Economics School of Louvain - ESL

Economics School of Namur - ESN

Loss Aversion and Second-Degree Price Discrimination: A Theoretical Approach

Author : Adrien Delogne

Thesis Director : Johannes Johnen

Thesis Reader : François Maniquet

Academic Year 2021-2022

Master in Economics, Research focus– 120 credits

Université catholique de Louvain - Economics School of Louvain - Place Montesquieu 3, 1348 Louvain-La-Neuve
Université de Namur – Economics School of Namur – Rempart de la Vierge 8, 5000 Namur

Loss Aversion and Second-Degree Price Discrimination: A Theoretical Approach

This thesis presents a model of second-degree price discrimination when a monopolist faces loss-averse consumers. A consumer's valuation is additively separable between a consumption utility function (which depends on the type), and a gain-loss utility function that is affected by deviations from a reference consumption plan. This consumption plan is determined after the consumers find out their type. Moreover, we assume that the monopolist is able to make each consumer type expect to buy a specific variety of goods. We find that loss aversion increases the likelihood that offering a single product to all consumers is the optimal choice for the monopolist. We also show the conditions for menu pricing to be optimal for the monopolist, and derive the welfare effects of loss aversion on the standard menu pricing model.

Acknowledgements

I would like to thank all the people that helped me in the realization of this thesis, and more generally to those who contributed to the success of my Master's degree. First and foremost, I would like to thank Pr. Johannes Johnen. He always made himself very available, and provided me with excellent advice. Indeed, his recommendations guided me in the right direction and his suggestions were always very constructive. This hard work and great guidance produced this thesis, which I can only be proud of. I not only want to thank him as a supervisor, but also as a professor. My interest for Industrial Organization would not be what it is without him and his valuable lectures.

Moreover, I want to thank all the economics professors I met throughout the course of my studies, who developed my reflective and analytical skills. In particular, I would like to thank Pr. Maniquet and Pr. Belleflamme. The former for his contagious passion for Microeconomics, and because he accepted to read this revised version. The latter because he first introduced me to Industrial Organization, a field I immediately fell in love with and that led to me to write this Master thesis and land an exciting job.

Thirdly, I want to thank all the people from UCLouvain that offered me professional opportunities while still being a student. I have been a Teaching Assistant for several classes in the recent years, therefore I would like to thank all the professors and the administrative staff who made this possible. These opportunities helped me have a different perspective on some economical and statistical concepts I thought I knew well, in addition to developing my communication and public speaking skills.

Last but not least, I would like to thank my family and my friends whose presence gave me motivation throughout the entire writing process.

1 Introduction **1**

2 Literature Review **3**

2.1 Screening and pricing strategies literature . . . 3

2.2 Reference-dependent preferences literature . . . 4

2.3 Loss Aversion and Second Degree Price Discrimination Literature . . . 7

3 The Model **8**

3.1 Introduction . . . 8

3.2 Consumers with standard preferences . . . 11

3.3 Loss-averse consumers . . . 13

3.4 Ex-ante versus Ex-post Consistent Reference Points . . . 18

4 Welfare effects **19**

5 Conclusion **21**

6 References **22**

7 Appendices **25**

1 Introduction

In neoclassical economics, a fundamental assumption is that willingness to pay is independent of context. It greatly eases many computations, as indifference curves do not depend on the initial values of endowment. However, there exists ample evidence that consumers are concerned about their gains or losses compared to a reference when considering whether or not buying some good (Kahneman & Tversky, 1991). More specifically, the endowment effect refers to the empirical observation that owners value an object more than non-owners of this good. This behavior has been widely studied, and the literature provides a prominent explanation for this: loss aversion. Agents dislike losses relative to a reference point more than they appreciate same-sized gains. Loss aversion (LA) is one of the most robust behavioral patterns in risky and riskless choice theory (Kahneman & Tversky, 1991). Its most notable theoretical representation comes from Kőszegi & Rabin (2006): they represent the consumers' valuation of a good as the sum of their intrinsic valuation and their relative valuation (which depends on the deviation from a reference point).

Moreover, in many markets, there are opportunities for a seller to use price discrimination. Whether we think of streaming services, airline tickets, cinemas or fast-foods, the sellers are often not able to infer on their customers' willingness to pay from some observable characteristics. To maximize their profit, sellers must therefore induce their consumers to reveal this private information. One way of doing so is to propose price/quality combinations that are valued differently by consumers, such that they self-select into the option that is the best for them.

If LA is such a well-established bias, it is then interesting to understand how it affects the incentives for price discrimination. Within this framework, if we assume that consumers are loss-averse, how are sellers' decisions influenced? The purpose of this paper is to develop a model which describes the impact of customers' loss aversion on the decisions of a monopolist who cannot infer on its buyers' type. Some papers showed that in the case of heterogeneous consumers, the monopolist would increase profits by offering a single product to all consumers rather than different products for different consumers (see Heidhues & Kőszegi (2008a), Herweg & Mierendorff (2013)). These results hold under the assumption that consumers form their reference point before they find out their type. However, in some specific situations, it is rather the case that consumers form their reference point after learning their type.

In this paper, we design a model that determines the optimal prices when a monopolist cannot observe consumers' type and that they are loss-averse. We consider that there are two types of consumers and that they form their reference point after they learned their types. We derive the conditions under which the monopolist prefers to offer a menu rather than selling a single product when consumers have reference-dependent preferences. We then show the welfare implications of adding bounded rationality in the standard menu pricing model.

To which type of settings does this model apply? Intuitively, this model better captures markets in which consumers are experienced and already know which product version they like best. It captures markets for experience goods, i.e. products and services with characteristics that can only be ascertained upon consumption because they are difficult to observe in advance. Here, consumers are already informed about product quality and are aware of their personal valuation of the different options. Moreover, since product quality is exogenous, the model better represents markets where the seller cannot easily change the quality of the goods. In some specific applications, quality levels are fixed — at least in the short run — or it may be costly for a monopolist to change the quality of the product line. Some examples of applications where our model could apply are cinema tickets, supