).

Figure 6: Levels of Differentiation by Treatment and Non Risk-Averse Profiles



Notes: Taking account only of those markets where the subject and its rival have the same risk profile, we obtain 19, 31, and 14 pairs of observations for risk-lovers and 20, 18, and 16 pairs of observations for risk-neutral subjects for the DC, LDU and HDU treatments, respectively.

more than in the DC treatment (two-tailed M-W tests: p=0.8101 for risk-lover subjects and p=0.4315 for risk-neutral subjects). These results are consistent with Predictions 1 and 2.

Result 2 *In line with the model predictions, only a high level of demand uncertainty acts as a differentiation force for both risk-lovers and risk-neutral subjects.*

4.2.2 Demand Uncertainty and Risk-Averse Subjects

The introduction of demand uncertainty for risk-averse firms generates opposite location forces: an agglomeration force and a differentiation force. As before, demand uncertainty lessens the *demand effect*, which pushes firms to differentiate more. However, the introduction of demand uncertainty also leads risk-averse firms to secure a smaller share of demand by locating closer to the center of the demand support. Then the global effect of demand uncertainty on differentiation strategies will depend on the size of the uncertainty and the degree of the firms risk aversion. For firms that are at least risk-averse according to the terminology in Holt and Laury (2002), the model predicts that the agglomeration force predominates regardless of the size of uncertainty. However, for lower degrees of risk aversion, the marginal utility of small stakes decreases so that the forces cancel out. Further, under a high level of demand uncertainty the differentiation force may even overcome the effect of risk aversion.

We compare these predictions with subjects' decisions. Table 4 reports the average level of differentiation observed by treatment for different ranges of the CRRA parameter.

Table 4: Risk-Averse Subjects and Levels of Differentiation

CRRA parameter	Predicted effect of demand uncertainty	Empirical data: Mean differentiation – DC treatment	Empirical data: Mean differentiation – Uncertainty treat.	M-W test ($p-value$)
Panel A: LDU treatment				
$r \geq 0.90$	Agglomeration	2.43 (7)	0.67 (3)	0.0500
$r \geq 0.70$	Agglomeration	1.62 (13)	0.89 (9)	0.0795
$r \geq 0.55$	Agglomeration	1.62 (13)	1.00 (14)	0.1126
$0.18 \leq r < 0.55$	No effect	0.85 (40)	1.40 (20)	0.0693
$0.18 \leq r < 0.53$	No effect	0.86 (29)	1.27 (15)	0.1675
$0.18 \leq r < 0.40$	No effect	0.91 (11)	1.29 (7)	0.4847
Panel B: HDU treatment				
$r \geq 0.90$	Agglomeration	2.43 (7)	1.50 (6)	0.0921
$r \geq 0.70$	Agglomeration	1.62 (13)	1.50 (8)	0.5000
$r \geq 0.45$	Agglomeration	1.22 (18)	1.59 (29)	0.1976
$0.30 \leq r < 0.45$	No effect	0.73 (11)	1.95 (21)	0.0225
$0.18 \leq r < 0.30$	Differentiation	No observation		–

Notes: This table reports the predicted effect of demand uncertainty relative to the DC treatment, and the level of differentiation observed in the data for different values of the CRRA parameter. Panels A and B presents the respective results for the LDU and HDU treatments. The numbers in parentheses correspond to the number of observations for the considered case. Column 5 presents the p-values for the Mann-Whitney U test. We conducted one-tailed tests except in the case of the null hypothesis of "No effect" which required a two-tailed test.

Panel A compares the levels of differentiation observed in the LDU treatment relative to the DC treatment. We find that risk-averse subjects differentiate less, on average, compared to the DC treatment (all the one-sided tests p-values are statistically significant for $r \geq 0.7$). Conversely, for slightly risk-averse subjects, there is no significant difference in the average differentiation between the DC and LDU treatments (we are not able to reject the null hypothesis of an equal level of differentiation for $0.18 \leq r < 0.53$). However, we observe that the test of an agglomeration effect (or the absence of effect) is barely significant if we include subjects with a degree of risk aversion of around 0.55. This applies to a small number of subjects who inexplicably differentiate more when faced with demand uncertainty. Overall, our results support our predictions and are confirmed by the parametric analyses which use a larger number of observations defined at the individual level (see Appendix E).

Result 3 *A large majority of subjects behave in line with our theoretical prediction: compared to the certainty case, low demand uncertainty induces risk-averse subjects to agglomerate but does not impact the level of differentiation of slightly risk-averse subjects.*

Panel B displays the average levels of differentiation between the HDU and DC treatments. We find that only the most risk-averse subjects ($r \geq 0.9$) behave as predicted and differentiate less compared to the DC treatment (one-tailed M-W test: p=0.0921). However, the result is barely statistically significant, certainly due to the small number of observations. For lower degrees of risk aversion, we show that the level of differentiation in the HDU treatment decreases as subjects' risk aversion increases. For instance, the average level of differentiation goes from 1.95 to 1.50 moving from the less to the more risk averse pairs of subjects. However, comparison with the levels of differentiation obtained in the DC treatment does not support the prediction of an agglomeration effect (or absence of an effect) entailed by high demand uncertainty.[36]

Result 4 *In line with the model predictions, a high level of demand uncertainty pushes the highest risk-averse subjects to agglomerate. However, for lower degrees of risk aversion, subjects differentiate too much compared to the certainty case which rejects the model predictions.*

In what follows we propose several explanations for the discrepancy between the behavior of risk-averse subjects facing a high level of demand uncertainty and the model predictions.

Biased estimate of the CRRA parameter The results of Panel B show that in a presence of a high demand uncertainty risk-averse subjects do not behave as predicted, except for the most risk-averse subjects (i.e., $r \geq 0.9$). A quite high level of differentiation is observed in the HDU treatment compared to the DC treatment, especially for low levels of risk-aversion. However, the reported average levels of differentiation are below the average level computed for risk-lovers (3.14) and risk-neutral subjects (1.94) in the HDU treatment. There are two elements that might explain this tendency of risk-averse subjects to differentiate. First, it is possible that risk-averse subjects do not evaluate the opposite forces induced by high demand uncertainty correctly, and thus either underestimate the risk of loosing demand or overestimate the differentiation force of demand uncertainty. However, despite this tendency to differentiate, we can confirm that the average level of differentiation is decreasing with the degree of risk-aversion. Second, it might be that this simply indicate that the estimated CRRA parameters are only a proxy for the true individual risk preferences and therefore may be biased upward. The latter explanation seems credible since we observe a similar level of differentiation between the lowest risk-averse ($0.30 \leq r < 0.45$) and the entire sample of risk-neutral subjects (1.95 vs 1.94 on average).

Sensitivity to location choice set It is possible also that risk-averse subjects are sensitive to the size of the location choice set. Because the introduction of demand uncertainty enlarges the support of the demand, it is possible that some subjects are attracted by more remote locations. We showed previously that in the case of perfect information about demand location, subjects do not differentiate more in the presence of longer demand support, irrespective of the degree of risk aversion. However, it is

[36]Note that we cannot test the prediction that high demand uncertainty generates a differentiation effect for the least risk-averse subjects since we do not observe this market configuration in our data.

possible that depending on their risk profile subjects react differently to the enlarged location choice set. If risk-averse subjects are more attracted by these remote locations, this might explain why they differentiate more when faced with demand uncertainty. To test this conjecture, we first compare the levels of differentiation between the DC and DC-LS treatments for subjects whose behavior differs, on average, from our theoretical predictions (i.e. $0.30 \leq r < 0.9$). The result of the Mann-Whitney U test rejects the hypothesis of an equal level of differentiation between these two treatments (two-tailed M-W test: DC vs DC-LS p =0.0164), meaning that a *longer support effect* is at play for this group of risk-averse subjects. Using the DC-LS treatment as the comparison group, we next test whether these subjects differentiate more in the HDU treatment. The result of the Mann-Whitney U test indicates that there is no significant difference in the levels of differentiation between the two treatments (two-tailed M-W test: DC-LS vs HDU p =0.1578). We can conclude that the differentiation observed for both slightly risk-averse and risk-averse subjects (i.e., $0.30 \leq r < 0.9$) is explained in part by the enlarged location choice set. This finding is reinforced if we restrict the range of the CRRA parameter to $0.30 \leq r < 0.45$ (two-tailed M-W test: DC-LS vs HDU p =0.5415).[37]

Demand uncertainty and cognitive burden As mentioned above, demand uncertainty yields opposite differentiation forces for risk-averse subjects. Therefore, it is likely that subjects need time to correctly assess the intensity of each force. If so, subjects should behave more in accordance with the model predictions in the final market. To test this conjecture, we compare levels of differentiation between the DC and HDU treatments, for the first and the last markets separately. Again, we focus on subjects whose behavior on average differs from the model predictions (i.e. $0.30 \leq r < 0.9$). We find that the average level of differentiation is substantially reduced in the last compared to the first market in the HDU (1.55 vs 2.45, respectively) but the Mann-Whitney U tests reject the null hypothesis of an equal level of differentiation between the DC and HDU treatments in both markets (two-tailed M-W tests: DC vs HDU p =0.0078 for the first market and DC vs HDU p =0.0405 for the last market). However, as long as we include the least risk-averse subjects in the sample (i.e. $0.18 \leq r < 0.9$), the difference appears no more significant in the final market (two-tailed M-W tests: DC vs HDU p =0.0009 for the first market and DC vs HDU p =0.1599 for the last market). These results highlight the difficulty encountered by slightly risk-averse subjects in making a correct assessment of the opposite forces of demand uncertainty.

[37]It is important to note that the differentiation force entailed by high demand uncertainty for risk-lovers and risk-neutral subjects is not driven by the *longer support effect*. Comparison between the DC-LS and HDU treatments shows that subjects differentiate more when faced with a high level of demand uncertainty (one-tailed M-W tests: DC-LS vs HDU p =0.0030 for risk-lover subjects and p =0.0003 for risk-neutral subjects). Finally, note that because we have only one pair of highly risk-averse subjects ($r \geq 0.9$) in the DC-LS treatment, we are not able to conduct this robustness test for this risk profile.

4.2.3 Demand Uncertainty in Asymmetric Markets

The previous findings are derived from markets where both subjects have the same attitude to risk. However the location-then-price game experiment generates a larger amount of data due to the pairing of subjects with heterogeneous risk profiles (asymmetric markets). In this section, we leverage the location choices observed in these asymmetric markets to derive some more general conclusions on the effect of demand uncertainty on differentiation strategies. First, we formulate new predictions by relaxing the assumption that a subject competes with a rival with the same risk profile. We concentrate on markets composed of a pair of subjects with heterogeneous risk profiles. As before, we assume that exogenous and perfectly known risk attitudes of the subject and its rival. This could be rational for exogenous firm characteristics (owner vs. manager or entrepreneurship vs. franchisee, for instance) or observation of firm decisions in other (independent) markets, for instance. As there are numerous risk attitude combinations, we simplify the analysis by aggregating risk-lover and risk-neutral firms in a non risk-averse category.[38] The modeling framework boils down to a location-then-price game between a non risk-averse firm and a risk-averse firm which is representative of 50.21% of the experimental markets.

For low degrees of risk aversion, the model predicts that firms differentiate more(equally) when confronting high(low) demand uncertainty. We revert to the situation of both firms assumed to be risk-lovers or risk-neutral. The presence of a slightly risk-averse firm is not sufficient to deviate from the equilibria observed with symmetric non risk-averse firms. This is intuitive since we have shown that in the case of symmetric markets, in a context of demand uncertainty slightly risk-averse subjects in many cases behave similarly to non risk-averse subjects (see Table 4).

If we compare these predictions with the data, we find that high demand uncertainty yields a differentiation effect that is statistically significant at the 1% level for $0.18 \leq r < 0.41$. We confirm also that a low level of demand uncertainty has no effect on the level of differentiation compared to the DC treatment, for a definition of slightly risk-averse subjects up to $0.18 \leq r < 0.41$ (two-tailed M-W tests: DC vs LDU p =0.1129).

Result 5 *In line with the model predictions derived for asymmetric markets, a high(low) demand uncertainty drives (does not drive) differentiation for slightly risk-averse subjects competing with a non risk-averse subjects.*

For high level of risk aversion (i.e., $r \geq 0.7$), the model predicts that compared to the certainty case demand uncertainty yields an agglomeration force regardless of the size of the uncertainty. This result is driven by the location of the risk-averse firm close to the center of the demand support and the move away from the center of the demand

[38]This make sense since we show that both risk profiles differentiate more(equally) when faced with high(low) demand uncertainty compared to the certainty case.

support by the non-risk averse firm in the case only of high demand uncertainty. This results in the respective location equilibria $(x^{\star}_{L1}, x^{\star}_{L2}) = (2, 5)$ and $(x^{\star}_{H1}, x^{\star}_{H2}) = (1, 4)$ under a low and high demand uncertainty respectively, whereas in the case of demand certainty the equilibrium remains $(x^{\star}_1, x^{\star}_2) = (2, 6)$. These strategies are in line with the predictions derived with symmetric markets. However, in the asymmetric markets case, the risk-averse firm has a higher incentive to locate closer to the center of the demand support because it internalizes that the non risk-averse firm will locate away from the center under demand uncertainty.

The data clearly reject the prediction that compared to the certainty case demand uncertainty reduces the level of differentiation in asymmetric markets. For a high level of demand uncertainty, we reject the null hypothesis of a lower average level of differentiation in the HDU treatment compared to the DC treatment for all possible CRRA parameter ranges with a lower bound at 0.7 (for instance, with $r \geq 0.7$, one-tailed M-W test: $p < 0.0001$; the average level of differentiation is 1.10 and 2.42 in the DC and HDU treatments, respectively). This finding is not a surprise since we showed previously that risk-averse subjects that compete with a rival with the same risk profile differentiate more than expected (see Section 4.2.2). It would seem that the results derived so far for asymmetric markets could be rationalized by the fact that in the absence of any information on rivals risk preferences, subjects location are not altered by them. This hypothesis is confirmed by running a Tobit regression by treatment where we regress the distance (in absolute value) between the center of the demand support and the subject's location on dummies for the rival's risk profile while controlling for subjects characteristics (see Appendix F). None of the dummy variables are statistically significant meaning that on average the distance between the center of the demand support and the subject's location is the same, regardless of its rival's risk preferences. Thus, it is highly likely that without additional information on rivals' characteristics subjects will assume that their rivals behave as they do.

Last, for a low level of demand uncertainty, we find that risk averse subjects also differentiate more in the LDU treatment compared to the DC treatment (one-tailed M-W test: $p < 0.0235$ with $r \geq 0.7$) and this result is robust to other CRRA parameter ranges. This finding is at odds with the predictions based on both asymmetric and symmetric markets. The empirical results obtained using symmetric markets and non risk-averse subjects suggest that at worst there would be the same absence of an effect of low demand uncertainty. It is therefore important to not generalize the findings obtained in a symmetric markets and low demand uncertainty context to other market configurations.

Result 6 *Contrary to the model predictions derived with asymmetric markets, both low and high demand uncertainty act as a differentiation force for risk-averse subjects competing with non risk-averse subjects.*

Table 5: Differentiation and Price Competition

	All periods of the price games						
Differentiation	%	Average price	S.D.	P25	P50	P75	Distance to demand center
Panel A: DC Treatment							
0	36.73	2.62	1.47	1	2	3	0.11
1	38.27	3.44	1.50	2	3	5	0.60
2	16.05	3.90	1.70	3	4	5	1.10
3	5.86	4.39	1.70	3	4	5	1.50
4	3.09	4.67	1.84	3	5	6	2.00
Panel B: LDU Treatment							
0	23.46	2.38	1.42	1	2	3	1.16
1	33.02	2.80	1.34	2	3	4	1.14
2	24.69	3.25	1.46	2	3	4	1.48
3	8.95	3.42	1.66	2	3	5	2.12
4	5.86	3.48	1.61	2	3	5	2.42
5	3.09	3.91	1.65	3	4	5	2.50
6	0.62	3.50	1.85	2	3	5	3.00
7	0.31	3.40	1.71	2	3	4	3.50
Panel C: HDU Treatment							
0	14.81	2.09	1.31	1	2	3	2.48
1	26.85	2.59	1.46	2	2	3	2.56
2	24.38	2.49	1.40	1	2	3	2.78
3	15.12	2.91	1.52	2	3	4	2.50
4	11.73	3.32	1.74	2	3	5	3.24
5	2.78	3.83	2.06	2	4	5	4.06
6	2.47	3.88	1.96	2	4	5	4.13
7	1.23	4.13	1.57	3	4.5	5	4.50
8	0.31	3.50	2.68	1	3	6	5.00
9	0.31	2.40	0.84	2	3	3	4.50

Note: The first columns report some summary statistics on prices by level of differentiation and by treatment. The 7^{th}column reports the average distance between a subject and the demand center.

4.3 Price Competition

Because demand uncertainty is revealed before the price subgame begins, the only source of uncertainty when fixing prices arises from the random allocation of the indifferent consumer(s). It follows that addressing the issue of risk attitudes in the price competition stage is now less crucial. We therefore examine how subjects set prices conditional on their location choices by pooling all the price data, regardless of subjects' risk attitudes. The analysis is conducted separately for each treatment, since the distance between subjects and the demand center might vary significantly among treatments. Finally, recall that in the experiment, subjects compete in prices with the same rival during 5 periods. These repeated interactions might lead prices in a given market to evolve over time. The results presented below account for all the periods of the price game but, are robust to considering only the first or the last period.[39]

[39]The robustness tests and an analysis of the dynamics of price competition are provided in the Online Appendix.

Table 6: Price Regressions

Dependent variable: Price			
	DC Treatment	LDU Treatment	HDU Treatment
Differentiation	0.6231***	0.3484***	0.3229***
	(0.0448)	(0.0415)	(0.0228)
Dist. to demand center	-0.1305	-0.2833***	-0.3300***
	(0.0915)	(0.0205)	(0.0251)
Coef. risk aversion	-0.0119	0.0669	-0.0026
	(0.1122)	(0.1001)	(0.0778)
Constant	5.7286***	3.3390***	3.3038***
	(0.8024)	(0.3000)	(0.2952)
Price period FE	Yes	Yes	Yes
Matching group FE	Yes	Yes	Yes
R^2	0.3428	0.2816	0.3482
Observations	3240	3240	3240

Notes: All the regressions include subjects socio-demographic characteristics (age, gender, work, undergraduate degree, economics student). Clustered standard errors (at the group matching level) are reported in parentheses.*, **, *** indicate significance at the 10%, 5%, 1% levels, respectively.

One of the advantages of our study is that it enabled us to investigate the relationship between the level of differentiation and price competition which has been widely debated in the theoretical literature. Table 5 reports the average price by level of differentiation which allows us to examine whether high levels of differentiation enable subjects to charge higher prices. In the case of the DC treatment (Panel A), we can confirm that on average, subjects are able to reduce the price competition when differentiation increases (Spearman rank correlation coefficient, $\rho = 0.3588$; $p < 0.0001$). This result supports the positive relationship between differentiation and price and corroborates the finding in Barreda-Tarrazona et al. (2011). However, this relationship does not hold if we consider the two highest levels of differentiation observed in the LDU and HDU treatments (see Panels B and C).

One explanation might be that some subjects are too far away from the demand center for certain realizations of the demand center. Although highly differentiated from their rivals, they prefer to set low prices and to engage in a greater price competition to attract distant consumers. To control for distance from the demand center in the price setting decision, we conduct a more formal empirical analysis where the price chosen by a subject is modeled as a function of the level of differentiation, the absolute value of the distance between the subject's location and the demand center, and the subjects' characteristics while controlling for the price competition period within a market and the time-invariant effect of the matching group. We estimate this specification for each treatment, separately. Table 6 reports the estimates with robust standard errors clustered at the matching group level.

The results of the estimations show that controlling for the distance to the demand center, we obtain the standard positive relationship between differentiation and prices, regardless of the treatment. Furthermore, it is interesting to note that the delicate tradeoff between relaxing the price competition and securing a larger share of the demand is even more altered as the subject is located farther away from the demand center. This is particularly evident in the HDU treatment, where the positive effect of differentiation on price is counterbalanced by the negative impact of distance to the demand center.

Result 7 *Conditional on the distance to the demand center, we observe a positive relationship between differentiation and price.*

5 Conclusion

Since the end of the 20th century, how to position a product in the characteristics space has become a central issue for firms offering brand new products. Due to ever-evolving consumer demand, firms face considerable uncertainty about consumer tastes. In response to this demand uncertainty, multinational firms spend billions of dollars on market research to gather information on consumer preferences.

Previous research on product differentiation predicts that firms will differentiate more as uncertainty increases. The reason for this is that it is more profitable for firms to differentiate in the context of demand uncertainty because price competition is relaxed and there is no guarantee that demand will decrease.

In this paper, we empirically tested the differentiation force of demand uncertainty based on a laboratory experiment. Our laboratory setting corresponds to a discrete version of the location-then-price game in Hotelling (1929). We follow previous works and model demand uncertainty as a random shift in the support of the demand (Casado-Izaga, 2000; Meagher and Zauner, 2004, 2005). Subjects simultaneously choose their location with imperfect information on the location of demand. Then demand is revealed and the subjects set prices. The experimental data confirm the central prediction in the literature that demand uncertainty acts as a differentiate force. However, this might be hiding some heterogeneous behaviors since it is expected that a risk-averse subject is likely to react differently from a risk-lover when confronted by a random outcome. We extended the model by considering different market configurations according to subjects' risk preferences: symmetric markets in which the subject competes with a rival with the same risk profile (risk-lover, risk-neutral, or risk-averse), and asymmetric markets in which a non risk-averse subject competes with a risk-averse subject. We tested the model predictions with the data, and confirmed that high demand uncertainty yields a differentiation force for both symmetric and asymmetric markets composed of risk-neutral or risk-lover subjects. We highlighted that demand uncertainty may not necessarily lead subjects to differentiate more. In the case of sufficiently risk-averse subjects competing together, we show that demand uncertainty pushes them to agglomerate, as predicted by the model.

These findings point to the importance of the attitude to risk in analyses of differentiation strategies under demand uncertainty. Depending on their risk preferences, subjects can react in opposite directions when faced with demand uncertainty: they may locate further away from the center of the demand support thus giving more importance to the *strategic effect* or might locate closer to the center of demand thus giving more importance to the *demand effect*. These maximal and minimal differentiation strategies are observed frequently in markets with important demand uncertainty such as new growth markets (e.g. mobile apps or social media) or industries with fast-evolving tastes (e.g. food and beverages). Therefore, our findings suggest that risk preferences might provide a valid explanation for the product positioning strategies observed in these markets. We would encourage future empirical studies to control for decision makers' risk attitude. However, even in a laboratory setting measuring risk preferences is difficult due to the existence of several factors that can affect risk preferences (e.g. monetary stakes play) and that might be unobservable (e.g. wealth).

Finally, we exploited our experimental setting to revisit the standard result of IO models that price competition softens as differentiation increases. Our empirical analysis of subjects' pricing decisions confirms a positive relationship between differentiation and price. Conditional on the distance to the demand center, we find that subjects set higher prices if differentiation increases.

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Appendix

A Price Equilibrium

To determine the subgame perfect Nash equilibria (SPEs) of the location-then-price game, we have to derive the price equilibrium for each pair of locations (x_1, x_2). To this end, for each pair of locations, we first compute the firm's demand and the resulting profit for every possible price combination; then, we determine the Nash equilibrium in prices. With all the Nash equilibrium in prices in hand, we finally determine the price equilibrium of the location-then-price game.

It is, however, possible to obtain multiple price equilibria for some pairs of locations. To illustrate how we select the unique price equilibrium, we provide below a numerical example. We assume that non-risk lover firms choose the riskless option, meaning the price equilibrium which ensures an equivalent level of profit with a safe number of consumers. If the multiplicity of equilibria persists, we consider the strict Nash equilibrium. However, if there is no strict Nash equilibrium, we assume that, we select the Pareto price equilibrium. For instance, assume risk-neutral firms and the pair of locations (3,4) in the DC treatment. There are two potential Nash price equilibria. In the first equilibrium, each firm sets a price equal to 1, and the corresponding profits are (3,4). In the second one, each firm sets a price equal to 2, and the corresponding profits are (6,8). The result is that the selected price equilibrium is (2,2), as it is Pareto optimal. When no Pareto price equilibrium exists, we select the joint profit-maximizing equilibrium. Finally, it is noteworthy that a price equilibrium in pure strategy does not exist for each pair of locations. For these particular price-setting games, we thus calculate a mixed-strategies Nash equilibrium by considering all the plausible price supports, that is, all the prices that have a positive probability of being played in an equilibrium strategy.

Note that while firms choose their location with perfect knowledge about the location of demand in the DC treatment, it is unknown in the LDU and HDU treatments. The uncertainty about demand location implies several potential demand locations that we assume uniformly distributed in the computation of the expected demand and the resulting expected profit. Otherwise, we proceed in exactly the same way as in the computation of the price Nash equilibria in the three experimental treatments. Table 7 gives the equilibrium prices, the firm's demand, and the firm's profit for each pair of locations for the DC treatment under the assumption that firms are risk-neutral. The firms' profits correspond to those reported in Table 1 in the manuscript. To save space, predictions for risk-lover and high risk-averse firms in the DC treatment as well as those derived for each risk profile in the LDU and HDU treatments are reported in the Online Appendix.

Table 7: Equilibrium Prices for Each Pair of Locations and Risk-Neutral Firms (DC Treatment)

Pair of locations	Prices	Demands	Profits
Level of differentiation equal to 0			
(1,1)	(1,1)	(3.5,3.5)	(3.5,3.5)
(2,2)	(1,1)	(3.5,3.5)	(3.5,3.5)
(3,3)	(1,1)	(3.5,3.5)	(3.5,3.5)
(4,4)	(1,1)	(3.5,3.5)	(3.5,3.5)
(5,5)	(1,1)	(3.5,3.5)	(3.5,3.5)
(6,6)	(1,1)	(3.5,3.5)	(3.5,3.5)
(7,7)	(1,1)	(3.5,3.5)	(3.5,3.5)
Level of differentiation equal to 1			
(1,2)	(1,1)	(1,6)	(1,6)
(2,3)	(1,1)	(2,5)	(2,5)
(3,4)	(2,2)	(3,4)	(6,8)
(4,5)	(2,2)	(4,3)	(8,6)
(5,6)	(1,1)	(5,2)	(5,2)
(6,7)	(1,1)	(6,1)	(6,1)
Level of differentiation equal to 2			
(1,3)	([2,3][0.41,0.59],[3,4][0.86,0.14])	(2.92,4.08)	(4.71,15.88)
(2,4)	([2,4,5][0.23,0.12,0.65],[4,5,6][1,0,0])	(2.75,4.25)	(10,17)
(3,5)	([4,5,6][0.11,0.48,0.41],[4,5,6][0.11,0.48,0.41])	(3.5,3.5)	(18.2,18.2)
(4,6)	([4,5,6][1,0,0],[2,4,5][0.23,0.12,0.65])	(4.25,2.75)	(17,10)
(5,7)	([3,4][0.86,0.14],[2,3][0.41,0.59])	(4.08,2.92)	(15.88,4.71)
Level of differentiation equal to 3			
(1,4)	([2,4,5][0.16,0.07,0.76],[5,6,7][1,0,0])	(1.77,5.23)	(10,22.42)
(2,5)	([4,6][0.06,0/94],[6,7][0.33,0.67])	(3.44,3.56)	(20.01,23.65)
(3,6)	([6,7][0.33,0.67],[4,6][0.06,0/94])	(3.56,3.44)	(23.65,20.01)
(4,7)	([5,6,7]1,0,0],[2,4,5][0.16,0.07,0.76])	(5.23,1.77)	(22.42,10)
Level of differentiation equal to 4			
(1,5)	(6,7)	(3,4)	(18,28)
(2,6)	(7,7)	(3.5,3.5)	(24.5,24.5)
(3,7)	(7,6)	(4,3)	(28,18)
Level of differentiation equal to 5			
(1,6)	(7,7)	(3,4)	(21,28)
(2,7)	(7,7)	(4,3)	(28,21)
Level of differentiation equal to 6			
(1,7)	(7,7)	(3.5,3.5)	(24.5,24.5)

Notes: For price equilibria in mixed strategies we report into brackets both the prices and the associated probabilities.

B Game Equilibrium Depending on Different Degrees of Risk Aversion

In this section, we report in Table 8 the location and price equilibria by treatment and for different degrees of risk aversion. This enables us to examine the effects of demand uncertainty when considering different levels of risk aversion. For comparison purposes, we also report the equilibria obtained with the values of the CRRA parameter considered in the manuscript (see Table 2).

Table 8: Location and Price Equilibria by Treatment and Risk Attitude

Treatment	Locations	Prices	Treatment	Locations	Prices
Panel A: Risk-neutral firms			**Panel G: Risk-averse firms with** $r = 0.5$		
DC	(2,6)	(7,7)	DC	(2,6)	(7,7)
LDU	(2,6)	(7,7)	LDU	(2,6)	(7,7)
HDU	(1,7)	(7,7)	HDU	(2,5)	(5,5)
Panel B: Risk-lover firms with $r = -1.6$			**Panel H: Risk-averse firms with** $r = 0.55$		
DC	(2,6)	(8,8)	DC	(2,6)	(7,7)
LDU	(2,6)	(7,7)	LDU	(2,5)	(6,6)
HDU	(1,7)	(7,7)	HDU	(2,5)	(5,5)
Panel C: Risk-lover firms with $r = -0.2$			**Panel I: Risk-averse firms with** $r = 0.65$		
DC	(2,6)	(8,8)	DC	(2,6)	(7,7)
LDU	(2,6)	(7,7)	LDU	(2,5)	(6,6)
HDU	(1,6)	(7,7)	HDU	(2,5)	(4,4)
Panel D: Risk-averse firms with $r = 0.3$			**Panel J: Risk-averse firms with** $r = 0.7$		
DC	(2,6)	(7,7)	DC	(2,6)	(7,7)
LDU	(2,6)	(7,7)	LDU	(2,5)	(6,6)
HDU	(2,6)	(6,6)	HDU	(3,5)	(3,3)
Panel E: Risk-averse firms with $r = 0.4$			**Panel K: Risk-averse firms with** $r = 0.9$		
DC	(2,6)	(7,7)	DC	(2,6)	(7,7)
LDU	(2,6)	(7,7)	LDU	(2,5)	(6,6)
HDU	(2,6)	(5,5)	HDU	(3,5)	(2,2)
Panel F: Risk-averse firms with $r = 0.45$			**Panel L: Risk-averse firms with** $r = 0.999$		
DC	(2,6)	(7,7)	DC	(2,6)	(7,7)
LDU	(2,6)	(7,7)	LDU	(2,5)	(6,6)
HDU	(2,5)	(5,5)	HDU	(3,4)	(1,1)

C Risk

C.1 Experimental Design

A wide variety of methods could be used to elicit individuals' risk preferences. In our design, we follow the experiment of Drichoutis and Lusk (2016). Each subject completes 10 decision tasks where each task represents a choice between two binary lotteries, A and B. As shown in Table 9, the probabilities remain constant and equal to 1/2 across the decision tasks and in the lowest payoff for each lottery.

Table 9: Elicitation Task for Risk Preferences

Decision task	Lottery A		Lottery B		Expected payoff difference (A-B)	Open CRRA interval if subject switches to lottery B	
	Prob 0.5	Prob 0.5	Prob 0.5	Prob 0.5			
1	1.68	1.60	2.01	1.00	0.13	$-\infty$	-1.71
2	1.76	1.60	2.17	1.00	0.10	-1.71	-0.95
3	1.84	1.60	2.32	1.00	0.06	-0.95	-0.49
4	1.92	1.60	2.48	1.00	0.02	-0.49	-0.15
5	2.00	1.60	2.65	1.00	-0.03	-0.15	0.14
6	2.08	1.60	2.86	1.00	-0.09	0.14	0.41
7	2.16	1.60	3.14	1.00	-0.19	0.41	0.68
8	2.24	1.60	3.54	1.00	-0.35	0.68	0.97
9	2.32	1.60	4.50	1.00	-0.79	0.97	1.37
10	2.40	1.60	4.70	1.00	-0.85	1.37	$+\infty$

Note: Payoffs are in Experimental Currency Units. The last three columns report the expected payoff differences and intervals for CRRA estimates and were not shown to subjects.

Compared to the well-known Holt and Laury (2002) task, the probabilities remain constant across the 10 decision tasks, and the euro payoffs change such that the switch point from lottery A to lottery B can only be explained by the shape of the utility function and, in turn, risk attitudes. This method has the clear advantage of removing non-linear probability weighting as an explanation for the switch between lottery A and lottery B.

Previous experimental studies have underlined several switching back behaviors from lottery B to lottery A after the first switch. As noted by Andersen et al. (2006), it is quite possible that such switching behaviors are the result of subjects being indifferent between lotteries. To limit this behavior and obtain a more precise estimation of risk attitudes, we allow an explicit indifferent option for each pairwise lottery. Although it is possible for them to switch back, they also have the option of explicitly selecting indifference. The decision task is thus presented as follows:

Figure 7: Computer Screen for a Decision Task in the Risk Experiment

Subjects' choices are used to determine their risk preferences. For instance, a risk-neutral subject would choose lottery A for the first four decisions listed in Table 9 because the expected value of lottery A exceeds the expected value of lottery B for the first four choices. As one moves down each row of Table 9, the expected value of lottery B exceeds the expected value of lottery A. Thus, responses to these pairwise lottery choices allow us to estimate the coefficient of relative risk aversion for each subject.

C.2 Structural Estimation of Risk Aversion

We estimate a structural model while assuming expected utility theory. We follow the modeling strategy of Harrison and Rutström (2008) and Andersen et al. (2010) to identify risk aversion parameters for the subjects in our sample.

From Table 9, we observe that subjects face a series of lottery choices j, where a choice has to be made between two lotteries A and B: $\{(p_j^A, y_h^A; 1-p_j^A, y_l^A); (p_j^B, y_h^B; 1-p_j^B, y_l^B)\}$. Lottery A (resp. B) offers a high outcome y_h^A (resp. y_h^B) with probability $p_j^A = 1/2$ (resp. $p_j^B = 1/2$) and a low outcome y_l^A (resp. y_l^B) with probability $1 - p_j^A = 1/2$ (resp. $1 - p_j^B = 1/2$). Note that lottery B has a larger variance than lottery A. We model individual utility as suggested by expected utility. The value function is written as follows:

$$u(y) = \frac{y^{1-r}}{1-r} \tag{5}$$

where y is the lottery prize and $r \neq 1$ is a parameter to be estimated. For $r = 1$, we assume that $u(y) = ln(y)$ if needed. Thus, r is the coefficient of relative risk aversion (CRRA), with $r < 0$, $r = 0$, and $r > 0$ yielding convex, linear or concave value functions, respectively, and thus risk-lover, risk-neutral or risk-averse subjects, respectively.

We model the decision using a discrete choice model in which we consider a latent variable d^* associated with the decision process. We do not observe d^* but only the choices that subjects make:

$$d = \begin{cases} 1 & \text{if } d^* > 0 \\ 0 & \text{if } d^* \leq 0 \end{cases} \tag{6}$$

It follows that for subject i and for a given lottery $k \in \{A, B\}$, the expected utility is written as:

$$EU_{ij}^k = (p_j^k)u_i(y_h^k) + \left(1 - p_j^k\right) u_i(y_l^k) \tag{7}$$

Finally, we allow subjects to make some errors; that is, the probability of choosing a lottery is not one when the expected utility of that lottery exceeds the expected utility of the other lottery. We consider the Fechner specification popularized by Hey and Orme (1994) that implies a simple change in the difference in expected utility:

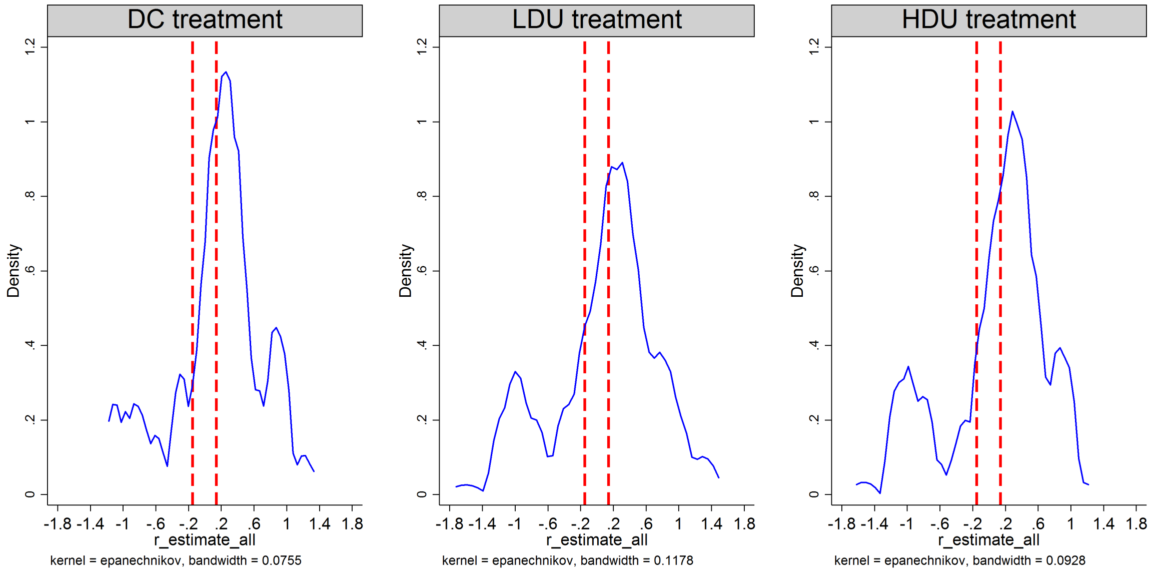
$$\nabla EU = (EU^B - EU^A)/`noise' \tag{8}$$

We estimate the CRRA parameter for each subject using a maximum likelihood estimator. The conditional log-likelihood function is written as in Eq.9, where $\Phi(\cdot)$ is the standard normal distribution function, $y_i = 1$ when lottery B is chosen, $y_i = -1$ when lottery A is chosen, $y_i = 0$ when the subject is indifferent and ∇EU is the difference in expected utility between the two lotteries.

$$\begin{aligned} ln(L(r, noise)) \;\; = \;\; & \sum_i [(\ln \Phi(\nabla EU)|y_i = 1) + (\ln \Phi(1 - \nabla EU)|y_i = -1) \\ & + (ln(1/2\Phi(\nabla EU) + 1/2\Phi(1 - \nabla EU))|y_i = 0)] \end{aligned} \tag{9}$$

The distribution of the CRRA estimates obtained in each treatment is plotted in Fig.8.

Figure 8: Estimated CCRA with a Power Function and Fechner Noise



Notes: The dashed lines represent the interval of the values of the CRRA parameter for risk-neutral subjects. Density at the left (resp. right) represents values for risk-lover (resp. risk-averse) subjects.

We observe that the densities of the CRRA estimates are similar across treatments (Kruskal Wallis test, p=0.3324). Furthermore, for each treatment, the main part of the density function lies to the right of the risk-neutral prediction, revealing a tendency toward risk-averse behavior among our participants. Using the CRRA estimates and the CRRA intervals reported in Table 9, we are able to determine the risk profile of each subject. The resulting repartition of risk profiles is reported in Table 10 by treatment. We note that the frequency of risk-lover, risk-neutral and risk-averse subjects does not notably differ across the experimental treatments (Pearson chi-square test: p =0.343). Furthermore, in each treatment, one-half of subjects is risk-averse, and the remaining subjects are almost equally divided between risk-lover and risk-neutral.

Table 10: Share of Risk Preferences by Treatment (in %)

Treatment	Risk-Lover	Risk-Neutral	Risk-Averse
DC	22.22	25.00	52.78
LDU	26.85	24.07	49.08
HDU	24.07	23.15	52.78

Finally, in Section 4.2 of the manuscript, we analyze how demand uncertainty impacts location decisions by risk profile. We first conduct the analysis by considering markets in which a subject competes with a rival of the same risk profile (i.e., symmetric markets). This selection process leads us to consider 38.58% of the pairs of subjects (375 in a total of 972 pairs). In a second step, we consider asymmetric markets composed of non risk-averse and risk-averse subjects. This corresponds to 488 pairs of subjects (50.21% of the pairs of subjects). The number of pairs of subjects by market configuration and by treatment are reported in Table 11. Note that a last market configuration, corresponding to a pairing between a risk-lover and a risk-neutral subject, is not represented in this table. It represents 109 pairs of subjects.

Table 11: Number of Pairs of Subjects Depending on Their Risk Preferences

	Identical Risk Preferences			Different Risk Preferences
Treatment	Risk-Lover	Risk-Neutral	Risk-Averse	Non Risk-Averse & Risk-Averse
DC	19	20	90	162
LDU	31	18	77	164
HDU	14	16	90	162

D Additional Tables

We present in Table 12 some descriptive statistics on subjects characteristics.

Table 12: Descriptive Statistics on Subjects Characteristics

Variable	DC treatment	LDU treatment	HDU treatment
Age	19.79	20.30	19.96
Woman	0.48	0.53	0.45
Educational level[a]			
Licence 1	0.32	0.34	0.41
Licence 2	0.36	0.27	0.27
Licence 3	0.17	0.22	0.16
Master 1	0.14	0.10	0.07
Master 2	0.00	0.03	0.05
Other	0.01	0.04	0.04
Field of study			
Economics	0.64	0.59	0.64
Administration, Economics and Social	0.01	0.00	0.02
Management	0.04	0.04	0.06
Law	0.10	0.12	0.11
Political Science	0.01	0.01	0.00
Medicine	0.01	0.03	0.00
Literature	0.01	0.02	0.01
Other	0.18	0.19	0.16
College			
University	0.98	0.94	0.92
Engineering school	0.01	0.01	0.01
Other	0.01	0.05	0.07
Labor activity	0.19	0.23	0.17
# of subjects	108	108	108

Notes: Mean of variables are reported. [a] For the educational level, once students receive their baccalaureate at the end of secondary school, they can enter the post-secondary education system (e.g., university). At this stage, they could be in first year of study (Licence 1), second year of study (Licence 2), third year of study (Licence 3; designated as a bachelor's degree). These three levels correspond to the undergraduate level. They could also be in graduate studies (first year as Master 1 or second year as Master 2).

E Tobit Estimates and Symmetric Markets - Effect of Demand Uncertainty on Location Choices

We provide in this section empirical evidence that gives support to the results of the non-parametric tests regarding the effects of risk attitudes on differentiation with symmetric markets (see Section 4.2). Indeed, for some risk profiles, the non-parametric tests are performed with a low number of observations which makes questionable the statistical power of the tests. We therefore conduct additional analyzes.

In order to overcome the problem of the low number of observations by market, we propose/construct a new measure of differentiation defined at the individual level which allows us to increase the size of the sample. This measure corresponds to the distance (in absolute value) between the center of the demand support and subject's location. It informs about the choice of the subject to locate further from the center in each market. We use this individual variable and conduct parametric analyzes by running Tobit models for different risk profiles. Precisely, we regress this distance measure against the level of demand uncertainty (a binary variable for each experimental treatment and the DC treatment taken as the reference) while controlling for subjects characteristics (CRRA parameter, age, gender, work, undergraduate, economics student) and round periods. As before, the regressions are performed using samples of subjects that compete with a rival of the same risk profile.

The estimates of the Tobit models are reported in Table 13 with robust standard errors in parentheses. The first two columns present the results of the estimation conducted with risk-lover and risk-neutral pairs of subjects. They both confirm that a high demand uncertainty significantly increases the distance variable (i.e., a proxy of the level of differentiation) for these risk profiles. Furthermore, we find no significant effect of a low demand uncertainty on differentiation. These results corroborate the findings of the non-parametric tests conducted in Section 4.2.

Columns (3-5) contain the estimation results for risk-averse subjects. We first consider the group of risk-averse subjects for which demand uncertainty does not lead to an agglomeration effect. Since there is no market in the data where both subjects have an estimated CRRA parameter below 0.3, this boils down to the case where the differentiation force of demand uncertainty is predicted to be counterbalanced by the agglomeration force of risk aversion. The sample is thus composed of subjects with a CRRA parameter between 0.30 and 0.45. The estimation results are reported in Column 3 and shows that subjects confronted to a high demand uncertainty differentiate more than in the DC treatment. This is consistent with the results of the non-parametric tests.[40] In Column 4, we consider the sample of subjects that are predicted to agglomerate when facing demand

[40] This finding is robust if we include in the sample all the subjects that are supposed to not agglomerate when facing a high level of demand uncertainty (i.e., with a CRRA parameter between 0.30 and 0.55).

Table 13: Tobit Models and Symmetric Markets

Dependent variable: Distance to the center of the demand support					
	Non Risk-Averse		Risk-Averse		
	Risk-Lover	Risk-Neutral	[0.30;0.45[	[0.55; ∞[	[0.90; ∞[
	(1)	(2)	(3)	(4)	(5)
LDU treatment	0.4895	0.5838	-0.0254	4.8999**	-2.5175***
	(0.3384)	(0.4145)	(0.4221)	(2.4351)	(0.7501)
HDU treatment	2.2449***	1.2786***	0.9907***	9.1704**	-0.8682*
	(0.5407)	(0.3651)	(0.3430)	(3.5418)	(0.4850)
LDU treatment × Coef. risk aversion				-6.3086**	
				(2.8765)	
HDU treatment × Coef. risk aversion				-9.7929**	
				(3.8297)	
Coef. risk aversion	-0.8052	0.1946	2.9004	4.0605*	-2.2389
	(0.4970)	(1.9609)	(1.9062)	(2.1617)	(1.6030)
Age	0.0500**	0.2824	0.0372	-0.1845	-0.3404*
	(0.0251)	(0.2045)	(0.0352)	(0.1375)	(0.1856)
Gender	-0.2956	-0.0074	0.7746**	0.4338	0.3686
	(0.3343)	(0.3876)	(0.2971)	(0.3338)	(0.5499)
Work	-0.9764**	-0.4174	0.1559	-0.5336	-1.5650**
	(0.4082)	(0.4734)	(0.4940)	(0.3719)	(0.6700)
Undergraduate	0.1187	0.8896	0.2288	-0.8059	-1.4985
	(0.3839)	(0.5670)	(0.3339)	(0.5394)	(1.4121)
Economics student	-0.3668	0.3810	-0.2783	0.2880	0.3568
	(0.3815)	(0.4170)	(0.3344)	(0.3781)	(0.4945)
Constant	-1.1978	-6.4455	-1.7898*	1.5411	12.8197**
	(0.8771)	(4.3074)	(1.0469)	(3.1572)	(5.6188)
σ	2.4812***	2.1624***	2.2987***	1.3060***	0.8254**
	(0.5150)	(0.4607)	(0.3921)	(0.3313)	(0.3138)
Pseudo-R^2	0.0968	0.0687	0.0702	0.1234	0.2923
Observations	128	108	140	70	32
Left-censored obs.	43	40	60	26	8

Notes: The Tobit regressions also include round dummies to control for potential learning or period effects. The estimated coefficients of the dummy variables are not shown to save space. Only the point estimate of the fourth round is significant (at the 10% level) in Columns 4 and 5. Robust standard errors reported in parentheses.*, **, *** indicate significance at the 10%, 5%, 1% level, respectively.

uncertainty (i.e., $r \geq 0.55$). In contrast to the model predictions, we find that, on average, subjects locate further away from the center of the demand support when facing demand uncertainty compared to the DC treatment. However the negative sign of the estimated coefficient(s) of the interaction terms between the LDU(HDU) treatments and the CRRA parameter indicates that the more averse subjects are, the more they locate closer to the center when facing demand uncertainty. Again, these results are in line with the results of the non-parametric tests computed with market-level data. Finally, we estimate in Column 5 a Tobit model for which we only consider high risk-averse subjects with an estimated CRRA parameter equal or above 0.90. In line with the model prediction and the non-parametric analysis, we find that on average high risk-averse subjects differentiate significantly less when facing demand uncertainty (LDU and HDU treatments) compared to the DC treatment.

F Tobit Estimates and Asymmetric Markets

We present in Table 14 the Tobit estimates where we regress the distance (in absolute value) between the center of the demand support and subject's location on its rival's risk profile. The following regressions are performed using the sample of asymmetric markets. The aim of these parametric analyzes is to test whether a subject modifies its differentiation strategy (captured here by its distance to the center of the demand support) depending on its rival's risk profile. As a subject participates in only one treatment, we perform the regressions by treatment which allows us to fully control for the effect of demand uncertainty. The specification also includes subjects characteristics (CRRA parameter, age, gender, work, undergraduate, economics student) and round periods. The size of the samples allows us to cluster standard errors at the independent matching groups level. As expected, the estimates reveal that subjects adopt the same differentiation strategy regardless of their rival's risk profile.

Table 14: Tobit Models and Asymmetric Markets

Dependent variable: Distance to the center of the demand support			
	DC treatment	LDU treatment	HDU treatment
	(1)	(2)	(3)
Risk neutral rival	-0.3059	-0.1231	-0.0923
	(0.3239)	(0.3237)	(0.2654)
Risk averse rival	-0.4002	0.5823	-0.5770
	(0.6026)	(0.3962)	(0.4034)
Coef. risk aversion	0.1965	0.3253	-0.6208**
	(0.4539)	(0.3098)	(0.2849)
Age	0.1494**	0.0278	0.0976***
	(0.0745)	(0.0265)	(0.0358)
Gender	-0.0396	0.1711	0.1176
	(0.2729)	(0.2702)	(0.2410)
Work	-0.1375	-0.1418	0.1298
	(0.2464)	(0.2637)	(0.2333)
Undergraduate	0.5727	0.1347	0.1376
	(0.3628)	(0.2946)	(0.2740)
Economics student	-0.3015	-0.0409	-0.0767
	(0.2217)	(0.2387)	(0.2749)
Constant	-3.3512**	-0.4432	-0.0149
	(1.6532)	(0.7529)	(0.9242)
σ	2.1024***	2.2499***	3.0494***
	(0.2633)	(0.2215)	(0.3506)
Pseudo-R^2	0.0327	0.0077	0.0190
Observations	324	328	324
Left-censored obs.	184	113	79

Notes: The Tobit regressions also include round dummies to control for potential learning or period effects. The estimated coefficients of the dummy variables are not shown to save space. The point estimate of the fourth, fifth and sixth round is significant in Column 1 as well as the fifth round in Column 3. Clustered standard errors at the independent matching groups level are reported in parentheses.*, **, *** indicate significance at the 10%, 5%, 1% level, respectively.

Online Appendix for Aurélie Bonein & Stéphane Turolla, "Spatial Competition with Demand Uncertainty: A Laboratory Experiment".

A Tacit Collusion

Throughout the paper, we have considered competing firms and non-cooperative equilibria. However, it is possible that firms attempt to collude by maximizing their joint profit. We examine the tacit collusion strategy with the simplifying assumption that risk preferences do not affect the collusive outcome. In addition, since firms are identical at the beginning of the game, no realistic explanations could be given for why their profits should differ at the end of the game. Thus, we restrict our theoretical resolution to the collusive strategies that provide equal profits for the two risk-neutral firms.

Under perfect information about consumer locations, the symmetric joint profit-maximizing solution is obtained for the locations $(x_1^c, x_2^c) = (2, 6)$ and prices $(p_1^c, p_2^c) = (8, 8)$. Expected profit is equal to $3.5 \times 8 = 28$ for each firm, thus yielding a joint profit equal to 56. This expected profit is much higher than that resulting from the subgame perfect Nash equilibrium (49).

The same joint profit-maximizing solution is naturally obtained in the case of a low level of demand uncertainty, thereby providing an expected profit for each firm equal to 26.4 instead of 24.5 for the non-cooperative equilibrium of risk-neutral firms.

In these two cases, the locations for colluding firms correspond to that of competing firms. Only the prices change and increase to maximize the joint profit. The prices set under collusive strategies are the highest prices that ensure full market coverage.

In the case of high demand uncertainty about consumer locations, the symmetric joint profit-maximizing solution corresponds to the subgame perfect Nash equilibrium (i.e., $(x_{H1}^c, x_{H2}^c) = (1, 7)$ and prices $(p_{H1}^c, p_{H2}^c) = (7, 7)$), providing a joint profit equal to 47.44. Any upward deviation from this price leads to a large decrease in the aggregate demand and thus in the expected profit. For this collusive strategy, the aggregate demand is equal to 6.78. If both firms deviate to a higher price, for instance, 8, the aggregate demand falls to 5.55, and this entails a lower expected profit. This results in the symmetric joint profit-maximizing outcome being necessarily the non-cooperative equilibrium.

B Equilibrium Prices and Price Equilibrium Payoffs in the DC Treatment

We report in this section the equilibrium prices and the equilibrium payoffs in the price subgame obtained for non risk-neutral subjects in the DC treatment. We limit our exposition to the values of the CRRA parameter used in Table 2 of the manuscript, i.e., $r = -0.2$ for risk-lover firms and $r = 0.9$ for high risk-averse firms.

B.1 Risk-Lover Firms ($r = -0.2$)

We report in Table 15 the equilibrium prices, the demands and the profits for each pair of locations in the DC treatment, under the assumption that firms are risk-lover with a CRRA parameter equal to -0.2. The payoff matrix for each pair of locations is given in Table 16.

Table 15: Equilibrium Prices for Each Pair of Locations and Risk-Lover Firms (DC Treatment)

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 0			
(1,1)	(2,2)	(3.5,3.5)	(9.89,9.89)
(2,2)	(2,2)	(3.5,3.5)	(9.89,9.89)
(3,3)	(2,2)	(3.5,3.5)	(9.89,9.89)
(4,4)	(2,2)	(3.5,3.5)	(9.89,9.89)
(5,5)	(2,2)	(3.5,3.5)	(9.89,9.89)
(6,6)	(2,2)	(3.5,3.5)	(9.89,9.89)
(7,7)	(2,2)	(3.5,3.5)	(9.89,9.89)
Level of differentiation equal to 1			
(1,2)	(1,2)	(4,3)	(4.72,8.22)
(2,3)	(1,2)	(4.5,2.5)	(5.26,6.60)
(3,4)	(2,2)	(3,4)	(7.15,10.10)
(4,5)	(2,2)	(4,3)	(10.10,7.15)
(5,6)	(2,1)	(2.5,4.5)	(6.60,5.26)
(6,7)	(2,1)	(3,4)	(8.22,4.72)
Level of differentiation equal to 2			
(1,3)	([3,4][0.35,0.65],[4,5][0.99,0.01])	(3.17,3.83)	(7.28,32.76)
(2,4)	([5,6][0.11,0.89],[6,7][0.99,0.01])	(2.56,4.44)	(21.63,42.92)
(3,5)	([6,7][0.93,0.07],[6,7][0.93,0.07])	(3.5,3.5)	(32.64,32.64)
(4,6)	([6,7][0.99,0.01],[5,6][0.11,0.89])	(4.44,2.56)	(42.92,21.63)
(5,7)	([4,5][0.99,0.01],[3,4][0.35,0.65])	(3.83,3.17)	(32.76,7.28)

Continued on next page

Table 15 – continued from previous page

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 3			
(1,4)	([4,5][0.11,0.89],[6,7][0.91,0.09])	(2.61,4.39)	(17.71,42.92)
(2,5)	([5,7][0.01,0.99],[7,8][0.77,0.23])	(3.13,3.87)	(33.71,45.33)
(3,6)	([7,8][0.77,0.23],[5,7][0.01,0.99])	(3.87,3.13)	(45.33,33.71)
(4,7)	([6,7][0.91,0.09],[4,5][0.89,0.11])	(4.39,2.61)	(42.92,17.71)
Level of differentiation equal to 4			
(1,5)	([4,6][0.01,0.99],[7,8][0.337,0.63])	(3.33,3.67)	(30.21,45.33)
(2,6)	(8,8)	(3.5,3.5)	(45.55,45.55)
(3,7)	([7,8][0.337,0.63],[4,6][0.01,0.99])	(3.67,3.33)	(45.33,30.21)
Level of differentiation equal to 5			
(1,6)	(7,8)	(3.5,3.5)	(38.81,45.55)
(2,7)	(8,7)	(3.5,3.5)	(45.55,38.81)
Level of differentiation equal to 6			
(1,7)	(7,7)	(3.5,3.5)	(38.81,38.81)

Notes: For equilibrium prices in mixed strategies we report into brackets both the level of prices and the associated probabilities.

Table 16: Equilibrium Payoffs in the Price Subgame and Risk-Lover Firms (DC Treatment)

	1	2	3	4	5	6	7
1	(9.89,9.89)	(4.72,8.22)	(7.28,32.76)*	(17.71,42.92)*	(30.21,45.33)*	(38.81,45.55)	(38.81,38.81)
2	(8.22,4.72)	(9.89,9.89)	(5.26,6.60)	(21.63,42.92)*	(33.71,45.33)*	(45.55,45.55)	(45.55,38.81)
3	(32.76,7.28)*	(6.60,5.26)	(9.89,9.89)	(7.15,10.11)	(32.64,32.64)*	(45.33,33.71)*	(45.33,30.21)*
4	(42.92,17.71)*	(42.92,21.63)*	(10.11,7.15)	(9.89,9.89)	(10.11,7.15)	(42.92,21.63)*	(42.92,17.71)*
5	(45.33,30.21)*	(45.33,33.71)*	(32.64,32.64)*	(7.15,10.11)	(9.89,9.89)	(6.60,5.26)	(32.76,7.28)*
6	(45.55,38.81)	(45.55,45.55)	(33.71,45.33)*	(21.63,42.92)*	(5.26,6.60)	(9.89,9.89)	(8.22,4.72)
7	(38.81,38.81)	(38.81,45.55)	(30.21,45.33)*	(17.71,42.92)*	(7.28,32.76)*	(4.72,8.22)	(9.89,9.89)

Notes: ($\star$) denote mixed strategy equilibrium.

B.2 High Risk-Averse Firms ($r = 0.9$)

We report in Table 17 the equilibrium prices, the demands and the profits for each pair of locations in the DC treatment, under the assumption that firms are highly risk-averse with a CRRA parameter equal to 0.9. The payoff matrix for each pair of locations is given in Table 18.

Table 17: Equilibrium Prices for Each Pair of Locations and High Risk-Averse Firms (DC Treatment)

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 0			
(1,1)	(1,1)	(3.5,3.5)	(6.07,6.07)
(2,2)	(1,1)	(3.5,3.5)	(6.07,6.07)
(3,3)	(1,1)	(3.5,3.5)	(6.07,6.07)
(4,4)	(1,1)	(3.5,3.5)	(6.07,6.07)
(5,5)	(1,1)	(3.5,3.5)	(6.07,6.07)
(6,6)	(1,1)	(3.5,3.5)	(6.07,6.07)
(7,7)	(1,1)	(3.5,3.5)	(6.07,6.07)
Level of differentiation equal to 1			
(1,2)	(1,1)	(1,6)	(10,11.96)
(2,3)	(2,2)	(2,5)	(11.49,12.59)
(3,4)	(2,2)	(3,4)	(11.96,12.31)
(4,5)	(2,2)	(4,3)	(12.31,11.96)
(5,6)	(2,2)	(5,2)	(12.59,11.49)
(6,7)	(1,1)	(6,1)	(11.96,10)
Level of differentiation equal to 2			
(1,3)	([2,3][0.04,0.96],[3,4][0.80,0.20])	(1.64,5.36)	(11.64,13.23)
(2,4)	([4,5][0.01,0.99],[5,6][0.90,0.10])	(2.55,4.45)	(12.87,13.64)
(3,5)	([4,5,6][0.08,0.41,0.56],[4,5,6][0.08,0.41,0.56])	(3.5,3.5)	(13.41,13.41)
(4,6)	([5,6][0.90,0.10],[4,5][0.01,0.99])	(4.45,2.55)	(13.64,12.87)
(5,7)	([3,4][0.80,0.20],[2,3][0.04,0.96])	(5.36,1.64)	(13.23,11.64)
Level of differentiation equal to 3			
(1,4)	([2,4,5][0.01,0.01,0.98],[5,6,7][0.55,0.36,0.09])	(2.32,4.67)	(12.76,13.70)
(2,5)	([4,6][0.01,0.99],[6,7][0.16,0.84])	(3.43,3.57)	(13.52,13.74)
(3,6)	([6,7][0.16,0.84],[4,6][0.01,0.99])	(3.57,3.43)	(13.74,13.52)
(4,7)	([5,6,7][0.55,0.36,0.09],[2,4,5][0.01,0.01,0.98])	(4.67,2.32)	(13.70,12.76)
Level of differentiation equal to 4			
(1,5)	(6,7)	(3,4)	(13.35,13.96)
(2,6)	(7,7)	(3.5,3.5)	(13.76,13.76)
(3,7)	(7,6)	(4,3)	(13.96,13.35)

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Table 17 – continued from previous page

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 5			
(1,6)	(7,7)	(3,4)	(13.56,13.96)
(2,7)	(7,7)	(4,3)	(13.96,13.56)
Level of differentiation equal to 6			
(1,7)	(7,7)	(3.5,3.5)	(13.76,13.76)

Notes: For equilibrium prices in mixed strategies we report into brackets both the level of prices and the associated probabilities.

Table 18: Equilibrium Payoffs in the Price Subgame and High Risk-Averse Firms (DC Treatment)

	1	2	3	4	5	6	7
1	(6.07,6.07)	(10,11.96)	(11.64,13.23)⋆	(12.76,13.70)⋆	(13.35,13.96)	(13.56,13.96)	(13.76,13.76)
2	(11.96,10)	(6.07,6.07)	(11.49,12.59)	(12.87,13.64)⋆	(13.52,13.74)⋆	(13.76,13.76)	(13.96,13.56)
3	(13.23,11.64)⋆	(12.59,11.49)	(6.07,6.07)	(11.96,12.31)	(13.41,13.41)⋆	(13.74,13.52)⋆	(13.96,13.35)
4	(13.70,12.76)⋆	(13.64,12.87)⋆	(12.31,11.96)	(6.07,6.07)	(12.31,11.96)	(13.64,12.87)⋆	(13.70,12.76)⋆
5	(13.96,13.35)	(13.74,13.52)⋆	(13.41,13.41)⋆	(11.96,12.31)	(6.07,6.07)	(12.59,11.49)	(13.23,11.64)⋆
6	(13.96,13.56)	(13.76,13.76)	(13.52,13.74)⋆	(12.87,13.64)⋆	(11.49,12.59)	(6.07,6.07)	(11.96,10)
7	(13.76,13.76)	(13.56,13.96)	(13.35,13.96)	(12.76,13.70)⋆	(11.64,13.23)⋆	(10,11.96)	(6.07,6.07)

Notes: (⋆) denote mixed strategy equilibrium.

C Equilibrium Prices and Price Equilibrium Payoffs in the LDU Treatment

We report in this section the equilibrium prices and the equilibrium payoffs in the price subgame obtained for each risk preference in the LDU treatment. In addition to the risk-neutral case, we limit our exposition to the values of the CRRA parameter used in Table 2 of the manuscript for non risk-neutral firms, i.e., $r = -0.2$ for risk-lover firms and $r = 0.9$ for high risk-averse firms.

C.1 Risk-Neutral Firms

We report in Table 19 the equilibrium prices, the demands and the profits for each pair of locations in the LDU treatment, under the assumption that firms are risk-neutral. The payoff matrix for each pair of locations is given in Table 20.

Table 19: Equilibrium Prices for Each Pair of Locations and Risk-Neutral Firms (LDU Treatment)

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 0			
(-1,-1)	(1,1)	(3.4,3.4)	(3.4,3.4)
(0,0)	(1,1)	(3.5,3.5)	(3.5,3.5)
(1,1)	(1,1)	(3.5,3.5)	(3.5,3.5)
(2,2)	(1,1)	(3.5,3.5)	(3.5,3.5)
(3,3)	(1,1)	(3.5,3.5)	(3.5,3.5)
(4,4)	(1,1)	(3.5,3.5)	(3.5,3.5)
(5,5)	(1,1)	(3.5,3.5)	(3.5,3.5)
(6,6)	(1,1)	(3.5,3.5)	(3.5,3.5)
(7,7)	(1,1)	(3.5,3.5)	(3.5,3.5)
(8,8)	(1,1)	(3.5,3.5)	(3.5,3.5)
(9,9)	(1,1)	(3.4,3.4)	(3.4,3.4)
Level of differentiation equal to 1			
(-1,0)	(1,1)	(0.2,6.8)	(0.2,6.8)
(0,1)	(1,2)	(3.8,3.2)	(3.8,6.4)
(1,2)	(1,2)	(4.1,2.9)	(4.1,5.8)
(2,3)	(1,2)	(4.5,2.5)	(4.5,5)
(3,4)	(2,2)	(3,4)	(6,8)
(4,5)	(2,2)	(4,3)	(8,6)
(5,6)	(2,1)	(2.5,4.5)	(5,4.5)
(6,7)	(2,1)	(2.9,4.1)	(5.8,4.1)
(7,8)	(2,1)	(3.2,3.8)	(6.4,3.8)
(8,9)	(1,1)	(6.8,0.2)	(6.8,0.2)

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Table 19 – continued from previous page

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 2			
(-1,1)	([1,2][0.61,0.39],[2,3][0.92,0.08])	(0.66,6.32)	(0.8,12.96)
(0,2)	([2,3][0.4,0.6],[3,4][0.94,0.06])	(1.1,5.88)	(2.63,17.94)
(1,3)	([3,4][0.23,0.77],[4,5][0.93,0.07])	(1.75,5.23)	(6.12,21.23)
(2,4)	([2,4][0.03,0.97],[5,6][0.90,0.10])	(2.57,4.41)	(12.74,22.42)
(3,5)	([4,6][0.14,0.86],[5,6][0.33,0.67])	(3.57,3.43)	(20,19.29)
(4,6)	([5,6][0.90,0.10],[2,4][0.03,0.97])	(4.41,2.57)	(22.42,12.74)
(5,7)	([4,5][0.93,0.07],[3,4][0.23,0.77])	(5.23,1.75)	(21.23,6.12)
(6,8)	([3,4][0.94,0.06],[2,3][0.4,0.6])	(5.88,1.1)	(17.94,2.63)
(7,9)	([2,3][0.92,0.08],[1,2][0.61,0.39])	(6.32,0.66)	(12.96,0.8)
Level of differentiation equal to 3			
(-1,2)	([2,4][0.22,0.78],[4,5][1,0])	(0.74,6.06)	(2.4,24.26)
(0,3)	([3,5][0.07,0.93],[5,6][1,0])	(0.98,5.82)	(6,27.72)
(1,4)	([3,6][0.17,0.83],[5,6][0.82,0.18])	(1.96,5)	(10.04,25.79)
(2,5)	(6,6)	(3,4)	(18,24)
(3,6)	(6,6)	(4,3)	(24,18)
(4,7)	([5,6][0.82,0.18],[3,6][0.17,0.83])	(5,1.96)	(25.79,10.04)
(5,8)	([5,6][1,0],[3,5][0.07,0.93])	(5.82,0.98)	(27.72,6)
(6,9)	([4,5][1,0],[2,4][0.22,0.78])	(6.06,0.74)	(24.26,2.4)
Level of differentiation equal to 4			
(-1,3)	([3,4][0.18,0.82],[4,7][1,0])	(2.59,4.41)	(3.6,24.18)
(0,4)	(5,6)	(2,4.8)	(10,28.8)
(1,5)	(6,6)	(2.5,4.5)	(15,27)
(2,6)	(7,7)	(3.5,3.5)	(24.5,24.5)
(3,7)	(6,6)	(4.5,2.5)	(27,15)
(4,8)	(6,5)	(4.8,2)	(28.8,10)
(5,9)	([4,7][1,0],[3,4][0.18,0.82])	(4.41,2.59)	(24.18,3.6)
Level of differentiation equal to 5			
(-1,4)	(5,6)	(1.6,5.2)	(8,31.2)
(0,5)	(5,6)	(2.5,4.5)	(12.5,27)
(1,6)	(7,7)	(3,4)	(21,28)
(2,7)	(7,7)	(4,3)	(28,21)
(3,8)	(6,5)	(4.5,2.5)	(27,12.5)
(4,9)	(6,5)	(5.2,1.6)	(31.2,8)
Level of differentiation equal to 6			
(-1,5)	(5,7)	(2.5,4.3)	(12.5,30.1)
(0,6)	(6,7)	(3,4)	(18,28)
(1,7)	(7,7)	(3.5,3.5)	(24.5,24.5)
(2,8)	(7,6)	(4,3)	(28,18)
(3,9)	(7,5)	(4.3,2.5)	(30.1,12.5)

Continued on next page

Table 19 – continued from previous page

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 7			
(-1,6)	(6,7)	(2.5,4.5)	(15,31.5)
(0,7)	(7,7)	(3,4)	(21,28)
(1,8)	(7,7)	(4,3)	(28,21)
(2,9)	(7,6)	(4.5,2.5)	(31.5,15)
Level of differentiation equal to 8			
(-1,7)	(6,7)	(3,4)	(18,28)
(0,8)	(7,6)	(3,4)	(21,24)
(1,9)	(7,6)	(4,3)	(28,18)
Level of differentiation equal to 9			
(-1,8)	(6,6)	(3,4)	(18,24)
(0,9)	(6,6)	(4,3)	(24,18)
Level of differentiation equal to 10			
(-1,9)	(5,6)	(4,3)	(20,18)

Notes: For equilibrium prices in mixed strategies we report into brackets both the level of prices and the associated probabilities.

Table 20: Equilibrium Payoffs in the Price Subgame and Risk-Neutral Firms (LDU Treatment)

	-1	0	1	2	3	4	5	6	7	8	9
-1	(3.4,3,4)	(0.2,6.8)	(0.8,12,9)*	(2,4,24.3)*	(3.6,24.2)*	(8,31.2)	(12.5,30.1)	(15,31.5)	(18,28)	(18,24)	(20,18)
0	(6.8,0.2)	(3.5,3.5)	(3.8,6.4)	(2.6,17.9)*	(6,27.7)*	(10,28.8)	(12.5,27)	(18,28)	(21,28)	(21,24)	(24,18)
1	(12.9,0.8)*	(6.4,3.8)	(3.5,3.5)	(4.1,5.8)	(6.1,21.2)*	(10,25.8)*	(15,27)	(21,28)	(24.5,24.5)	(28,21)	(28,18)
2	(24.3,2.4)*	(17.9,2.6)*	(5.8,4.1)	(3.5,3.5)	(4.5,5)	(12.7,22.4)*	(18,24)	(24.5,24.5)	(28,21)	(28,18)	(31.5,15)
3	(24.2,3.6)*	(27.7,6) *	(21.2,6.1)*	(5,4.5)	(3.5,3.5)	(6,8)	(20,19.3)*	(24,18)	(27,15)	(27,12.5)	(30.1,12.5)
4	(31.2,8)	(28.8,10)	(25.8,10)*	(22.4,12.7)*	(8,6)	(3.5,3.5)	(8,6)	(22.4,12.7)*	(25.8,10)*	(28.8,10)	(31.2,8)
5	(30.1,12.5)	(27,12.5)	(27,15)	(24,18)	(19.3,20)*	(6,8)	(3.5,3.5)	(5,4.5)	(21.2,6.1)*	(27.7,6)*	(24.2,3.6)*
6	(31.5,15)	(28,18)	(28,21)	(24.5,24.5)	(18,24)	(12.7,22.4)*	(4.5,5)	(3.5,3.5)	(5.8,4.1)	(17.9,2.6)*	(24.3,2.4)*
7	(28,18)	(28,21)	(24.5,24.5)	(21,28)	(15,27)	(10,25.8)*	(6.1,21.2)*	(4.1,5.8)	(3.5,3.5)	(6.4,3.8)	(12.9,0.8)*
8	(24,18)	(21,24)	(21,28)	(18,28)	(12.5,27)	(10,28.8)	(6,27.7)*	(2.6,17.9)*	(3.8,6.4)	(3.5,3.5)	(6.8,0.2)
9	(18,20)	(18,24)	(18,28)	(15,31.5)	(12.5,30.1)	(8,31.2)	(3.6,24.2)*	(2.4,24.3)*	(0.8,12.9)*	(0.2,6.8)	(3.4,3.4)

Notes: ($\star$) denote mixed strategy equilibrium.

C.2 Risk-Lover Firms ($r = -0.2$)

We report in Table 21 the equilibrium prices, the demands and the profits for each pair of locations in the LDU treatment, under the assumption that firms are risk-lover with a CRRA parameter equal to -0.2. The payoff matrix for each pair of locations is given in Table 22.

Table 21: Equilibrium Prices for Each Pair of Locations and High Risk-Lover Firms (LDU Treatment)

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 0			
(-1,-1)	(2,2)	(3.2,3.2)	(8.9,8.9)
(0,0)	(2,2)	(3.4,3.4)	(9.56,9.56)
(1,1)	(2,2)	(3.5,3.5)	(9.89,9.89)
(2,2)	(2,2)	(3.5,3.5)	(9.89,9.89)
(3,3)	(2,2)	(3.5,3.5)	(9.89,9.89)
(4,4)	(2,2)	(3.5,3.5)	(9.89,9.89)
(5,5)	(2,2)	(3.5,3.5)	(9.89,9.89)
(6,6)	(2,2)	(3.5,3.5)	(9.89,9.89)
(7,7)	(2,2)	(3.5,3.5)	(9.89,9.89)
(8,8)	(2,2)	(3.4,3.4)	(9.56,9.56)
(9,9)	(2,2)	(3.2,3.2)	(8.9,8.9)
Level of differentiation equal to 1			
(-1,0)	(1,2)	(3.5,3.3)	(4.24,9.22)
(0,1)	(1,2)	(3.8,3.2)	(4.58,8.89)
(1,2)	(1,2)	(4.1,2.9)	(4.89,7.93)
(2,3)	(1,2)	(4.5,2.5)	(5.33,6.68)
(3,4)	(2,2)	(3,4)	(7.36,10.26)
(4,5)	(2,2)	(4,3)	(10.26,7.36)
(5,6)	(2,1)	(2.5,4.5)	(6.68,5.33)
(6,7)	(2,1)	(2.9,4.1)	(7.93,4.89)
(7,8)	(2,1)	(3.2,3.8)	(8.89,4.58)
(8,9)	(2,1)	(3.3,3.5)	(9.22,4.24)
Level of differentiation equal to 2			
(-1,1)	([1,2][0.71,0.29],[2,3][0.92,0.08])	(0.72,6.26)	(1.46,17.98)
(0,2)	([2,4][0.49,0.51],[3,4][0.97,0.03])	(0.95,6.05)	(2.95,27.39)
(1,3)	([3,4][0.28,0.72],[4,5][0.91,0.09])	(1.8,5.18)	(8.72,32.73)
(2,4)	([4,5][0.04,0.96],[5,6][0.87,0.13])	(2.59,4.39)	(18.63,35.25)
(3,5)	([4,6][0.12,0.88],[5,6][0.29,0.71])	(3.56,3.44)	(31.35,29.79)
(4,6)	([5,6][0.87,0.13],[4,5][0.04,0.96])	(4.39,2.59)	(35.25,18.63)
(5,7)	([4,5][0.91,0.09],[3,4][0.28,0.72])	(5.18,1.8)	(32.73,8.72)
(6,8)	([3,4][0.97,0.03],[2,4][0.49,0.51])	(6.05,0.95)	(27.39,2.95)
(7,9)	([2,3][0.92,0.08],[1,2][0.71,0.29])	(6.26,0.72)	(17.98,1.46)

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Table 21 – continued from previous page

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 3			
(-1,2)	([2,4][0.27,0.73],[4,5][0.96,0.04])	(0.79,5.99)	(2.96,38.14)
(0,3)	([3,5][0.09,0.91],[5,6][0.94,0.06])	(1.02,5.76)	(8.25,44.97)
(1,4)	([3,6][0.21,0.79],[5,6][0.68,0.32])	(2.13,4.8)	(15.07,41.04)
(2,5)	(6,6)	(3,4)	(27.49,38.35)
(3,6)	(6,6)	(4,3)	(38.35,27.49)
(4,7)	([5,6][0.68,0.32],[3,6][0.21,0.79])	(4.8,2.13)	(41.04,15.07)
(5,8)	([5,6][0.94,0.06],[3,5][0.09,0.91])	(5.76,1.02)	(44.97,8.25)
(6,9)	([4,5][0.96,0.04],[2,4][0.27,0.73])	(5.99,0.79)	(38.14,2.96)
Level of differentiation equal to 4			
(-1,3)	([3,4][0.22,0.78],[4,7][0.97,0.03])	(2.65,4.35)	(4.71,38.18)
(0,4)	(5,6)	(2,4.8)	(14.16,47.34)
(1,5)	(6,6)	(2.5,4.5)	(22.56,44.09)
(2,6)	(7,7)	(3.5,3.5)	(39.61,39.61)
(3,7)	(6,6)	(4.5,2.5)	(44.09,22.56)
(4,8)	(6,5)	(4.8,2)	(47.34,14.16)
(5,9)	([4,7][0.97,0.03],[3,4][0.22,0.78])	(4.35,2.65)	(38.18,4.71)
Level of differentiation equal to 5			
(-1,4)	(5,6)	(1.6,5.2)	(11.12,52.06)
(0,5)	(6,7)	(2.5,4.3)	(22.56,50.1)
(1,6)	(7,7)	(3,4)	(33.08,46.14)
(2,7)	(7,7)	(4,3)	(46.14,33.08)
(3,8)	(7,6)	(4.3,2.5)	(50.1,22.56)
(4,9)	(6,5)	(5.2,1.6)	(52.06,11.12)
Level of differentiation equal to 6			
(-1,5)	(5,7)	(2.5,4.3)	(18.12,50.1)
(0,6)	(6,7)	(3,4)	(27.49,46.14)
(1,7)	(7,7)	(3.5,3.5)	(39.61,39.61)
(2,8)	(7,6)	(4,3)	(46.14,27.49)
(3,9)	(7,5)	(4.3,2.5)	(50.1,18.12)
Level of differentiation equal to 7			
(-1,6)	(6,7)	(2.5,4.5)	(22.56,53.05)
(0,7)	(7,7)	(3,4)	(33.08,46.14)
(1,8)	(7,7)	(4,3)	(46.14,33.08)
(2,9)	(7,6)	(4.5,2.5)	(53.05,22.56)
Level of differentiation equal to 8			
(-1,7)	(6,7)	(3,4)	(27.49,46.14)
(0,8)	(6,7)	(4,3)	(38.35,33.08)

Continued on next page

Table 21 – continued from previous page

Pairs of locations	Prices	Demands	Profits
(1,9)	(7,6)	(4,3)	(46.14,27.49)
Level of differentiation equal to 9			
(-1,8)	(6,6)	(3,4)	(27.49,38.35)
(0,9)	(6,6)	(4,3)	(38.35,27.49)
Level of differentiation equal to 10			
(-1,8)	(5,6)	(4,3)	(30.81,27.49)

Notes: For equilibrium prices in mixed strategies we report into brackets both the level of prices and the associated probabilities.

Table 22: Equilibrium Payoffs in the Price Subgame and Risk-Lover Firms (LDU Treatment)

	-1	0	1	2	3	4	5	6	7	8	9
-1	(8.9,8.9)	(4.2,9.2)	(1.5,18)*	(3,38.1)*	(4.7,38.2)*	(11.1,52.1)	(18.1,50.1)	(22.5,53)	(27.5,46.1)	(27.5,38.3)	(30.8,27.5)
0	(9.2,4.2)	(9.6,9.6)	(4.6,8.9)	(2.9,27.4)*	(8.2,45)*	(14.2,47.3)	(22.5,50.1)	(27.5,46.1)	(33.1,46.1)	(38.3,33.1)	(38.3,27.5)
1	(18,1.5)*	(8.9,4.6)	(9.9,9.9)	(4.9,7.9)	(8.7,32.7)*	(15.1,41)*	(22.5,44.1)	(33.1,46.1)	(39.6,39.6)	(46.1,33.1)	(46.1,27.5)
2	(38.1,3)*	(27.4,2.9)*	(7.9,4.9)	(9.9,9.9)	(5.3,6.7)	(18.6,35.2)*	(27.5,38.3)	(39.6,39.6)	(46.1,33.1)	(46.1,27.4)	(53,22.5)
3	(38.2,4.7)*	(45,8.2)*	(32.7,8.7)*	(6.7,5.3)	(9.9,9.9)	(7.3,10.3)	(31.3,29.8)*	(38.3,27.5)	(44.1,22.5)	(50.1,22.5)	(50.1,18.1)
4	(52.1,11.1)	(47.3,14.2)	(41,15.1)*	(35.2,18.6)*	(10.3,7.3)	(9.9,9.9)	(10.3,7.3)	(35.2,18.6)*	(41,15.1)*	(47.3,14.2)	(52.1,11.1)
5	(50.1,18.1)	(50.1,22.5)	(44.1,22.5)	(38.3,27.5)	(29.8,31.3)*	(7.3,10.3)	(9.9,9.9)	(6.7,5.3)	(32.7,8.7)*	(45,8.2)*	(38.2,4.7)*
6	(53,22.5)	(46.1,27.5)	(46.1,33.1)	(39.6,39.6)	(27.5,38.3)	(18.6,35.2)*	(5.3,6.7)	(9.9,9.9)	(7.9,4.9)	(27.4,2.9)*	(38.1,3)*
7	(46.1,27.5)	(46.1,33.1)	(39.6,39.6)	(33.1,46.1)	(22.5,44.1)	(15.1,41)*	(8.7,32.7)*	(4.9,7.9)	(9.9,9.9)	(8.9,4.6)	(18,1.5)*
8	(38.3,27.5)	(33.1,38.3)	(33.1,46.1)	(27.4,46.1)	(22.5,50.1)	(14.2,47.3)	(8.2,45)*	(2.9,27.4)*	(4.6,8.9)	(9.5,9.5)	(9.2,4.2)
9	(27.5,30.8)	(27.5,38.3)	(27.5,46.1)	(22.5,53)	(18.1,50.1)	(11.1,52.1)	(4.7,38.2)*	(3,38.1)*	(1.5,18)*	(4.2,9.2)	(8.9,8.9)

Notes: ($\star$) denote mixed strategy equilibrium.

C.3 High Risk-Averse Firms ($r = 0.9$)

We report in Table 23 the equilibrium prices, the demands and the profits for each pair of locations in the LDU treatment, under the assumption that firms are highly risk-averse with a CRRA parameter equal to 0.9. The payoff matrix for each pair of locations is given in Table 24.

Table 23: Equilibrium Prices for Each Pair of Locations and High Risk-Averse Firms (LDU Treatment)

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 0			
(-1,-1)	(1,1)	(3.4,3.4)	(6.05,6.05)
(0,0)	(1,1)	(3.5,3.5)	(6.07,6.07)
(1,1)	(1,1)	(3.5,3.5)	(6.07,6.07)
(2,2)	(1,1)	(3.5,3.5)	(6.07,6.07)
(3,3)	(1,1)	(3.5,3.5)	(6.07,6.07)
(4,4)	(1,1)	(3.5,3.5)	(6.07,6.07)
(5,5)	(1,1)	(3.5,3.5)	(6.07,6.07)
(6,6)	(1,1)	(3.5,3.5)	(6.07,6.07)
(7,7)	(1,1)	(3.5,3.5)	(6.07,6.07)
(8,8)	(1,1)	(3.5,3.5)	(6.07,6.07)
(9,9)	(1,1)	(3.4,3.4)	(6.05,6.05)
Level of differentiation equal to 1			
(-1,0)	(1,1)	(0.2,6.8)	(2,12.11)
(0,1)	(1,1)	(0.6,6.4)	(4.14,12.03)
(1,2)	(1,1)	(1.2,5.8)	(6.38,11.9)
(2,3)	(1,1)	(2,5)	(8.67,11.7)
(3,4)	(2,2)	(3,4)	(11.81,12.23)
(4,5)	(2,2)	(4,3)	(12.23,11.81)
(5,6)	(1,1)	(5,2)	(11,7,8.67)
(6,7)	(1,1)	(5.8,1.2)	(11.9,6.38)
(7,8)	(1,1)	(6.4,0.6)	(12.03,4.14)
(8,9)	(1,1)	(6.8,0.2)	(12.11,2)
Level of differentiation equal to 2			
(-1,1)	(1,2)	(0.6,6.4)	(4.14,12.89)
(0,2)	(1,2)	(1.2,5.8)	(6.38,12.75)
(1,3)	(1,2)	(2,5)	(8.67,12.54)
(2,4)	(2,3)	(3,4)	(11.81,12.74)
(3,5)	([2,4][0.04,0.96],[2,4][0.04,0.96])	(3.5,3.5)	(12.6,12.6)
(4,6)	(3,2)	(4,3)	(12.74,11.81)
(5,7)	(2,1)	(5,2)	(12.54,8.67)
(6,8)	(2,1)	(5.8,1.2)	(12.75,6.38)
(7,9)	(2,1)	(6.4,0.6)	(12.89,4.14)

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Table 23 – continued from previous page

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 3			
(-1,2)	(1,3)	(1.2,5.8)	(6.38,13.28)
(0,3)	(1,3)	(2,5)	(8.67,13.06)
(1,4)	(2,4)	(3,4)	(11.81,13.11)
(2,5)	(6,6)	(3,4)	(13.18,13.66)
(3,6)	(6,6)	(4,3)	(13.66,13.18)
(4,7)	(4,2)	(4,3)	(13.11,11.81)
(5,8)	(3,1)	(5,2)	(13.06,8.67)
(6,9)	(3,1)	(5.8,1.2)	(13.28,6.38)
Level of differentiation equal to 4			
(-1,3)	(1,4)	(2,5)	(8.67,13.44)
(0,4)	(2,5)	(3,4)	(11.81,13.41)
(1,5)	(5,6)	(3,4)	(12.95,13.65)
(2,6)	(6,6)	(3.5,3.5)	(13.42,13.42)
(3,7)	(6,5)	(4,3)	(13.65,12.95)
(4,8)	(5,2)	(3,4)	(13.41,11.81)
(5,9)	(4,1)	(5,2)	(13.44,8.67)
Level of differentiation equal to 5			
(-1,4)	(2,6)	(3,3.8)	(11.81,13.6)
(0,5)	(4,6)	(3,4)	(12.66,13.66)
(1,6)	(6,6)	(3,4)	(13.18,13.66)
(2,7)	(6,6)	(4,3)	(13.66,13.18)
(3,8)	(6,4)	(4,3)	(13.66,12.66)
(4,9)	(6,2)	(3.8,3)	(13.6,11.81)
Level of differentiation equal to 6			
(-1,5)	(3,6)	(3,4)	(12.3,13.66)
(0,6)	(6,7)	(3,4)	(13.18,13.87)
(1,7)	(6,6)	(3.5,3.5)	(13.42,13.42)
(2,8)	(7,6)	(4,3)	(13.87,13.18)
(3,9)	(6,3)	(4,3)	(13.66,12.3)
Level of differentiation equal to 7			
(-1,6)	(5,7)	(3,4)	(12.95,13.87)
(0,7)	(6,6)	(3,4)	(13.18,13.66)
(1,8)	(6,6)	(4,3)	(13.66,13.18)
(2,9)	(7,5)	(4,3)	(13.87,12.95)
Level of differentiation equal to 8			
(-1,7)	(6,7)	(3,4)	(13.18,13.87)
(0,8)	(6,6)	(3.5,3.5)	(13.42,13.42)

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Table 23 – continued from previous page

Pairs of locations	Prices	Demands	Profits
(1,9)	(7,6)	(4,3)	(13.87,13.18)
Level of differentiation equal to 9			
(-1,8)	(6,6)	(3,4)	(13.18,13.66)
(0,9)	(6,6)	(4,3)	(13.66,13.18)
Level of differentiation equal to 10			
(-1,9)	(5,6)	(4,3)	(13.41,13.18)

Notes: For equilibrium prices in mixed strategies we report into brackets both the level of prices and the associated probabilities.

Table 24: Equilibrium Payoffs in the Price Subgame and High Risk-Averse Firms (LDU Treatment)

	-1	0	1	2	3	4	5	6	7	8	9
-1	(6,6)	(2,12.1)	(4.1,12.9)	(6.4,13.3)	(8.7,13.4)	(11.8,13.6)	(12.3,13.7)	(12.9,13.9)	(13.2,13.9)	(13.2,13.6)	(13.4,13.2)
0	(12.1,2)	(6.1,6.1)	(4.1,12)	(6.4,12.7)	(8.7,13.1)	(11.8,13.4)	(12.7,13.7)	(13.2,13.9)	(13.2,13.7)	(13.4,13.4)	(13.7,13.2)
1	(12.9,4.1)	(12,4.1)	(6.1,6.1)	(6.4,11.9)	(8.7,12.5)	(11.8,13.1)	(12.9,13.7)	(13.2,13.7)	(13.4,13.4)	(13.7,13.2)	(13.9,13.2)
2	(13.3,6.4)	(12.7,6.4)	(11.9,6.4)	(6.1,6.1)	(8.7,11.7)	(11.8,12.7)	(13.2,13.7)	(13.4,13.4)	(13.7,13.2)	(13.9,13.2)	(13.9,12.9)
3	(13.4,8.7)	(13.1,8.7)	(12.5,8.7)	(11.7,8.7)	(6.1,6.1)	(11.8,12.2)	(12.6,12.6)*	(13.7,13.2)	(13.7,12.9)	(13.7,12.7)	(13.7,12.3)
4	(13.6,11.8)	(13.4,11.8)	(13.1,11.8)	(12.7,11.8)	(12.2,11.8)	(6.1,6.1)	(12.2,11.8)	(12.7,11.8)	(13.1,11.8)	(13.4,11.8)	(13.6,11.8)
5	(13.7,12.3)	(13.7,12.7)	(13.7,12.9)	(13.7,13.2)	(12.6,12.6)*	(11.8,12.2)	(6.1,6.1)	(11.7,8.7)	(12.5,8.7)	(13.1,8.7)	(13.4,8.7)
6	(13.9,12.9)	(13.9,13.2)	(13.7,13.2)	(13.4,13.4)	(13.2,13.7)	(11.8,12.7)	(8.7,11.7)	(6.1,6.1)	(11.9,6.4)	(12.7,6.4)	(13.3,6.4)
7	(13.9,13.2)	(13.7,13.2)	(13.4,13.4)	(13.2,13.7)	(12.9,13.7)	(11.8,13.1)	(8.7,12.5)	(6.4,11.9)	(6.1,6.01)	(12,4.1)	(12.9,4.1)
8	(13.7,13.2)	(13.4,13.4)	(13.2,13.7)	(13.2,13.9)	(12.7,13.7)	(11.8,13.4)	(8.7,13.1)	(6.4,12.7)	(4.1,12)	(6.1,6.1)	(12.11,2)
9	(13.2,13.4)	(13.2,13.7)	(13.2,13.9)	(12.9,13.9)	(12.3,13.7)	(11.8,13.6)	(8.7,13.4)	(6.4,13.3)	(4.1,12.9)	(2,12.1)	(6,6)

Notes: ($\star$) denote mixed strategy equilibrium.

D Equilibrium Prices and Price Equilibrium Payoffs in the HDU Treatment

We report in this section the equilibrium prices and the equilibrium payoffs in the price subgame obtained for each risk preference in the HDU treatment. In addition to the risk-neutral case, we limit our exposition to the values of the CRRA parameter used in Table 2 of the manuscript for non risk-neutral firms, i.e., $r = -0.2$ for risk-lover firms and $r = 0.9$ for high risk-averse firms.

D.1 Risk-Neutral Firms

We report in Table 25 the equilibrium prices, the demands and the profits for each pair of locations in the HDU treatment, under the assumption that firms are risk-neutral. The payoff matrix for each pair of locations is given in Table 26.

Table 25: Equilibrium Prices for Each Pair of Locations and Risk-Neutral Firms (HDU Treatment)

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 0			
(-3,-3)	(1,1)	(2.67,2.67)	(2.67,2.67)
(-1,-1)	(1,1)	(2.94,2.94)	(2.94,2.94)
(-1,-1)	(1,1)	(3.17,3.17)	(3.17,3.17)
(0,0)	(1,1)	(3.33,3.33)	(3.33,3.33)
(1,1)	(1,1)	(3.44,3.44)	(3.44,3.44)
(2,2)	(1,1)	(3.5,3.5)	(3.5,3.5)
(3,3)	(1,1)	(3.5,3.5)	(3.5,3.5)
(4,4)	(1,1)	(3.5,3.5)	(3.5,3.5)
(5,5)	(1,1)	(3.5,3.5)	(3.5,3.5)
(6,6)	(1,1)	(3.5,3.5)	(3.5,3.5)
(7,7)	(1,1)	(3.44,3.44)	(3.44,3.44)
(8,8)	(1,1)	(3.33,3.33)	(3.33,3.33)
(9,9)	(1,1)	(3.17,3.17)	(3.17,3.17)
(10,10)	(1,1)	(2.94,2.94)	(2.94,2.94)
(11,11)	(1,1)	(2.67,2.67)	(2.67,2.67)
Level of differentiation equal to 1			
(-3,-2)	(1,1)	(0.11,5.78)	(0.11,5.78)
(-2,-1)	(1,1)	(0.33,6)	(0.33,6)
(-1,0)	(1,1)	(0.67,6)	(0.67,6)
(0,1)	(1,1)	(1.11,5.78)	(1.11,5.78)
(1,2)	(1,1)	(1.67,5.33)	(1.67,5.33)
(2,3)	(2,2)	(2.34,4.66)	(4.67,9.33)
(3,4)	(2,2)	(3.11,3.89)	(6.22,7.78)

Continued on next page

Table 25 – continued from previous page

Pairs of locations	Prices	Demands	Profits
(4,5)	(2,2)	(3.89,3.11)	(7.78,6.22)
(5,6)	(2,2)	(4.66,2.34)	(9.33,4.67)
(6,7)	(1,1)	(5.33,1.67)	(5.33,1.67)
(7,8)	(1,1)	(5.78,1.11)	(5.78,1.11)
(8,9)	(1,1)	(6,0.67)	(6,0.67)
(9,10)	(1,1)	(6,0.33)	(6,0.33)
(10,11)	(1,1)	(5.78,0.11)	(5.78,0.11)
Level of differentiation equal to 2			
(-3,-1)	([1,3][0.51,0.49],[2,3][1,0])	(0.22,5.66)	(0.33,11.33)
(-2,0)	([3,4][0.07,0.93],[4,5][1,0])	(0.51,4.82)	(2,19.28)
(-1,1)	([3,4][0.11,0.89],[4,5][0.96,0.04])	(0.93,4.93)	(3.44,19.90)
(0,2)	([3,4][0.14,0.86],[4,5][0.89,0.11])	(1.49,4.80)	(5.14,19.62)
(1,3)	([3,5][0.19,0.81],[4,5][0.69,0.31])	(1.99,4.57)	(8.84,19.50)
(2,4)	([5,6][0,1],[5,6][0.28,0.72])	(2.50,3.81)	(11.84,21.67)
(3,5)	(5,5)	(3.39,3.39)	(16.94,16.94)
(4,6)	([5,6][0.28,0.72],[5,6][0,1])	(3.81,2.50)	(21.67,11.84)
(5,7)	([4,5][0.69,0.31],[3,5][0.19,0.81])	(4.57,1.99)	(19.50,8.84)
(6,8)	([4,5][0.89,0.11],[3,4][0.14,0.86])	(4.80,1.49)	(19.62,5.14)
(7,9)	([4,5][0.96,0.04],[3,4][0.11,0.89])	(4.93,0.93)	(19.90,3.44)
(8,10)	([4,5][1,0],[3,4][0.07,0.93])	(4.82,0.51)	(19.28,2)
(9,11)	([2,3][1,0],[1,3][0.51,0.49])	(5.66,0.22)	(11.33,0.33)
Level of differentiation equal to 3			
(-3,0)	([2,3][0.07,0.93],[4,5][0.95,0.05])	(0.53,4.78)	(1.44,19.28)
(-2,1)	([2,3][0.11,0.89],[4,5][0.87,0.13])	(0.97,4.85)	(2.43,19.90)
(-1,2)	([3,5][0.17,0.83],[4,6][0.93,0.07])	(1.03,5.23)	(4.25,21.43)
(0,3)	([3,6][0.06,0.94],[5,6][0.64,0.36])	(1.58,4.59)	(8.94,24.43)
(1,4)	([3,6][0.08,0.92],[5,6][0.06,0.94])	(2.49,3.86)	(13.88,22.90)
(2,5)	(6,6)	(3,3.55)	(18,21.33)
(3,6)	(6,6)	(3.55,3)	(21.33,18)
(4,7)	([5,6][0.06,0.94],[3,6][0.08,0.92])	(3.86,2.49)	(22.90,13.88)
(5,8)	([5,6][0.64,0.36],[3,6][0.06,0.94])	(4.59,1.58)	(24.43,8.94)
(6,9)	([4,6][0.93,0.07],[3,5][0.17,0.83])	(5.23,1.03)	(21.43,4.25)
(7,10)	([4,5][0.87,0.13],[2,3][0.11,0.89])	(4.85,0.97)	(19.90,2.43)
(8,11)	([4,5][0.95,0.05],[2,3][0.07,0.93])	(4.78,0.53)	(19.28,1.44)
Level of differentiation equal to 4			
(-3,1)	([2,4][0.11,0.89],[4,6][0.91,0.09])	(0.59,5.18)	(1.88,21.39)
(-2,2)	(4,5)	(1.11,4.78)	(4.44,23.89)
(-1,3)	(6,6)	(1.39,4.5)	(8.33,27)
(0,4)	(6,6)	(2,4.33)	(12,26)
(1,5)	(6,6)	(2.72,3.94)	(16.33,23.67)
(2,6)	(6,6)	(3.39,3.39)	(20.33,20.33)

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Table 25 – continued from previous page

Pairs of locations	Prices	Demands	Profits
(3,7)	(6,6)	(3.94,2.72)	(23.67,16.33)
(4,8)	(6,6)	(4.33,2)	(26,12)
(5,9)	(6,6)	(4.5,1.39)	(27,8.33)
(6,10)	(5,4)	(4.78,1.11)	(23.89,4.44)
(7,11)	([4,6][0.91,0.09],[2,4][0.11,0.89])	(5.18,0.59)	(21.39,1.88)
Level of differentiation equal to 5			
(-3,2)	(5,6)	(0.89,4.44)	(4.44,26.67)
(-2,3)	(5,6)	(1.39,4.5)	(6.94,27)
(-1,4)	(6,6)	(1.67,4.67)	(10,28)
(0,5)	(6,6)	(2.33,4.33)	(14,26)
(1,6)	(6,6)	(3.12,3.78)	(18.67,22.67)
(2,7)	(6,6)	(3.78,3.12)	(22.67,18.67)
(3,8)	(6,6)	(4.33,2.33)	(26,14)
(4,9)	(6,6)	(4.67,1.67)	(28,10)
(5,10)	(6,5)	(4.5,1.39)	(27,6.94)
(6,11)	(6,5)	(4.44,0.89)	(26.67,4.44)
Level of differentiation equal to 6			
(-3,3)	(5,6)	(1.11,4.78)	(5.56,28.67)
(-2,4)	(6,6)	(1.39,4.94)	(8.33,29.67)
(-1,5)	(7,7)	(2,4.33)	(14,30.33)
(0,6)	(7,7)	(2.72,3.94)	(19.06,27.61)
(1,7)	(7,7)	(3.39,3.39)	(23.72,23.72)
(2,8)	(7,7)	(3.94,2.72)	(27.61,19.06)
(3,9)	(7,7)	(4.33,2)	(30.33,14)
(4,10)	(6,6)	(4.94,1.39)	(29.67,8.33)
(5,11)	(6,5)	(4.78,1.11)	(28.67,5.56)
Level of differentiation equal to 7			
(-3,4)	(5,6)	(1.39,4.94)	(6.94,29.67)
(-2,5)	(6,7)	(2,4.33)	(12,30.33)
(-1,6)	(7,7)	(2.33,4.33)	(16.33,30.33)
(0,7)	(7,7)	(3.11,3.77)	(21.78,26.44)
(1,8)	(7,7)	(3.77,3.11)	(26.44,21.78)
(2,9)	(7,7)	(4.33,2.33)	(30.33,16.33)
(3,10)	(7,6)	(4.33,2)	(30.33,12)
(4,11)	(6,5)	(4.94,1.39)	(29.67,6.94)
Level of differentiation equal to 8			
(-3,5)	(6,7)	(1.67,4.67)	(10,32.67)
(-2,6)	(6,7)	(2.33,4.33)	(14,30.33)
(-1,7)	(6,7)	(3.11,3.78)	(18.67,26.44)
(0,8)	(6,7)	(3.89,3.11)	(23.33,21.78)

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Table 25 – continued from previous page

Pairs of locations	Prices	Demands	Profits
(1,9)	(7,6)	(3.78,3.11)	(26.44,18.67)
(2,10)	(7,6)	(4.33,2.33)	(30.33,14)
(3,11)	(7,6)	(4.67,1.67)	(32.67,10)
Level of differentiation equal to 9			
(-3,6)	(5,7)	(2.33,4.33)	(11.67,30.33)
(-2,7)	(6,6)	(2.33,4.67)	(14,28)
(-1,8)	(6,6)	(3.11,3.89)	(18.67,23.33)
(0,9)	(6,6)	(3.89,3.11)	(23.33,18.67)
(1,10)	(6,6)	(4.67,2.33)	(28,14)
(2,11)	(7,5)	(4.33,2.33)	(30.33,11.67)
Level of differentiation equal to 10			
(-3,7)	(5,6)	(2.33,4.67)	(11.67,28)
(-2,8)	(5,6)	(3.11,3.89)	(15.56,23.33)
(-1,9)	(5,6)	(3.88,3.11)	(19.44,18.67)
(0,10)	(6,5)	(3.89,3.11)	(23.33,15.56)
(1,11)	(6,5)	(4.67,2.33)	(28,11.67)
Level of differentiation equal to 11			
(-3,8)	(4,6)	(3.11,3.88)	(12.44,23.33)
(-2,9)	(5,5)	(3.11,3.88)	(15.56,19.44)
(-1,10)	(5,5)	(3.88,3.11)	(19.44,15.56)
(0,11)	(6,4)	(3.88,3.11)	(23.33,12.44)
Level of differentiation equal to 12			
(-3,9)	(4,5)	(3.11,3.89)	(12.44,19.44)
(-2,10)	(4,5)	(3.89,3.11)	(15.56,15.56)
(-1,11)	(5,4)	(3.89,3.11)	(19.44,12.44)
Level of differentiation equal to 13			
(-3,10)	(4,5)	(3.11,3.89)	(12.44,19.44)
(-2,11)	(5,4)	(3.89,3.11)	(19.44,12.44)
Level of differentiation equal to 14			
(-3,11)	(4,4)	(3.11,3.11)	(12.44,12.44)

Notes: For equilibrium prices in mixed strategies we report into brackets both the level of prices and the associated probabilities.

Table 26: Equilibrium Payoffs in the Price Subgame and Risk-Neutral Firms (HDU Treatment)

	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11
-3	(2.7,2.7)	(0.1,5.8)	(0.3,11.3)*	(1.4,19.3)	(1.9,21.4)	(4.4,25.3)	(5.6,28.7)	(6.9,29.7)	(10,32.7)	(11.7,30.3)	(11.7,28)	(12.4,23.3)	(12.4,19.4)	(12.4,15.6)	(12.4,12.4)
-2	(5.8,0.1)	(2.9,2.9)	(0.3,6)	(2,19.3)*	(2.4,19.9)*	(4.4,23.9)	(6.9,27)	(8.3,28)	(12,30.3)	(14,30.3)	(14,28)	(15.6,23.3)	(15.6,19.4)	(15.6,15.6)	(15.6,12.4)
-1	(11.3,0.3)*	(6,0.3)	(3.2,3.2)	(0.7,6)	(3.4,19.9)*	(4.2,21.4)*	(8.3,25.3)	(10,28)	(14,28)	(16.3,30.3)	(18.7,26.4)	(18.7,23.3)	(19.4,18.7)	(19.4,15.6)	(19.4,12.4)
0	(19.3,1.4)*	(19.3,2)*	(6,0.7)	(3.3,3.3)	(1.1,5.8)	(5.1,19.6)*	(8.9,24.4)*	(12,26)	(16.3,28)	(19.1;27.6)	(21.8,26.4)	(23.3,21.8)	(23.3,18.7)	(23.3,15.6)	(23.3,12.4)
1	(21.4,1.9)	(19.9,2.4)*	(19.9,3.4)*	(5.8,1.1)	(3.4,3.4)	(1.7,5.3)	(8.8,19.5)*	(13.9,22.9)*	(16.3,23.7)	(18.7,22.7)	(23.7,23.7)	(26.4,21.8)	(26.4,18.7)	(28,14)	(28,11.7)
2	(25.3,4.4)	(23.9,4.4)	(21.4,4.2)*	(19.6,5.1)*	(5.3,1.7)	(3.5,3.5)	(4.7,9.3)	(11.8,21.7)*	(18,21.3)	(20.3,20.3)	(22.7,18.7)	(27.6,19.1)	(30.3,16.3)	(30.3,14)	(30.3,11.7)
3	(28.7,5.6)	(27,6.9)	(25.3,8.3)	(24.4,8.9)*	(19.5,8.8)*	(9.3,4.7)	(3.5,3.5)	(6.2,7.8)	(16.9,16.9)	(21.3,18)	(23.7,16.3)	(28,16.3)	(28,14)	(30.3,12)	(32.7,10)
4	(29.7,6.9)	(28,8.3)	(28,10)	(26,12)	(22.9,13.9)*	(21.7,11.8)*	(7.8,6.2)	(3.5,3.5)	(7.8,6.2)	(21.7,11.8)*	(22.9,13.9)*	(26,12)	(28,10)	(28,8.3)	(29.7,6.9)
5	(32.7,10)	(30.3,12)	(28,14)	(28,16.3)	(23.7,16.3)	(21.3,18)	(16.9,16.9)	(6.2,7.8)	(3.5,3.5)	(9.3,4.7)	(19.5,8.8)*	(24.4,8.9)*	(25.3,8.3)	(27,6.9)	(28.7,5.6)
6	(30.3,11.7)	(30.3,14)	(30.3,16.3)	(27.6,19.1)	(22.7,18.7)	(20.3,20.3)	(18,21.3)	(11.8,21.7)*	(4.7,9.3)	(3.5,3.5)	(5.3,1.7)	(19.6,5.1)*	(21.4,4.2)*	(23.9,4.4)	(25.3,4.4)
7	(28,11.7)	(28,14)	(26.4,18.7)	(26.4,21.8)	(23.7,23.7)	(18.7,22.7)	(16.3,23.7)	(13.9,22.9)*	(8.8,19.5)*	(1.7,5.3)	(3.4,3.4)	(5.8,1.1)	(19.9,3.4)*	(19.9,2.4)*	(21.4,1.9)
8	(23.3,12.4)	(23.3,15.6)	(23.3,18.7)	(21.8,23.3)	(21.8,26.4)	(19.1,27.6)	(16.3,28)	(12,26)	(8.9,24.4)*	(5.1,19.6)*	(1.1,5.8)	(3.3,3.3)	(6,0.7)	(19.3,2)*	(19.3,1.4)*
9	(19.4,12.4)	(19.4,15.6)	(18.7,19.4)	(18.7,23.3)	(18.7,26.4)	(16.3,30.3)	(14,28)	(10,28)	(8.3,25.3)	(4.2,21.4)*	(3.4,19.9)*	(0.7,6)	(3.2,3.2)	(6,0.3)	(11.3,0.3)*
10	(15.6,12.4)	(15.6,15.6)	(15.6,19.4)	(15.6,23.3)	(14,28)	(14,30.3)	(12,30.3)	(8.3,28)	(6.9,27)	(4.4,23.9)	(2.4,19.9)*	(2,19.3)*	(0.3,6)	(2.9,2.9)	(5.8,0.1)
11	(12.4,12.4)	(12.4,15.6)	(12.4,19.4)	(12.4,23.3)	(11.7,28)	(11.7,30.3)	(10,32.7)	(6.9,29.7)	(5.6,28.7)	(4.4,25.3)	(1.9,21.4)	(1.4,19.3)	(0.3,11.3)*	(0.1,5.8)	(2.7,2.7)

Notes: ($\star$) denote mixed strategy equilibrium.

D.2 Risk-Lover Firms ($r = -0.2$)

We report in Table 27 the equilibrium prices, the demands and the profits for each pair of locations in the HDU treatment, under the assumption that firms are risk-lover with a CRRA parameter equal to -0.2. The payoff matrix for each pair of locations is given in Table 28.

Table 27: Equilibrium Prices for Each Pair of Locations and Risk-Lover Firms (HDU Treatment)

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 0			
(-3,-3)	(1,1)	(2.67,2.67)	(3.15,3.15)
(-2,-2)	(2,2)	(2.67,2.67)	(7.24,7.24)
(-1,-1)	(2,2)	(2.94,2.94)	(8.10,8.10)
(0,0)	(2,2)	(3.17,3.17)	(8.80,8.80)
(1,1)	(2,2)	(3.33,3.33)	(9.34,9.34)
(2,2)	(2,2)	(3.44,3.44)	(9.70,9.70)
(3,3)	(2,2)	(3.5,3.5)	(9.89,9.89)
(4,4)	(2,2)	(3.5,3.5)	(9.89,9.89)
(5,5)	(2,2)	(3.5,3.5)	(9.89,9.89)
(6,6)	(2,2)	(3.44,3.44)	(9.70,9.70)
(7,7)	(2,2)	(3.33,3.33)	(9.34,9.34)
(8,8)	(2,2)	(3.17,3.17)	(8.80,8.80)
(9,9)	(2,2)	(2.94,2.94)	(8.10,8.10)
(10,10)	(2,2)	(2.67,2.67)	(7.24,7.24)
(11,11)	(1,1)	(2.67,2.67)	(3.15,3.15)
Level of differentiation equal to 1			
(-3,-2)	(1,2)	(2.72,2.61)	(3.2,7.06)
(-2,-1)	(1,2)	(3,2.78)	(3.68,7.55)
(-1,0)	(1,2)	(3.5,2.83)	(4.16,7.71)
(0,1)	(1,2)	(3.89,2.77)	(4.63,7.55)
(1,2)	(1,2)	(4.28,2.61)	(5.11,7.06)
(2,3)	(2,2)	(2.34,4.66)	(5.91,12.51)
(3,4)	(2,2)	(3.11,3.89)	(8.11,10.31)
(4,5)	(2,2)	(3.89,3.11)	(10.31,8.11)
(5,6)	(2,2)	(4.66,2.34)	(12.51,5.91)
(6,7)	(2,1)	(2.61,4.28)	(7.06,5.11)
(7,8)	(2,1)	(2.77,3.89)	(7.55,4.63)
(8,9)	(2,1)	(2.83,3.5)	(7.71,4.16)
(9,10)	(2,1)	(2.78,3)	(7.55,3.68)
(10,11)	(2,1)	(2.61,2.72)	(7.06,3.2)
Level of differentiation equal to 2			
(-3,-1)	([1,3][0.61,0.39],[2,3][0.98,0.02])	(0.27,5.61)	(0.35,15.38)

Continued on next page

Table 27 – continued from previous page

Pairs of locations	Prices	Demands	Profits
(-2,0)	([3,4][0.10,0.90],[4,5][0.98,0.02])	(0.52,4.80)	(2.53,29.40)
(-1,1)	([3,4][0.14,0.86],[4,5][0.94,0.06])	(0.94,4.91)	(4.80,30.37)
(0,2)	([3,4][0.17,0.83],[4,5][0.87,0.13])	(1.51,4.76)	(7.92,22.91)
(1,3)	([3,5][0.23,0.77],[4,5][0.61,0.39])	(2.10,4.43)	(13.35,29.70)
(2,4)	([4,5][0.02,0.98],[5,6][0.69,0.31])	(2.11,4.08)	(22.03,34.10)
(3,5)	(5,5)	(3.39,3.39)	(26.54,26.54)
(4,6)	([5,6][0.69,0.31],[4,5][0.02,0.98])	(4.08,2.11)	(34.10,22.03)
(5,7)	([4,5][0.61,0.39],[3,5][0.23,0.77])	(4.43,2.10)	(29.70,13.35)
(6,8)	([4,5][0.87,0.13],[3,4][0.17,0.83])	(4.76,1.51)	(22.91,7.92)
(7,9)	([4,5][0.94,0.06],[3,4][0.14,0.86])	(4.91,0.94)	(30.37,4.80)
(8,10)	([4,5][0.98,0.02],[3,4][0.10,0.90])	(4.80,0.52)	(29.40,2.53)
(9,11)	([2,3][0.98,0.02],[1,3][0.61,0.39])	(5.61,0.27)	(15.38,0.35)
Level of differentiation equal to 3			
(-3,0)	([2,3][0.10,0.90],[4,5][0.94,0.06])	(0.54,4.75)	(1.83,29.40)
(-2,1)	([2,4][0.17,0.83],[4,5][0.82,0.18])	(0.84,4.95)	(3.66,31.66)
(-1,2)	([3,5][0.22,0.78],[4,6][0.87,0.13])	(1.11,5.09)	(6.67,33.02)
(0,3)	([3,6][0.08,0.92],[5,6][0.48,0.52])	(1.67,4.43)	(13.95,38.86)
(1,4)	(6,6)	(2.33,4)	(22.10,38.60)
(2,5)	(6,6)	(3,3.55)	(28.92,34.41)
(3,6)	(6,6)	(3.55,3)	(34.41,28.92)
(4,7)	(6,6)	(4,2.33)	(38.60,22.10)
(5,8)	([5,6][0.48,0.52],[3,6][0.08,0.92])	(4.43,1.67)	(38.86,13.95)
(6,9)	([4,6][0.87,0.13],[3,5][0.22,0.78])	(5.09,1.11)	(33.02,6.67)
(7,10)	([4,5][0.82,0.18],[2,4][0.17,0.83])	(4.95,0.84)	(31.66,3.66)
(8,11)	([4,5][0.94,0.06],[2,3][0.10,0.90])	(4.75,0.54)	(29.40,1.83)
Level of differentiation equal to 4			
(-3,1)	([2,4][0.15,0.85],[4,6][0.86,0.14])	(0.65,5.15)	(2.84,33.01)
(-2,2)	([2,4][0.22,0.78],[4,6][0.54,0.46])	(1.40,4.47)	(6.11,33.02)
(-1,3)	(6,6)	(1.39,4.5)	(12.53,43.97)
(0,4)	(6,6)	(2,4.33)	(18.68,42.31)
(1,5)	(6,6)	(2.72,3.94)	(26.20,38.51)
(2,6)	(6,6)	(3.39,3.39)	(33.03,33.03)
(3,7)	(6,6)	(3.94,2.72)	(38.51,26.20)
(4,8)	(6,6)	(4.33,2)	(42.31,18.68)
(5,9)	(6,6)	(4.5,1.39)	(43.97,12.53)
(6,10)	([4,6][0.54,0.46],[2,4][0.22,0.78])	(4.47,1.40)	(33.02,6.11)
(7,11)	([4,6][0.86,0.14],[2,4][0.15,0.85])	(5.15,0.65)	(33.01,2.84)
Level of differentiation equal to 5			
(-3,2)	(5,6)	(0.89,4.44)	(6.18,43.40)
(-2,3)	(5,6)	(1.39,4.5)	(10.07,43.97)
(-1,4)	(6,6)	(1.67,4.67)	(15.27,46.02)

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Table 27 – continued from previous page

Pairs of locations	Prices	Demands	Profits
(0,5)	(7,7)	(2.33,4)	(26.59,46.45)
(1,6)	(7,7)	(3,3.56)	(34.80,41.40)
(2,7)	(7,7)	(3.56,3)	(41.40,34.80)
(3,8)	(7,7)	(4,2.33)	(46.45,26.59)
(4,9)	(6,6)	(4.67,1.67)	(46.02,15.27)
(5,10)	(6,5)	(4.5,1.39)	(43.97,10.07)
(6,11)	(6,5)	(4.44,0.89)	(43.40,6.18)
Level of differentiation equal to 6			
(-3,3)	(5,6)	(1.11,4.78)	(7.87,47.17)
(-2,4)	(6,6)	(1.39,4.94)	(12.53,49.21)
(-1,5)	(7,7)	(2,4.33)	(22.48,50.91)
(0,6)	(7,7)	(2.72,3.94)	(31.53,46.34)
(1,7)	(7,7)	(3.39,3.39)	(39.74,39.74)
(2,8)	(7,7)	(3.94,2.72)	(46.34,31.53)
(3,9)	(7,7)	(4.33,2)	(50.91,22.48)
(4,10)	(6,6)	(4.94,1.39)	(49.21,12.53)
(5,11)	(6,5)	(4.78,1.11)	(47.17,7.87)
Level of differentiation equal to 7			
(-3,4)	(6,7)	(1.39,4.5)	(12.53,52.90)
(-2,5)	(6,7)	(2,4.33)	(18.68,50.91)
(-1,6)	(7,7)	(2.33,4.33)	(26.59,51.28)
(0,7)	(7,7)	(3.11,3.77)	(36.47,44.68)
(1,8)	(7,7)	(3.77,3.11)	(44.68,36.47)
(2,9)	(7,7)	(4.33,2.33)	(51.28,26.59)
(3,10)	(7,6)	(4.33,2)	(50.91,18.68)
(4,11)	(7,6)	(4.5,1.39)	(52.90,12.53)
Level of differentiation equal to 8			
(-3,5)	(6,7)	(1.67,4.67)	(15.27,55.37)
(-2,6)	(6,7)	(2.33,4.33)	(22.09,51.28)
(-1,7)	(6,7)	(3.11,3.78)	(30.31,44.68)
(0,8)	(6,7)	(3.89,3.11)	(38.52,36.47)
(1,9)	(7,6)	(3.78,3.11)	(44.68,30.31)
(2,10)	(7,6)	(4.33,2.33)	(51.28,22.09)
(3,11)	(7,6)	(4.67,1.67)	(55.37,15.27)
Level of differentiation equal to 9			
(-3,6)	(5,7)	(2.33,4.33)	(17.76,51.28)
(-2,7)	(5,7)	(3.11,3.78)	(24.35,44.68)
(-1,8)	(6,6)	(3.11,3.89)	(30.31,38.52)
(0,9)	(6,6)	(3.89,3.11)	(38.52,30.31)
(1,10)	(7,5)	(3.78,3.11)	(44.68,24.35)

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Table 27 – continued from previous page

Pairs of locations	Prices	Demands	Profits
(2,11)	(7,5)	(4.33,2.33)	(51.28,17.76)
Level of differentiation equal to 10			
(-3,7)	(5,6)	(2.33,4.67)	(17.76,46.74)
(-2,8)	(5,6)	(3.11,3.89)	(24.35,38.52)
(-1,9)	(5,6)	(3.88,3.11)	(30.95,30.31)
(0,10)	(6,5)	(3.89,3.11)	(38.52,24.35)
(1,11)	(6,5)	(4.67,2.33)	(46.74,17.76)
Level of differentiation equal to 11			
(-3,8)	(4,6)	(3.11,3.88)	(18.63,38.52)
(-2,9)	(5,5)	(3.11,3.88)	(24.35,30.95)
(-1,10)	(5,5)	(3.88,3.11)	(30.95,24.35)
(0,11)	(6,4)	(3.88,3.11)	(38.52,18.63)
Level of differentiation equal to 12			
(-3,9)	(4,5)	(3.11,3.89)	(18.63,30.95)
(-2,10)	(5,5)	(3.11,3.11)	(24.35,24.35)
(-1,11)	(5,4)	(3.89,3.11)	(30.95,18.63)
Level of differentiation equal to 13			
(-3,10)	(4,5)	(3.11,3.89)	(18.63,24.35)
(-2,11)	(5,4)	(3.89,3.11)	(24.35,18.63)
Level of differentiation equal to 14			
(-3,11)	(4,4)	(3.11,3.11)	(18.63,18.63)

Notes: For equilibrium prices in mixed strategies we report into brackets both the level of prices and the associated probabilities.

Table 28: Equilibrium Payoffs in the Price Subgame and Risk-Lover Firms (HDU Treatment)

	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11
-3	(3.1,3.1)	(3.2,7.1)	(0.3,15.4)*	(1.8,29.4)*	(2.8,33)*	(6.2,43.4)	(7.9,47.2)	(12.5,52.9)	(15.3,55.4)	(17.8,51.3)	(17.8,46.7)	(18.6,38.5)	(18.6,30.9)	(18.6,24.3)	(12.6,18.6)
-2	(7.1,3.2)	(7.2,7.2)	(3.7,7.5)	(2.5,29.4)*	(3.7,31.7)*	(6.1,33)*	(10.1,44)	(12.5,49.2)	(18.7,50.9)	(22.1,51.3)	(24.3,44.7)	(24.3,38.5)	(24.3,30.9)	(24.3,24.3)	(24.3,18.6)
-1	(15.4,0.3)*	(7.5,3.7)	(8.1,8.1)	(4.1,7.7)	(4.8,30.4)*	(6.7,33)*	(12.5,44)	(15.3,46)	(22.5,50.9)	(26.6,51.2)	(30.3,44.6)	(30.3,38.5)	(30.9,30.3)	(30.9,24.3)	(30.9,18.6)
0	(29.4,1.8)*	(29.4,2.5)*	(7.7,4.1)	(8.8,8.8)	(4.6,7.5)	(7.9,22.9)*	(13.9,38.9)*	(18.7,42.3)	(26.6,46.4)	(31.5,46.3)	(36.5,44.3)	(38.5,36.5)	(38.5,30.3)	(38.5,24.3)	(38.5,18.6)
1	(33,2.8)*	(31.7,3.7)*	(30.4,4.8)*	(7.5,4.6)	(9.3,9.3)	(5.1,7.1)	(13.3,29.7)*	(22.1,38.6)	(26.2,38.5)	(34.8,41.4)	(39.7,39.7)	(44.7,36.5)	(44.6,30.3)	(44.7,24.3)	(46.7,17.7)
2	(43.4,6.2)	(33,6.1)*	(33,6.7)*	(22.9,7.9)*	(5.1,7.1)	(9.7,9.7)	(5.9,12.5)	(22,34.1)*	(28.9,34.4)	(33,33)	(41.4,34.8)	(46.3,31.5)	(51.3,26.6)	(51.3,22.1)	(51.3,17.8)
3	(47.2,7.9)	(44,10.1)	(44,12.5)	(38.9,13.9)*	(29.7,13.3)*	(12.5,5.9)	(9.9,9.9)	(8.1,10.3)	(26.6,26.6)	(34.4,28.9)	(38.5,26.2)	(46.4,26.6)	(50.9,22.5)	(50.9,18.7)	(55.4,15.3)
4	(52.9,12.5)	(49.2,12.5)	(46,15.3)	(42.3,18.7)	(38.6,22.1)	(34.1,22)*	(10.3,8.1)	(9.9,9.9)	(10.3,8.1)	(34.1,22)*	(38.6,22.1)	(42.3,18.7)	(46,15.3)	(49.2,12.5)	(52.9,12.5)
5	(55.4,15.3)	(50.9,18.7)	(50.9,22.5)	(46.4,26.6)	(38.5,26.2)	(34.4,28.9)	(26.6,26.6)	(8.1,10.3)	(9.9,9.9)	(12.5,5.9)	(29.7,13.3)*	(38.9,13.9)*	(44,12.5)	(44,10.1)	(47.2,7.9)
6	(51.3,17.8)	(51.3,22.1)	(51.3,26.6)	(46.3,31.5)	(41.4,34.8)	(33,33)	(28.9,34.4)	(22,34.1)*	(5.9,12.5)	(9.7,9.7)	(7.1,5.1)	(22.9,7.9)*	(33,6.7)*	(33,6.1)*	(43.4,6.2)
7	(46.7,17.8)	(44.7,24.3)	(44.6,30.3)	(44.7,36.5)	(39.7,39.7)	(34.8,41.4)	(26.2,38.5)	(22.1,38.6)	(13.3,29.7)*	(5.1,7.1)	(9.4,9.4)	(7.5,4.6)	(30.4,4.8)*	(31.7,3.7)*	(33,2.8)*
8	(38.5,18.6)	(38.5,24.3)	(38.5,30.3)	(36.5,38.5)	(36.5,44.7)	(31.5,46.3)	(26.6,46.4)	(18.7,42.3)	(13.9,38.9)*	(7.9,22.9)*	(4.6,7.5)	(8.8,8.8)	(7.7,4.1)	(29.4,2.5)*	(29.4,1.8)*
9	(30.9,18.6)	(30.9,24.3)	(30.3,30.9)	(30.3,38.5)	(30.3,44.6)	(26.6,51.2)	(22.5,50.9)	(15.3,46)	(12.5,44)	(6.7,33)*	(4.8,30.4)*	(4.1,7.7)	(8.1,8.1)	(7.5,3.7)	(15.4,0.3)*
10	(24.3,18.6)	(24.3,24.3)	(24.3,30.9)	(24.3,38.5)	(24.3,44.7)	(22.1,51.3)	(18.7,50.9)	(12.5,49.2)	(10.1,44)	(6.1,33)*	(3.7,31.7)*	(2.5,29.4)	(3.7,7.5)	(7.2,7.2)	(7.1,3.2)
11	(18.6,12.6)	(18.6,24.3)	(18.6,30.9)	(18.6,38.5)	(17.7,46.7)	(17.8,51.3)	(15.3,55.4)	(12.5,52.9)	(7.9,47.2)	(6.2,43.4)	(2.8,33)*	(1.8,29.4)*	(0.3,15.4)*	(3.2,7.1)*	(3.1,3.1)

Notes: * denote mixed strategy equilibrium.

D.3 High Risk-Averse Firms ($r = 0.9$)

We report in Table 29 the equilibrium prices, the demands and the profits for each pair of locations in the HDU treatment, under the assumption that firms are highly risk-averse with a CRRA parameter equal to 0.9. The payoff matrix for each pair of locations is given in Table 30.

Table 29: Equilibrium Prices for Each Pair of Locations and High Risk-Averse Firms (HDU Treatment)

Pairs of locations	Prices	Demands	Profits
Level of differentiation equal to 0			
(-3,-3)	(1,1)	(2.67,2.67)	(5.87,5.87)
(-2,-2)	(1,1)	(2.94,2.94)	(5.95,5.95)
(-1,-1)	(1,1)	(3.17,3.17)	(6,6)
(0,0)	(1,1)	(3.33,3.33)	(6.04,6.04)
(1,1)	(1,1)	(3.44,3.44)	(6.06,6.06)
(2,2)	(1,1)	(3.5,3.5)	(6.07,6.07)
(3,3)	(1,1)	(3.5,3.5)	(6.07,6.07)
(4,4)	(1,1)	(3.5,3.5)	(6.07,6.07)
(5,5)	(1,1)	(3.5,3.5)	(6.07,6.07)
(6,6)	(1,1)	(3.5,3.5)	(6.07,6.07)
(7,7)	(1,1)	(3.44,3.44)	(6.06,6.06)
(8,8)	(1,1)	(3.33,3.33)	(6.04,6.04)
(9,9)	(1,1)	(3.17,3.17)	(6,6)
(10,10)	(1,1)	(2.94,2.94)	(5.95,5.95)
(11,11)	(1,1)	(2.67,2.67)	(5.87,5.87)
Level of differentiation equal to 1			
(-3,-2)	(1,1)	(0.11,5.78)	(1.11,11.88)
(-2,-1)	(1,1)	(0.33,6)	(2.30,11.94)
(-1,0)	(1,1)	(0.67,6)	(3.54,11.94)
(0,1)	(1,1)	(1.11,5.78)	(4.82,11.88)
(1,2)	(1,1)	(1.67,5.33)	(6.12,11.74)
(2,3)	(1,1)	(2.34,4.66)	(7.45,11.50)
(3,4)	(1,1)	(3.11,3.89)	(8.8,10.15)
(4,5)	(1,1)	(3.89,3.11)	(10.15,8.8)
(5,6)	(1,1)	(4.66,2.34)	(11.50,7.45)
(6,7)	(1,1)	(5.33,1.67)	(11.74,6.12)
(7,8)	(1,1)	(5.78,1.11)	(11.88,4.82)
(8,9)	(1,1)	(6,0.67)	(11.94,3.54)
(9,10)	(1,1)	(6,0.33)	(11.94,2.30)
(10,11)	(1,1)	(5.78,0.11)	(11.88,1.11)
Level of differentiation equal to 2			
(-3,-1)	(1,2)	(0.33,5.56)	(2.30,12.68)

Continued on next page

Table 29 – continued from previous page

Pairs of locations	Prices	Demands	Profits
(-2,0)	(1,2)	(0.67,5.67)	(3.54,12.72)
(-1,1)	(1,2)	(1.11,5.56)	(4.81,12.68)
(0,2)	(1,2)	(1.67,5.22)	(6.12,12.56)
(1,3)	(1,2)	(2.33,4.67)	(7.45,12.33)
(2,4)	(1,2)	(3.11,3.89)	(8.80,10.88)
(3,5)	(2,2)	(3.5,3.5)	(10.16,10.16)
(4,6)	(2,1)	(3.89,3.11)	(10.88,8.80)
(5,7)	(2,1)	(4.67,2.33)	(12.33,7.45)
(6,8)	(2,1)	(5.22,1.67)	(12.56,6.12)
(7,9)	(2,1)	(5.56,1.11)	(12.68,4.81)
(8,10)	(2,1)	(5.67,0.67)	(12.72,3.54)
(9,11)	(2,1)	(5.56,0.33)	(12.68,2.30)
Level of differentiation equal to 3			
(-3,0)	(1,3)	(0.67,5.22)	(3.54,13.13)
(-2,1)	(1,3)	(1.11,5.22)	(4.82,13.13)
(-1,2)	(1,3)	(1.67,5)	(6.12,13.03)
(0,3)	(1,3)	(2.33,4.56)	(7.45,12.82)
(1,4)	(1,2)	(2.72,4.28)	(8.13,11.60)
(2,5)	(1,2)	(3.5,3.5)	(9.48,10.16)
(3,6)	(2,1)	(3.5,3.5)	(10.16,9.48)
(4,7)	(2,1)	(4.28,2.72)	(11.60,8.13)
(5,8)	(3,1)	(4.56,2.33)	(12.82,7.45)
(6,9)	(3,1)	(5,1.67)	(13.03,6.12)
(7,10)	(3,1)	(5.22,1.11)	(13.13,4.82)
(8,11)	(3,1)	(5.22,0.67)	(13.13,3.54)
Level of differentiation equal to 4			
(-3,1)	(1,4)	(1.11,4.78)	(4.82,13.38)
(-2,2)	(1,4)	(1.67,4.67)	(6.12,13.33)
(-1,3)	(1,4)	(2.33,4.33)	(7.45,13.14)
(0,4)	(1,2)	(2.3,4.7)	(7.45,12.33)
(1,5)	(1,2)	(3.11,3.89)	(8.80,10.88)
(2,6)	(2,2)	(3.5,3.5)	(10.15,10.15)
(3,7)	(2,1)	(3.89,3.11)	(10.88,8.80)
(4,8)	(2,1)	(4.7,2.3)	(12.33,7.45)
(5,9)	(4,1)	(4.33,2.33)	(13.14,7.45)
(6,10)	(4,1)	(4.67,1.67)	(13.33,6.12)
(7,11)	(4,1)	(4.78,11.1)	(13.38,4.82)
Level of differentiation equal to 5			
(-3,2)	(1,5)	(1.67,4.22)	(6.12,13.5)
(-2,3)	(1,5)	(2.33,4)	(7.45,13.35)
(-1,4)	(1,3)	(2.33,4.67)	(7.45,12.84)

Continued on next page

Table 29 – continued from previous page

Pairs of locations	Prices	Demands	Profits
(0,5)	(1,2)	(2.72,4.28)	(8.13,11.60)
(1,6)	(1,2)	(3.5,3.5)	(9.48,10.16)
(2,7)	(2,1)	(3.5,3.5)	(10.16,9.48)
(3,8)	(2,1)	(4.28,2.72)	(11.60,8.13)
(4,9)	(3,1)	(4.67,2.33)	(12.84,7.45)
(5,10)	(5,1)	(4,2.33)	(13.35,7.45)
(6,11)	(5,1)	(4.22,1.67)	(13.5,6.12)
Level of differentiation equal to 6			
(-3,3)	(1,5)	(2,4.33)	(6.79,13.49)
(-2,4)	(1,4)	(2.33,4.55)	(7.45,13.19)
(-1,5)	(1,2)	(2.33,4.67)	(7.45,12.33)
(0,6)	(1,2)	(3.11,3.89)	(8.80,10.88)
(1,7)	(2,2)	(3.5,3.5)	(10.16,10.16)
(2,8)	(2,1)	(3.89,3.11)	(10.88,8.80)
(3,9)	(2,1)	(4.67,2.33)	(12.33,7.45)
(4,10)	(4,1)	(4.55,2.33)	(13.19,7.45)
(5,11)	(5,1)	(4.33,2)	(13.49,6.79)
Level of differentiation equal to 7			
(-3,4)	(1,5)	(2.33,4.33)	(7.45,13.43)
(-2,5)	(1,3)	(2.33,4.66)	(7.45,12.84)
(-1,6)	(1,2)	(2.72,4.28)	(8.13,11.60)
(0,7)	(1,2)	(3.5,3.5)	(9.48,10.16)
(1,8)	(2,1)	(3.5,3.5)	(10.16,9.48)
(2,9)	(2,1)	(4.28,2.72)	(11.60,8.13)
(3,10)	(3,1)	(4.66,2.33)	(12.84,7.45)
(4,11)	(5,1)	(4.33,2.33)	(13.43,7.45)
Level of differentiation equal to 8			
(-3,5)	(1,4)	(2.33,4.67)	(7.45,13.21)
(-2,6)	(1,2)	(2.33,4.67)	(7.45,12.33)
(-1,7)	(1,2)	(3.11,3.89)	(8.80,10.88)
(0,8)	(2,2)	(3.5,3.5)	(10.16,10.16)
(1,9)	(2,1)	(3.89,3.11)	(10.88,8.80)
(2,10)	(2,1)	(4.67,2.33)	(12.33,7.45)
(3,11)	(4,1)	(4.67,2.33)	(13.21,7.45)
Level of differentiation equal to 9			
(-3,6)	(1,3)	(2.33,4.67)	(7.45,12.84)
(-2,7)	(1,2)	(2.72,4.28)	(8.13,11.60)
(-1,8)	(1,2)	(3.5,3.5)	(9.48,10.16)
(0,9)	(2,1)	(3.5,3.5)	(10.16,9.48)
(1,10)	(2,1)	(4.28,2.72)	(11.60,8.13)

Continued on next page

Table 29 – continued from previous page

Pairs of locations	Prices	Demands	Profits
(2,11)	(3,1)	(4.67,2.33)	(12.84,7.45)
Level of differentiation equal to 10			
(-3,7)	(1,2)	(2.33,4.67)	(7.45,12.33)
(-2,8)	(1,2)	(3.11,3.89)	(8.80,10.88)
(-1,9)	(2,2)	(3.5,3.5)	(10.16,10.16)
(0,10)	(2,1)	(3.89,3.11)	(10.88,8.80)
(1,11)	(2,1)	(4.67,2.33)	(12.33,7.45)
Level of differentiation equal to 11			
(-3,8)	(1,2)	(2.72,4.28)	(8.13,11.60)
(-2,9)	(1,2)	(3.5,3.5)	(9.47,10.16)
(-1,10)	(2,1)	(3.5,3.5)	(10.16,9.47)
(0,11)	(2,1)	(4.28,2.72)	(11.60,8.13)
Level of differentiation equal to 12			
(-3,9)	(1,2)	(3.11,3.89)	(8.80,10.88)
(-2,10)	(2,2)	(3.5,3.5)	(10.16,10.16)
(-1,11)	(2,1)	(3.89,3.11)	(10.88,8.80)
Level of differentiation equal to 13			
(-3,10)	(1,2)	(3.5,3.5)	(9.47,10.16)
(-2,11)	(2,1)	(3.5,3.5)	(10.16,9.47)
Level of differentiation equal to 14			
(-3,11)	(2,2)	(3.5,3.5)	(10.16,10.16)

Notes: For equilibrium prices in mixed strategies we report into brackets both the level of prices and the associated probabilities.

Table 30: Equilibrium Payoffs in the Price Subgame and High Risk-Averse Firms (HDU Treatment)

	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11
-3	(5.9,5.9)	(1.1,11.9)	(2.3,12.6)	(3.5,13.1)	(4.8,13.4)	(6.1,13.5)	(6.8,13.5)	(7.4,13.4)	(7.4,13.2)	(7.4,12.8)	(7.4,12.3)	(8.1,11.6)	(8.8,10.9)	(9.5,10.2)	(10.2,10.2)
-2	(11.9,1.1)	(5.9,5.9)	(2.3,11.9)	(3.5,12.7)	(4.8,13.1)	(6.1,13.3)	(7.4,13.3)	(7.4,13.2)	(7.4,12.8)	(7.4,12.3)	(8.1,11.6)	(8.8,10.9)	(9.5,10.2)	(10.2,10.2)	(10.2,9.5)
-1	(12.6,2.3)	(11.9,2.3)	(6,6)	(3.5,11.9)	(4.8,12.7)	(6.1,13)	(7.4,13.1)	(7.4,12.8)	(7.4,12.3)	(8.1,11.6)	(8.8,10.9)	(9.5,10.2)	(10.2,10.2)	(10.2,9.5)	(10.9,8.8)
0	(13.1,3.5)	(12.7,3.5)	(11.9,3.5)	(6,6)	(4.8,11.9)	(6.1,12.6)	(7.4,12.8)	(7.4,12.3)	(8.1,11.6)	(8.8,10.9)	(9.5,10.2)	(10.2,10.2)	(10.2,9.5)	(10.9,8.8)	(11.6,8.1)
1	(13.4,4.8)	(13.1,4.8)	(12.7,4.8)	(11.9,4.8)	(6,6)	(6.1,11.7)	(7.4,12.3)	(8.1,11.6)	(8.8,10.9)	(9.5,10.2)	(10.2,10.2)	(10.2,9.5)	(10.9,8.8)	(11.6,8.1)	(12.3,7.4)
2	(13.5,6.1)	(13.3,6.1)	(13,6.1)	(12.6,6.1)	(11.7,6.1)	(6.1,6.1)	(7.4,11.5)	(8.8,10.9)	(9.5,10.2)	(10.2,10.2)	(10.2,9.5)	(10.9,8.8)	(11.6,8.1)	(12.3,7.4)	(12.8,7.4)
3	(13.5,6.8)	(13.3,7.4)	(13.1,7.4)	(12.8,7.4)	(12.3,7.4)	(11.5,7.4)	(6.1,6.1)	(8.8,10.2)	(10.2,10.2)	(10.2,9.5)	(10.9,8.8)	(11.6,8.1)	(12.3,7.4)	(12.8,7.4)	(13.2,7.4)
4	(13.4,7.4)	(13.2,7.4)	(12.8,7.4)	(12.3,7.4)	(11.6,8.1)	(10.9,8.8)	(10.2,8.8)	(6.1,6.1)	(10.2,8.8)	(10.9,8.8)	(11.6,8.1)	(12.3,7.4)	(12.8,7.4)	(13.2,7.4)	(13.4,7.4)
5	(13.2,7.4)	(12.8,7.4)	(12.3,7.4)	(11.6,8.1)	(10.9,8.8)	(10.2,9.5)	(10.2,10.2)	(8.8,10.2)	(6.1,6.1)	(11.5,7.4)	(12.3,7.4)	(12.8,7.4)	(13.1,7.4)	(13.3,7.4)	(13.5,6.8)
6	(12.8,7.4)	(12.3,7.4)	(11.6,8.1)	(10.9,8.8)	(10.2,9.5)	(10.2,10.2)	(9.5,10.2)	(8.8,10.9)	(7.4,11.5)	(6.1,6.1)	(11.7,6.1)	(12.6,6.1)	(13,6.1)	(13.3,6.1)	(13.5,6.1)
7	(12.3,7.4)	(11.6,8.1)	(10.9,8.8)	(10.2,9.5)	(10.2,10.2)	(9.5,10.2)	(8.8,10.9)	(8.1,11.6)	(7.4,12.3)	(6.1,11.7)	(6.1,6.1)	(11.9,4.8)	(12.7,4.8)	(13.1,4.8)	(13.4,4.8)
8	(11.6,8.1)	(10.9,8.8)	(10.2,9.5)	(10.2,10.2)	(9.5,10.2)	(8.8,10.9)	(8.1,11.6)	(7.4,12.3)	(7.4,12.8)	(6.1,12.6)	(4.8,11.9)	(6,6)	(11.9,3.5)	(12.7,3.5)	(13.1,3.5)
9	(10.9,8.8)	(10.2,9.5)	(10.2,10.2)	(9.5,10.2)	(8.8,10.9)	(8.1,11.6)	(7.4,12.3)	(7.4,12.8)	(7.4,13.1)	(6.1,13)	(4.8,12.7)	(3.5,11.9)	(6,6)	(11.9,2.3)	(12.6,2.3)
10	(10.2,9.5)	(10.2,10.2)	(9.5,10.2)	(8.8,10.9)	(8.1,11.6)	(7.4,12.3)	(7.4,12.8)	(7.4,13.2)	(7.4,13.3)	(6.1,13.3)	(4.8,13.1)	(3.5,12.7)	(2.3,11.9)	(5.9,5.9)	(11.9,1.1)
11	(10.2,10.2)	(9.5,10.2)	(8.8,10.9)	(8.1,11.6)	(7.4,12.3)	(7.4,12.8)	(7.4,13.2)	(7.4,13.4)	(6.8,13.5)	(6.1,13.5)	(4.8,13.4)	(3.5,13.1)	(2.3,12.6)	(1.1,11.9)	(5.9,5.9)

E Instructions

Note: Text in italics in brackets denotes the changes depending on experimental treatments. The instructions were originally written in French.

Welcome. You are participating in two distinct experiments. The choices you will make during an experiment will thus have no effect on the other experiment. If you read these instructions carefully, you may earn a significant sum of money. The amount of your earnings depends not only on your decisions but also on the decisions of other participants with whom you will interact. Your final payoff corresponds to your earnings in the two experiments. We will add a participation fee of 3 euros to this earned amount.

It is important that you do not talk to any of the other participants until the experiment is over. If you have a question at any time, please raise your hand and a monitor will come to your desk to answer it in private. If you do not respect this rule, we will be forced to terminate the experiment, and you will not be paid.

All your answers will be treated anonymously and will be collected through the computer network. You will indicate your choices on the computer you are seated in front of, and the computer will inform you about your earnings in Experimental Currency Units (ECU).

Instructions for Experiment 1

The Experimental Currency Units you have earned during the 30 periods of this experiment will be paid to you in euros according to the following exchange rate: 25 ECU = 1 euro

Details of the experiment

Consider a market with 2 sellers offering an identical product. There are 7 potential simulated buyers who can buy at most one unit of the product. Only sellers are in this room. Therefore, you necessarily play the role of a seller. A market lasts 5 periods:

- In period 1, you will choose your location and the price of your product.
- For periods 2 to 5, you will set only the price of your product; locations are those of the first period.

We now detail how the first period of a market proceeds.

1st stage: Location choice of sellers

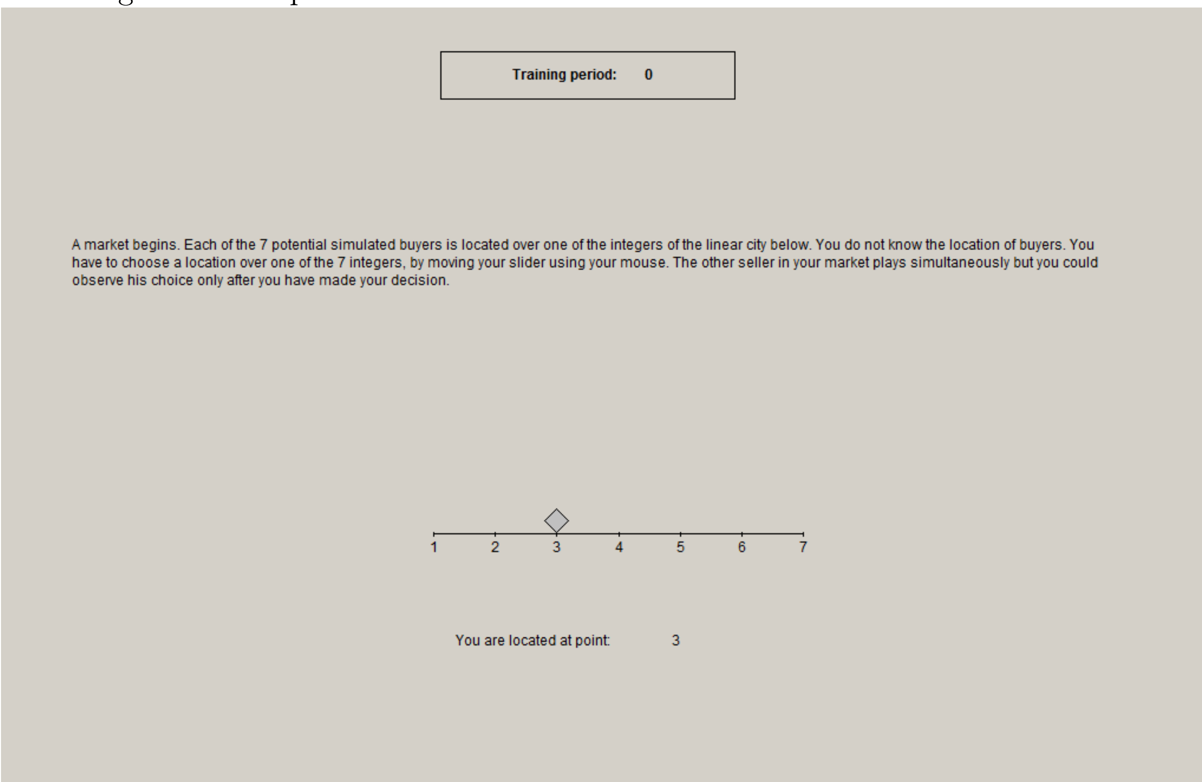
There are 7 potential simulated buyers in the market, each being positioned at each one of the integers on the line below:

Linear city 1 2 3 4 5 6 7

[The figure changes depending on the experimental treatment. See below].

For simplicity, we will refer to the line above as the linear city. There is a potential buyer at number 1, another at number 2 ... and another located at number 7 of the linear city. Each seller chooses his location by moving to an integer of the linear city. Thus, each seller can locate at the position numbered 1, 2, 3, ..., 7. Both sellers have to simultaneously choose their location. To do so, they position their slider over 1 of the 7 integers, as shown in the screenshot below (Fig.9.)

Figure 9: Computer Screen for the Location Decision in the DC Treatment



Note that both sellers can position themselves on the same integer.

[For the LDU treatment: There are 7 potential simulated buyers in the market, each being positioned on one of the integers on the line below.]

Linear city 1 2 3 4 5 6 7 8 9 10 11

[For simplicity, we will refer to the line as the linear city. Buyers are necessarily located next to each other. In other words, there is no location without a buyer between the first and seventh buyer. For instance:]

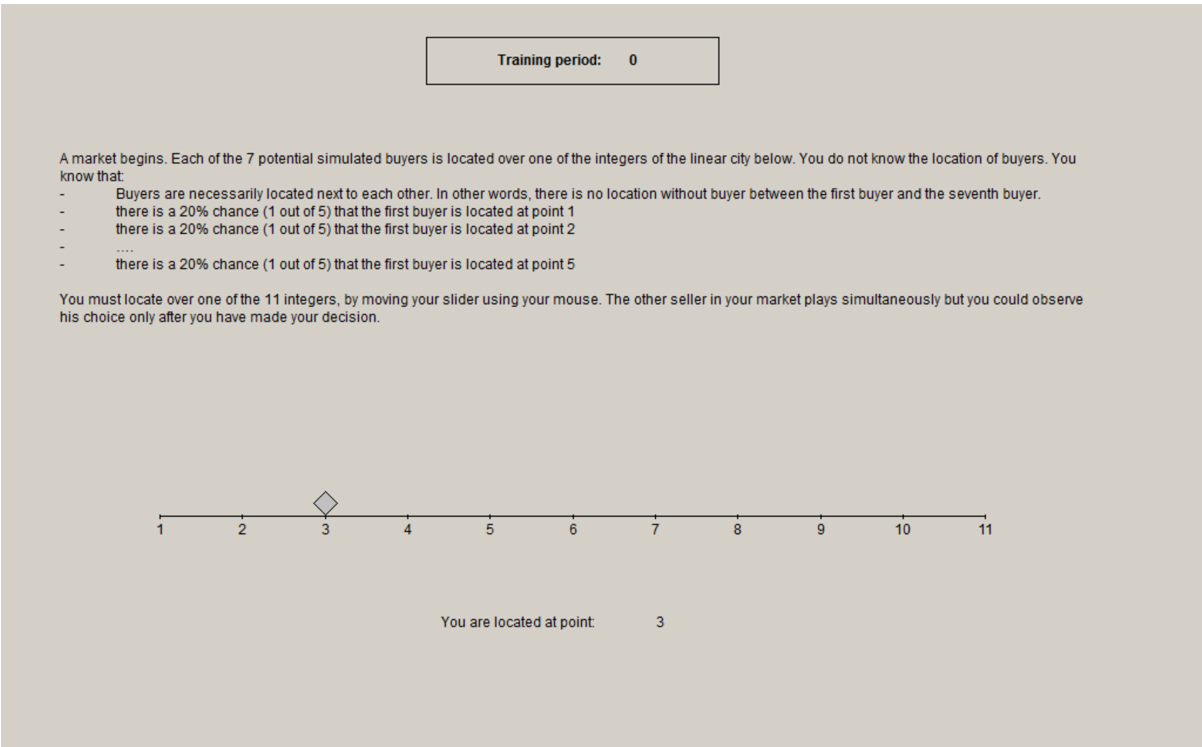
- *[If Buyer 1 is located at point 3, this means that Buyer 2 is located at point 4, Buyer 3 is located at point 5, and so on until Buyer 7 located at point 9.]*

- *[If Buyer 1 is located at point 1, this means that Buyer 2 is located at point 2, Buyer 3 is located at point 3, and so on until Buyer 7 located at point 7.]*

[Each seller chooses his location by moving to an integer of the linear city. Thus each seller can locate at the position numbered 1, 2, 3,....., 11. When choosing his location, the seller does not know buyers' location. The seller only knows the following:]

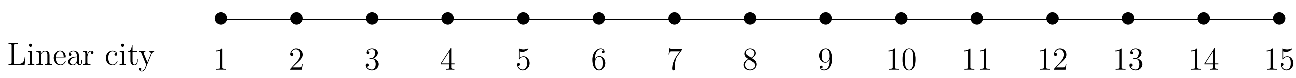
- *[there is an 20% chance (1 out of 5) that the first buyer is located at point 1]*
- *[there is an 20% chance (1 out of 5) that the first buyer is located at point 2]*
- .....
- *[there is an 20% chance (1 out of 5) that the first buyer is located at point 5]*

[Both sellers simultaneously choose their location. To do so, they position their slider over 1 of the 11 integers, as shown in the screenshot below. Note that both sellers can position themselves on the same integer.]



[For the HDU treatment: There are 7 potential simulated buyers in the market, each being positioned on one of the integers on the line below.]

[For simplicity, we will refer to the line as the linear city. Buyers are necessarily located next to each other. In other words, there is no location without a buyer between the first and seventh buyer. For instance:]

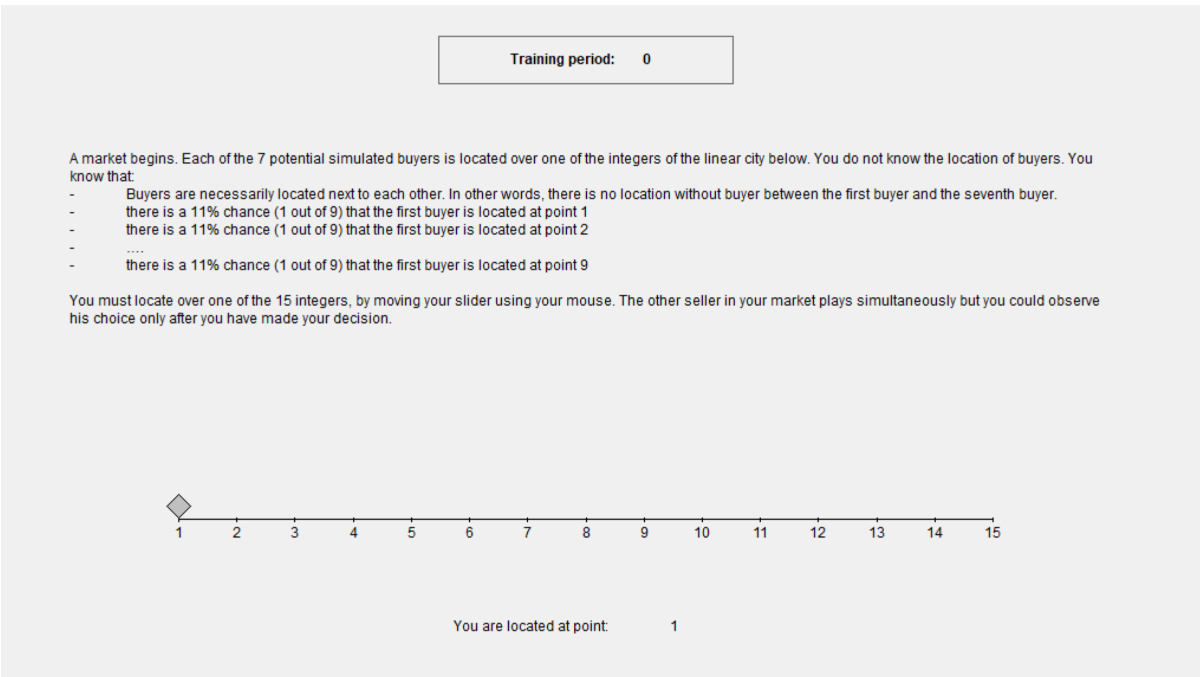


- *[If Buyer 1 is located at point 3, this means that Buyer 2 is located at point 4, Buyer 3 is located at point 5, and so on until Buyer 7 located at point 9.]*
- *[If Buyer 1 is located at point 1, this means that Buyer 2 is located at point 2, Buyer 3 is located at point 3, and so on until Buyer 7 located at point 7.]*

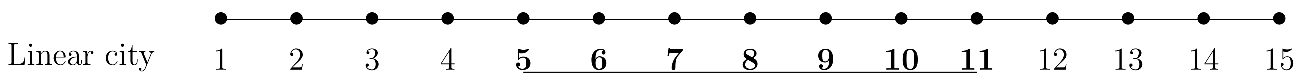
[Each seller chooses his location by moving to an integer of the linear city. Thus each seller can locate at the position numbered 1, 2, 3,....., 15. When choosing his location, the seller does not know buyers' location. The seller only knows the following:]

- *[there is an 11% chance (1 out of 9) that the first buyer is located at point 1]*
- *[there is an 11% chance (1 out of 9) that the first buyer is located at point 2]*
- .....
- *[there is an 11% chance (1 out of 9) that the first buyer is located at point 5]*

[Both sellers simultaneously choose their location. To do so, they position their slider over 1 of the 15 integers, as shown in the screenshot below. Note that both sellers can position themselves on the same integer.]

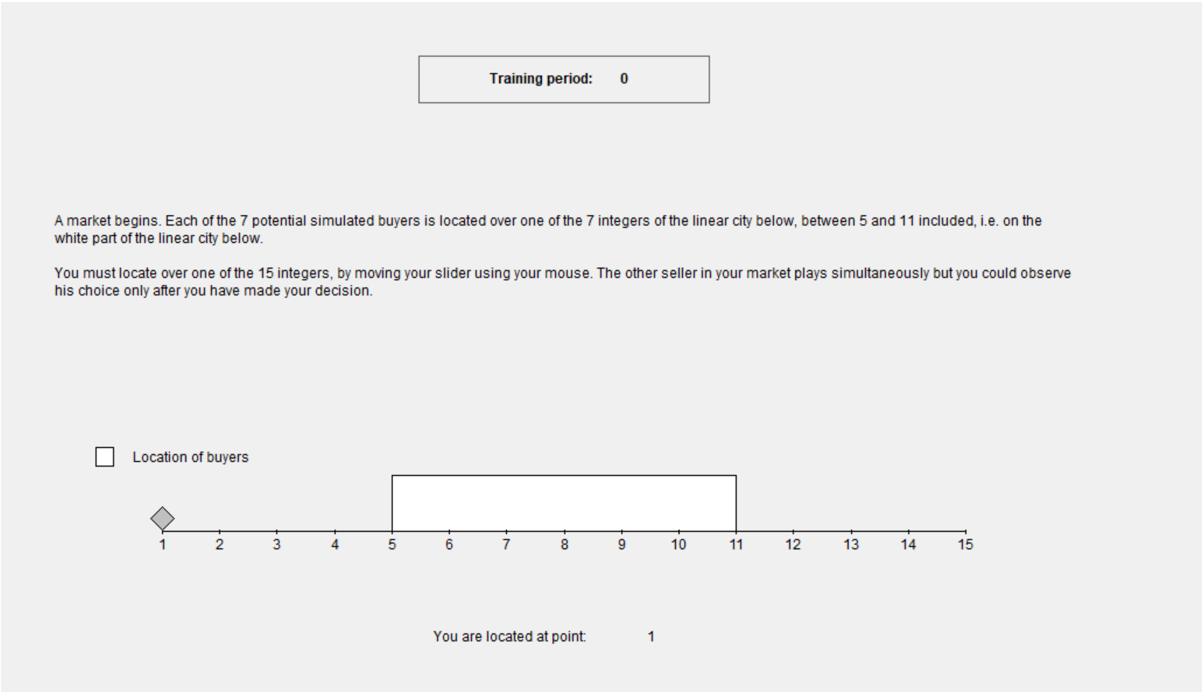


[For the DC-LS treatment: There are 7 potential simulated buyers in the market, each being positioned on integers 5 to 11 (numbers in bold and underlined) on the line below.]



[For simplicity, we will refer to the line as the linear city. There is a consumer located at number 5, another consumer located at number 6, ... and another at number 11 of the linear city. This means that there is no consumers at numbers: 1,2,3,4,12,13,14,15.]

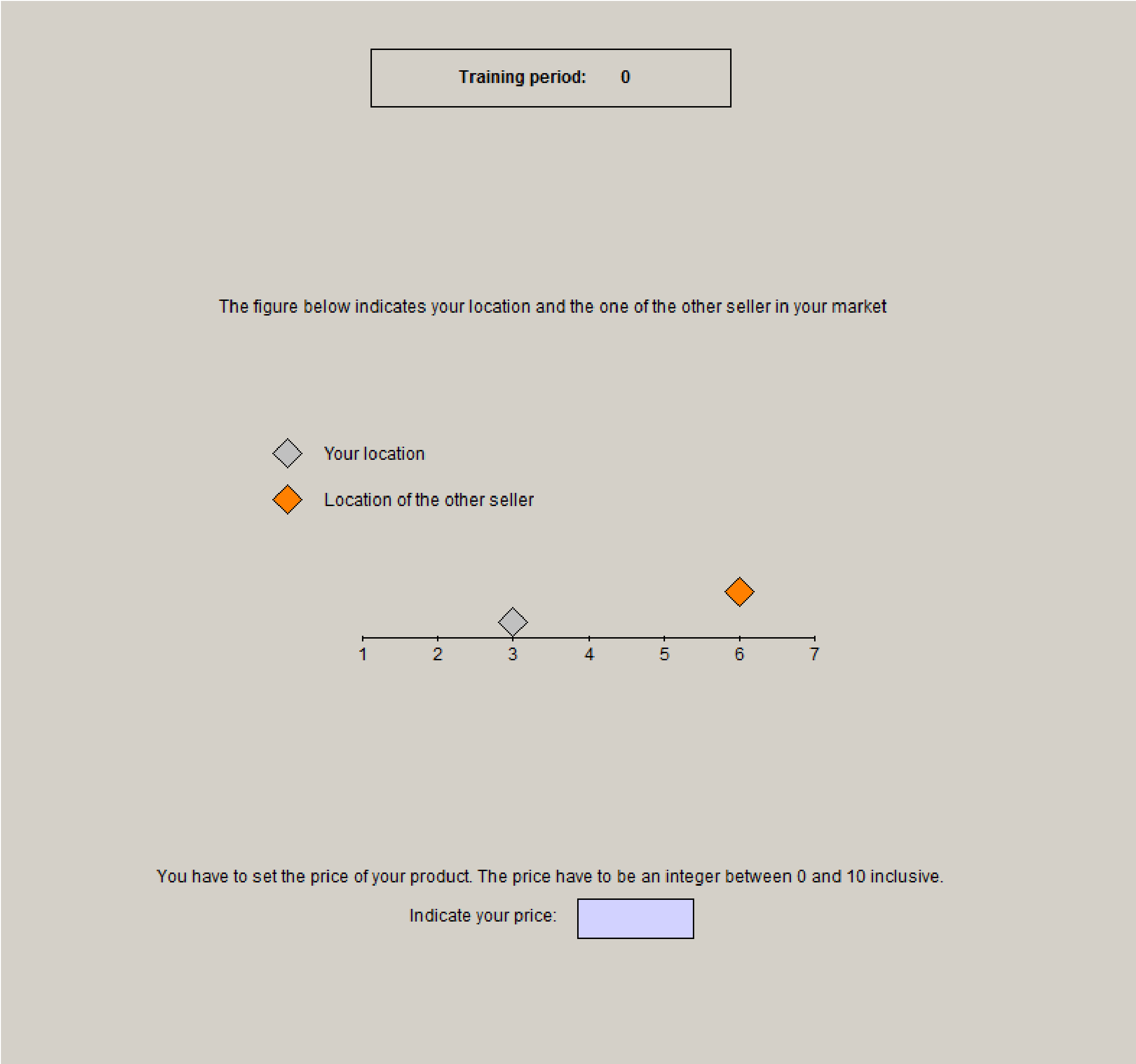
[Both sellers simultaneously choose their location. To do so, they position their slider over 1 of the 15 integers, as shown in the screenshot below. Note that both sellers can position themselves on the same integer.]



2nd stage: Price decision

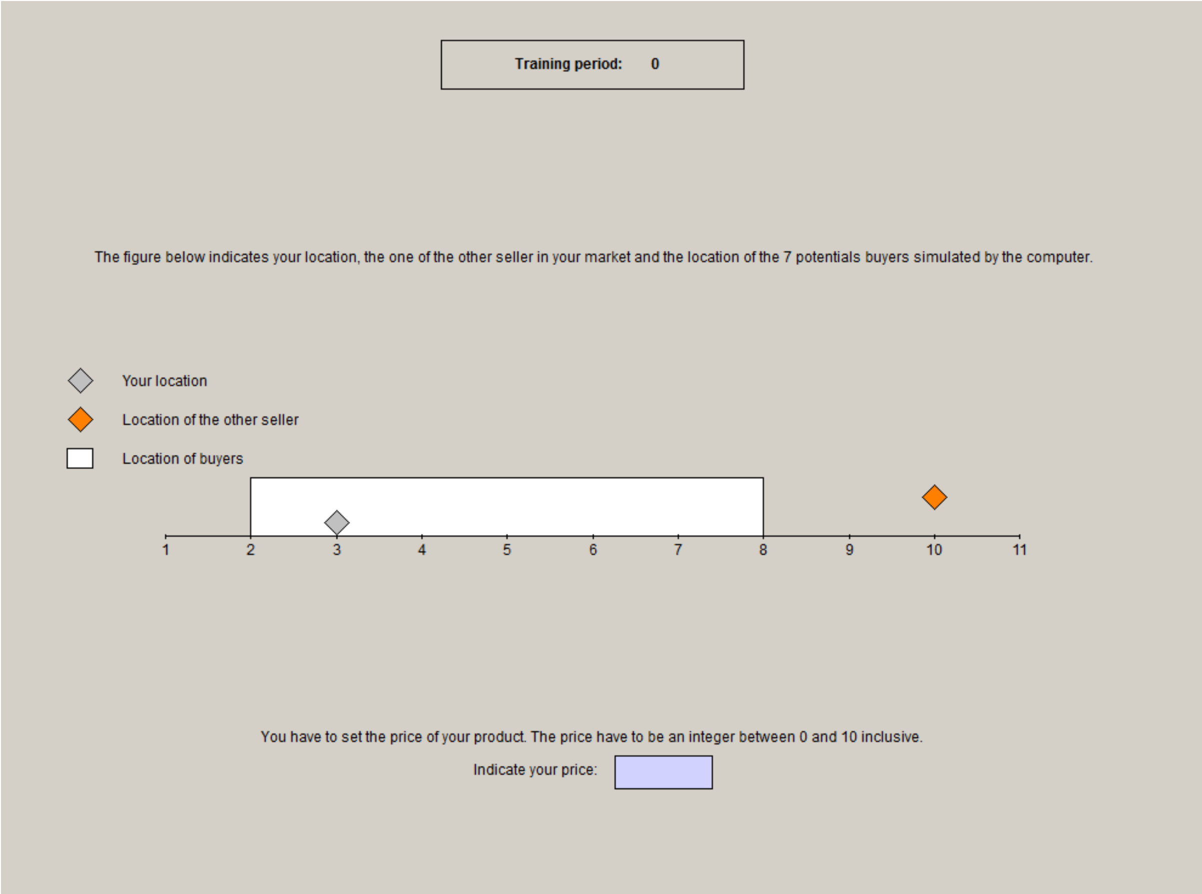
Once each seller is positioned, he observes his location and the location of the other seller in the linear city. Each seller sets the price of his product taking into account that his production cost is null. The price has to be an integer from 0 to 10 (inclusive). Each seller has to choose a price among 0, 1, 2 .., 10 and notes it in the dedicated box as shown in the screenshot below (Fig.10.)

Figure 10: Computer Screen for the Price Decision in the DC Treatment



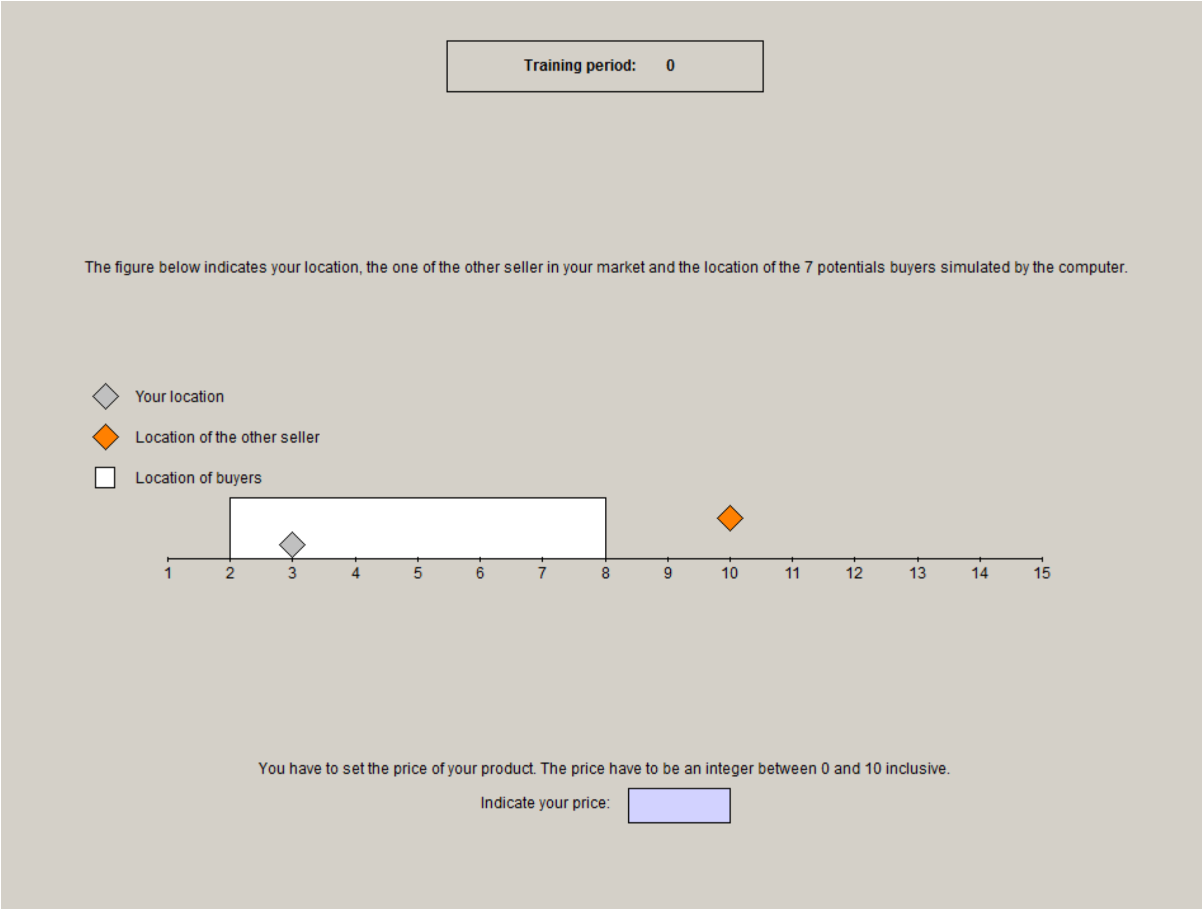
[In the LDU treatment, the screenshot is as follows]

Figure 11: Computer Screen for the Price Decision in the LDU Treatment



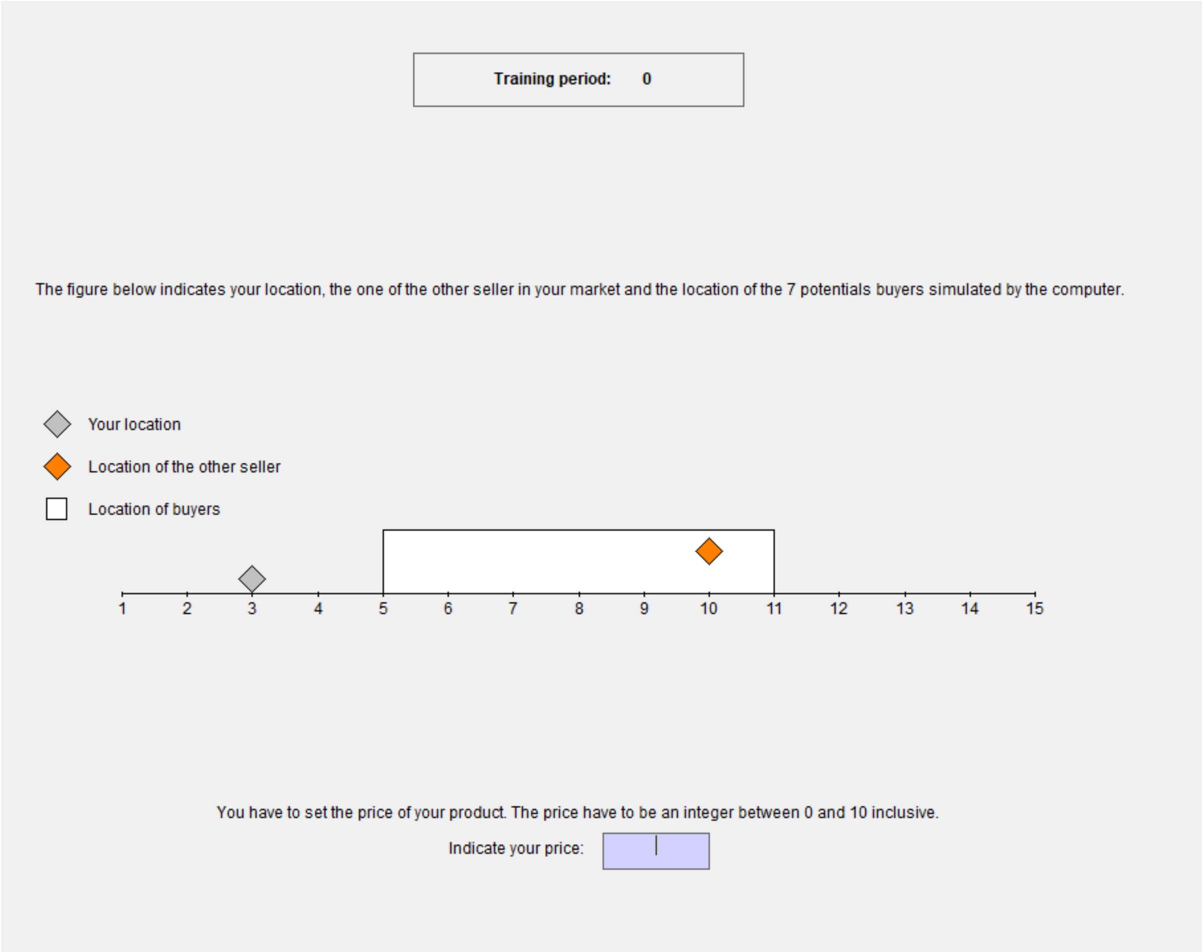
[In the HDU treatment, the screenshot is as follows]

Figure 12: Computer Screen for the Price Decision in the HDU Treatment



[In the DC-LS treatment, the screenshot is as follows]

Figure 13: Computer Screen for the Price Decision in the DC-LS treatment



Your goal is to get as much profits as you can for each period, knowing that your profit is computed as follows :

Your profit = your price × the number of buyers who buy your product

3rd stage: Buyers decisions

Potential buyers are simulated by the computer. Each simulated buyer has an initial endowment equal to 10 ECU. For each buyer, the computer calculates the payoff of the buyer following the purchase of 1 unit of the product and this for the 2 sellers. The payoff for the buyer is computed as follows:

Buyer payoff = 10 - price of the product purchased - transportation cost

The transportation cost is equal to the difference between the location of the seller and the buyer. For example, if the seller is located at 2 and the buyer at 4, the transportation cost is equal to $|2 - 4| = 2$. Therefore, a buyer will buy from the seller that is less expensive for him after considering the price and the transportation cost.

Therefore:

- Each simulated buyer purchases if the gain he derives from buying is positive or null.
- Otherwise, he will not buy, and his payoff for the period will be zero (in fact, if he bought in this case, his payoff would be negative. It is therefore preferable for the buyer not to buy and have a payoff equal to 0).
- If the payoff of the simulated buyer is the same regardless of the seller from whom he buys the product, he will purchase half a unit of the good from each seller.

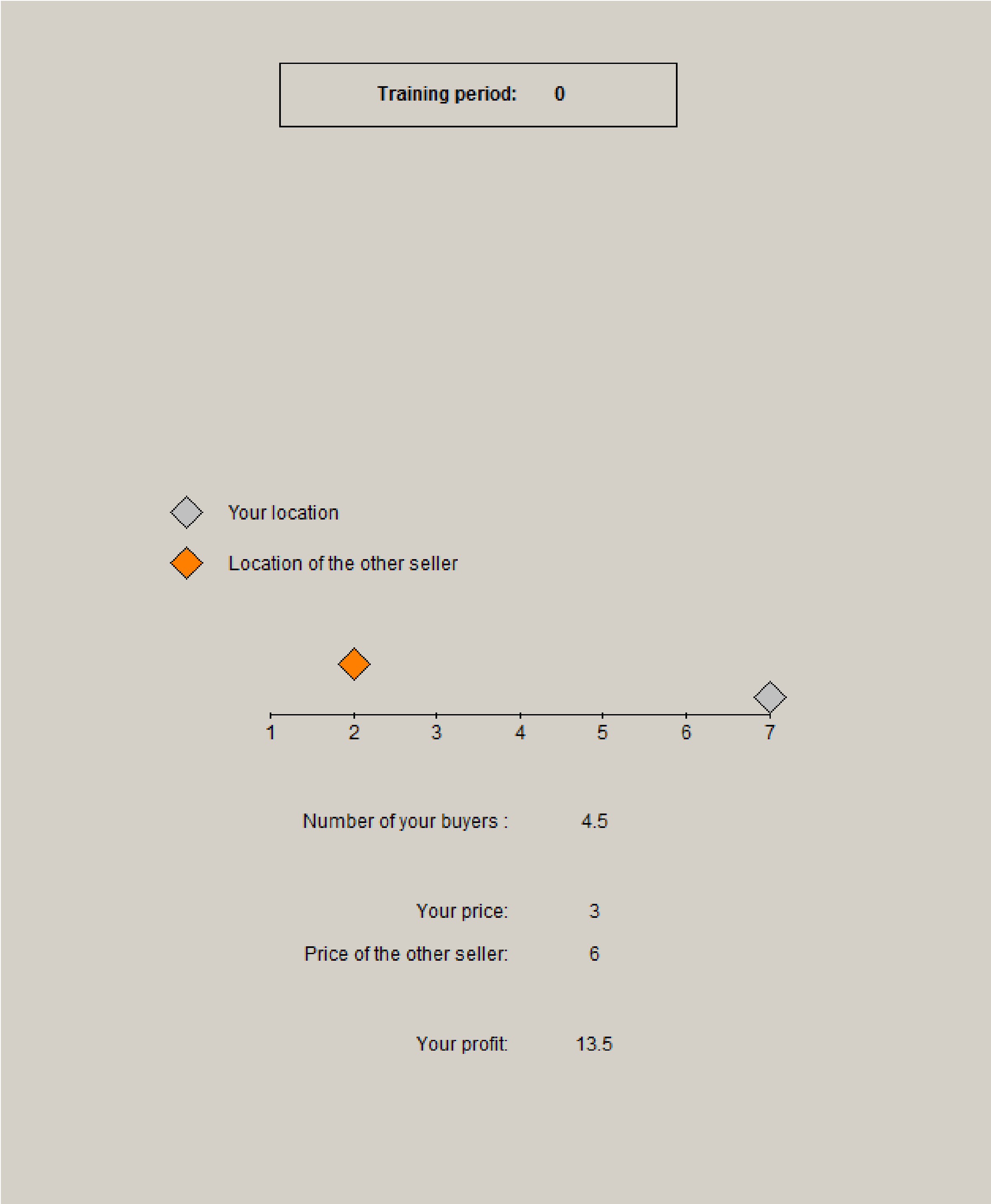
4th stage: History

Once each simulated buyer is assigned to a seller:

- each seller learns the total number of buyers he obtains and his payoff for that period,
- and each seller learns the price of the other seller in the market;

this is shown in the screenshot below (Fig.14.)

Figure 14: Computer Screen for History in the DC Treatment



[For the LDU, HDU and DC-LS treatments, the screen-shots vary only in the size of the demand support.]

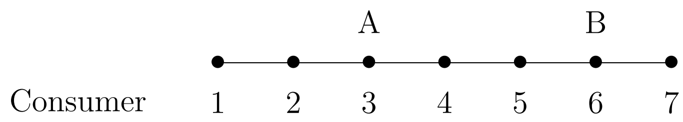
After reading this information, a new period starts. However, the locations of sellers remain the same as those selected in step 1. Therefore, period 2 begins at step 2 as for periods 3 to 5.

At the end of these 4 periods (i.e., periods 2 to 5), a new market starts in which you will be paired with a new seller. In other words, you will never interact with the seller(s) met in the previous market(s).

To help you with the experiment, 5 practice periods will be implemented: 1 period of location choices and prices for sellers, then 4 periods when sellers must choose only price. These training periods will not be taken into account in determining your final payoff.

Prior to this training, here are two examples.

Example 1 : seller A is positioned at point 3, and seller B is positioned at point 6. Seller A sets a price equal to 2, and seller B sets a price equal to 1.



A buyer positioned at point 1 will buy from seller A :

- His payoff if he buys from seller A is equal to 10 - price of seller A- |location seller A - buyer location| : $10 - 2 - |3 - 1| = 6$.
- His payoff if he buys from seller B is equal to 10 - price of seller B- |location seller B - buyer location| : $10 - 1 - |6 - 1| = 4$.

The payoff of buyer 1 is higher if he buys the product of seller A than that of seller B. Therefore, he will buy the product of seller A and obtains a payoff equal to 6.

In this situation, buyer positioned at point 4 obtains the same payoff from buying the product of seller A or seller B. He will buy half a unit of the product from each seller.

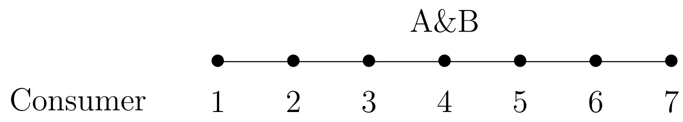
- His payoff if he buys from seller A is equal to 10 - price of seller A- |location seller A - buyer location| : $10 - 2 - |3 - 4| = 7$.
- His payoff if he buys from seller B is equal to 10 - price of seller B- |location seller B - buyer location| : $10 - 1 - |6 - 4| = 7$.

The payoff of buyer 4 is the same whether he buys the product of seller A or seller B. Therefore, he will buy half a unit of the product from each seller.

Suppose that we proceed in this manner for all potential buyers. Finally, seller A sells to 3 buyers, seller B also sells to 3 buyers, and 1 buyer buys half a unit of the product from each seller. The payoff of each seller is equal to the following:

- Payoff of seller A = Price of seller A $\times$ Number of buyers = $2 \times 3.5 = 7$.
- Payoff of seller B = Price of seller B $\times$ Number of buyers = $1 \times 3.5 = 3.5$.

Example 2: seller A is positioned at point 4, and seller B is positioned at point 4. Seller A sets a price equal to 9, and seller B sets a price equal to 8.



A buyer positioned at point 2 will buy from seller B:

- His payoff if he buys from seller A is equal to 10 - price of seller A- |location seller A - buyer location| : $10 - 9 - |4 - 2| = -1 < 0$.
- His payoff if he buys from seller B is equal to 10 - price of seller B- |location seller B - buyer location| : $10 - 8 - |4 - 2| = 0$.

The payoff of buyer 2 is higher if he buys the product of seller B rather than that of seller A. Therefore, he will buy the product of seller B and obtains a payoff equal to 0.

In this situation, a buyer positioned at point 7 obtains a negative payoff from buying the product, regardless of the seller. He will not buy the good:

- His payoff if he buys from seller A is equal to 10 - price of seller A- |location seller A - buyer location| : $10 - 9 - |4 - 7| = -2 < 0$.
- His payoff if he buys from seller B is equal to 10 - price of seller B- |location seller B - buyer location| : $10 - 8 - |4 - 7| = -1 < 0$.

Suppose that we proceed in this manner for all potential buyers. Finally, seller A sells to 0 buyer, seller B sells to 5 buyers, and 2 buyers do not buy. The payoff of each seller is equal to the following:

- Payoff of seller A = Price of seller A $\times$ Number of buyers = $9 \times 0 = 0$.
- Payoff of seller B = Price of seller B $\times$ Number of buyers = $8 \times 5 = 40$.

Before the experiment starts, you must answer a short questionnaire to verify your understanding of the instructions.

F Pricing Behaviors and Price Dynamics

In this section, we test the robustness of the positive relationship between differentiation and prices across time, and we analyze the pricing decisions of subjects over time. For that purpose, we first replicate the analysis conducted in the manuscript by considering the first and last periods of the price subgame, separately. Next, we compare the levels of prices in both periods and highlight some specific patterns according to the level of differentiation. We then provide in a last step some explanations of the price dynamics observed.

We begin by reporting in Columns (2-3) of Table 31 the average price, by level of differentiation and by treatment, computed both in the first and in the last period of the price subgame. Two patterns emerged from the computed averages.

First, we observe that the standard hypothesis that price competition is relaxed when differentiation increases is not necessarily supported in the first period. The positive relationship between differentiation and prices is only satisfied for the DC treatment (Spearman rank correlation coefficients, DC treatment: $\rho = 0.1841$ and $p < 0.0001$; LDU treatment: $\rho = 0.0593$ and $p = 0.1318$; HDU treatment: $\rho = 0.0262$ and $p = 0.5052$). This finding is in line with the results reported in the manuscript when considering all price periods. As previously explained, the absence of a statistically significant correlation between differentiation and prices in the LDU and HDU treatments may stem from a longer distance between the subject's location and the demand center. We thus reproduce the regression analyses conducted in Table 6 using the price data of the first period. The aim of this analysis is to test for the positive correlation between differentiation and prices while controlling for the distance to the demand center and subjects characteristics. The estimation results are reported in Columns (1-3) of Table 32. We find a positive and statistically significant relationship between differentiation and prices for all the treatments, once controlling for the distance to the demand center. Turning now to the prices set in the last period, we verify whether the positive relationship holds for all the treatments. We find that this is the case when using the raw data (Spearman rank correlation coefficients, DC treatment: $\rho = 0.4856$ and $p < 0.0001$; LDU treatment: $\rho = 0.4681$ and $p = 0 < 0.0001$; HDU treatment: $\rho = 0.4093$ and $p < 0.0001$). This result suggests that subjects take advantage of the repeated interactions to better understand that a high level of differentiation enables them to relax price competition. Finally, controlling for the distance to the demand center through the regression analyses, we confirm the statistical significance of the positive relationship between differentiation and prices in the last period (see the estimates in Columns 4-6 of Table 32).

A second pattern emerges from the comparison of the average prices chosen in the first and last periods. As observed in Columns (1-2), we find that prices are, on average, higher in the first period than in the last period for low and intermediate levels of differ-

Table 31: Price Decisions at the Beginning and at the End of the Price Game

	Average price		Prices	
Differentiation	First period	Last period	Non-cooperative equilibrium	Collusive outcome
Panel A: DC Treatment				
0	3.92	1.98	1	(5,7)
1	4.31	2.92	(1,2)	(6,8)
2	4.52	3.67	(2,6)	(6,9)
3	4.84	4.34	(2,7)	(7,9)
4	4.40	5.1	(6,7)	(8,9)
Panel B: LDU Treatment				
0	3.65	1.66	1	(4,7)
1	3.73	2.27	(1,2)	(5,7)
2	3.95	2.99	(1,6)	(7,9)
3	4.09	3.41	(2,6)	(7,9)
4	3.42	3.63	(3,7)	(7,9)
5	4.15	3.65	(4,7)	8
6	3.50	3.50	(5,7)	(7,8)
7	4.50	2.50	(5,7)	7
Panel C: HDU Treatment				
0	3.24	1.51	1	(4,6)
1	3.47	2.04	(1,2)	(5,7)
2	3.32	2.06	(1,6)	(5,8)
3	3.41	2.69	(2,6)	(5,8)
4	3.50	3.39	(2,6)	(6,8)
5	3.78	4.05	(4,7)	(7,9)
6	3.56	3.81	(5,7)	(7,8)
7	3.87	4.12	(5,7)	7
8	3.00	3.5	(6,7)	(6,7)
9	1.50	3	(5,7)	(5,7)

Notes: The columns denoted *Prices* report the minimum and maximum prices for the non-cooperative equilibrium and the collusive outcome, for risk-neutral firms, by differentiation level and for each treatment. A single value means a unique price for both firms. Note that, for the particular case of a null differentiation in the collusive outcome, we only retain outcome with symmetric prices.

entiation (i.e., differentiation levels between 0 and 3), and this result holds regardless of the treatment. This tendency is, however, reversed for the highest levels of differentiation in the DC and HDU treatments. In these cases, we observe that the average prices chosen in the last period are higher than those set in the first period. To provide some explanations for these opposite price changes, we first examine whether subjects set prices in accordance with the non-cooperative equilibrium prices in the first period. Column (4) of Table 31 gives the range of the non-cooperative equilibrium prices for each level of differentiation and each treatment. For all the treatments, we find that the average prices are set in accordance with the non-cooperative equilibria only in the case of intermediate levels of differentiation (i.e., 2-3 for DC, 2-5 for LDU and 2-4 for HDU). For the other levels of differentiation, two opposite behavioral strategies are observed. When subjects highly differentiate (i.e., differentiation equal to 4 in the DC and above 5 in the LDU and

Table 32: Price Regressions

Dependent variable: Price	First period			Last period		
	DC Treatment	LDU Treatment	HDU Treatment	DC Treatment	LDU Treatment	HDU Treatment
Differentiation	0.3484***	0.1123*	0.1123***	0.7945***	0.5361***	0.4499***
	(0.0690)	(0.0535)	(0.0379)	(0.0717)	(0.0540)	(0.0294)
Dist. to demand center	-0.1911	-0.3345***	-0.4107***	-0.0815	-0.3128***	-0.3050***
	(0.1279)	(0.0455)	(0.0235)	(0.0953)	(0.0342)	(0.0408)
Coef. risk aversion	-0.1317	0.1709	-0.2012	0.0129	-0.0308	0.0929
	(0.2049)	(0.1559)	(0.1480)	(0.1208)	(0.0893)	(0.0736)
Constant	7.1604***	3.7848***	2.9037***	2.9757**	1.1245***	1.4287***
	(1.5092)	(0.6260)	(0.4581)	(1.0943)	(0.3341)	(0.3598)
Matching group FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.2184	0.2020	0.2923	0.3491	0.3333	0.4185
Observations	648	648	648	648	648	648

Notes: All the regressions include subjects socio-demographic characteristics (age, gender, work, undergraduate, economics student). Clustered standard errors (at the group matching level) reported in parentheses.*, **, *** indicate significance at the 10%, 5%, and 1% level, respectively.

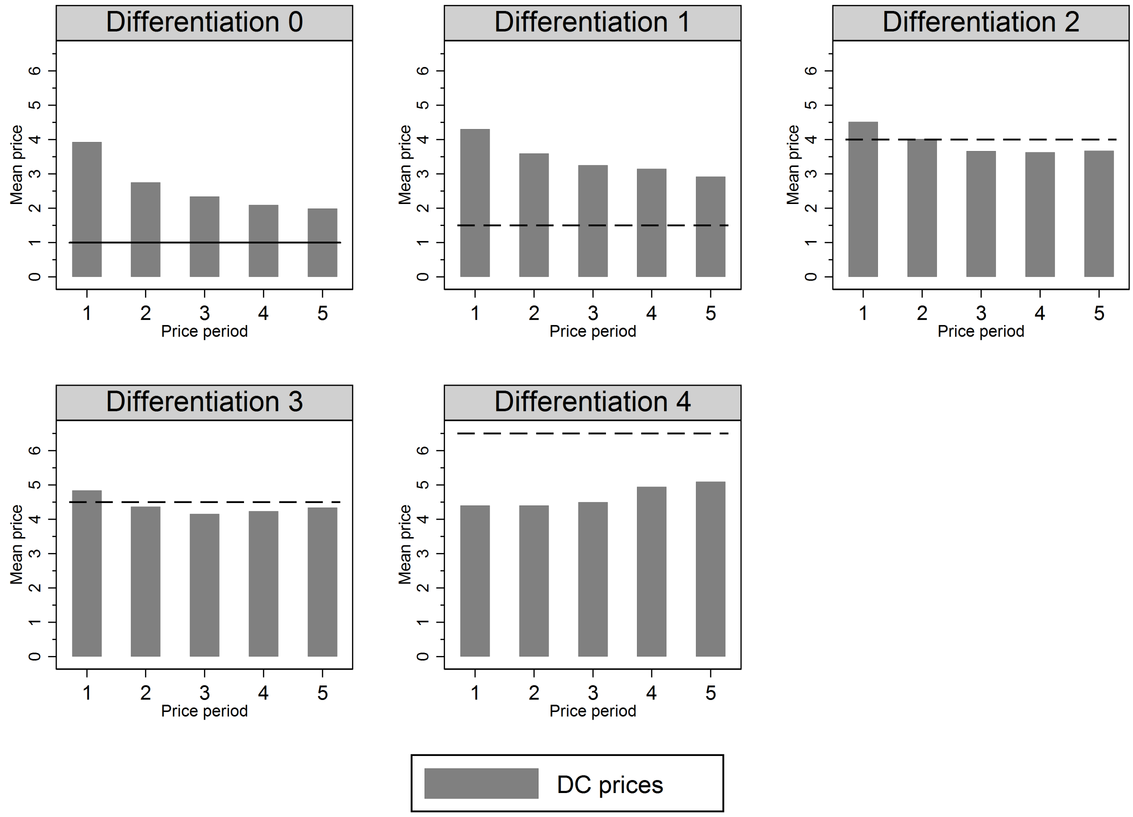
HDU treatments), we note that they partially fail to relax price competition by setting prices that remain slightly below the non-cooperative equilibrium. These deviations can be explained by the distance between the subject's location and the demand center. Indeed, under high levels of differentiation, it is more likely that one of the two subjects is farther away from the demand center. This, in turn, forces the subject located farther away to set a low price, which triggers greater price competition. Conversely, for low levels of differentiation (i.e., 0 and 1), we find that the average prices decline over time but remain above the range of the non-cooperative equilibrium prices. This means that in the case of null or minimal differentiation, subjects attempt to tacitly collude by fixing prices above the non-cooperative equilibrium.

Taken together, it seems that in the case of low or high differentiation, subjects take advantage of the repeated interactions over time to adjust (up or down) their price in a direction more in accordance with the non-cooperative price equilibria, regardless of the treatment. To provide some evidence of these dynamic behaviors, we plot in Figs. 15–17 the evolution of the average prices over time for each treatment while controlling for the level of differentiation.

Overall, we observe that prices notably decline over time for low levels of differentiation but do not sufficiently fall down in the range of the non-cooperative equilibrium prices. Does this mean that subjects succeed in colluding over time? To answer this question, we report in the last column of Table 31 the range of the collusive prices. We show that considering both the first and last periods we cannot assert that subjects collude in prices because the chosen prices are far below the collusive prices. Nevertheless, if we consider all price periods, the attempt to collude in prices is clear. As shown in Figs. 15–17, when subjects are located at the same location or next to one another, they attempt to tacitly collude in the first period by setting prices significantly higher than the non-cooperative predictions. However, by failing to achieve the collusive outcome, the low level of differentiation forces them to gradually reduce their prices in the following periods, and subjects face fiercer price competition in the last periods.

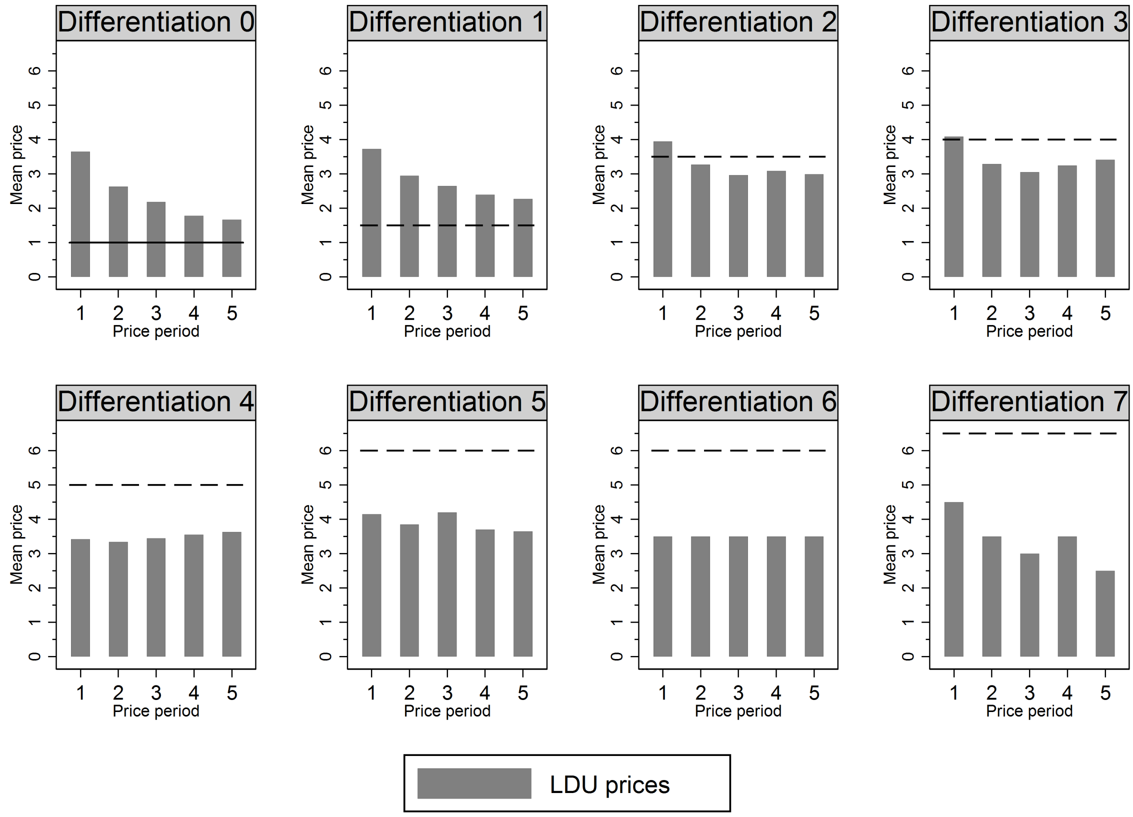
Finally, considering the highest levels of differentiation in Figs. 15–17, we observe that subjects are not able to completely relax price competition. Even if prices increase over time, the prices set at the end of the game are far below the range of the non-cooperative equilibrium prices. As stressed previously, one explanation of this result stems from the introduction of demand uncertainty. In these setups, the likelihood that a subject is located far away from the demand center, compared to its rival, increases with the level of demand uncertainty. As a result, the incentive for a subject to engage in tougher price competition also increases with the level of uncertainty, which prevents him from reaching the non-cooperative price equilibrium.

Figure 15: Evolution of Prices During the 5 Periods of the Price Subgame in the DC Treatment



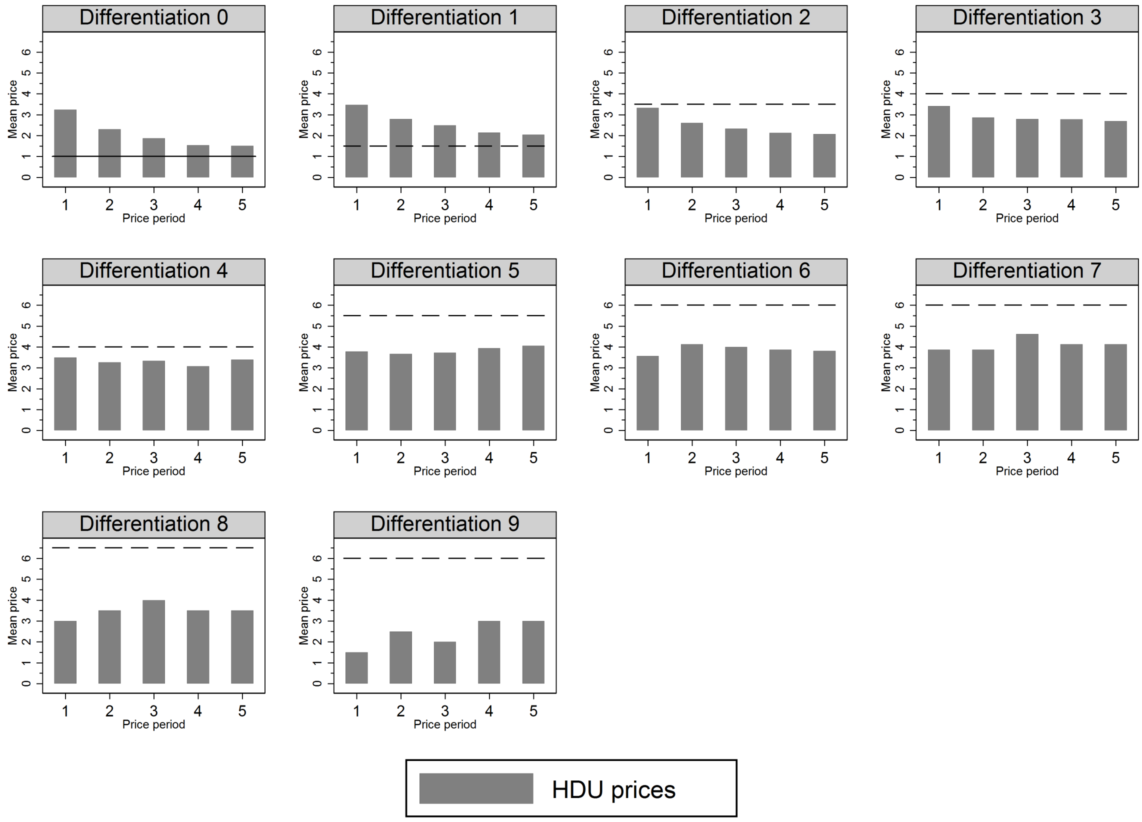
Notes: The graph displays in each panel the mean price set by time period for a given level of differentiation in the DC treatment. A solid horizontal line represents the unique equilibrium price for all pairs of locations. A dashed horizontal line represents the average of multiple equilibrium prices in the case of mixed strategy equilibria and multiple pure strategy equilibria.

Figure 16: Evolution of Prices During the 5 Periods of the Price Subgame in the LDU Treatment



Notes: The graph displays in each panel the mean price set by time period for a given level of differentiation in the LDU treatment. A solid horizontal line represents the unique equilibrium price for all pairs of locations. A dashed horizontal line represents the average of multiple equilibrium prices in the case of mixed strategy equilibria and multiple pure strategy equilibria.

Figure 17: Evolution of Prices During the 5 Periods of the Price Subgame in the HDU Treatment



Notes: The graph displays in each panel the mean price set by time period for a given level of differentiation in the HDU treatment. A solid horizontal line represents the unique equilibrium price for all pairs of locations. A dashed horizontal line represents the average of multiple equilibrium prices in the case of mixed strategy equilibria and multiple pure strategy equilibria.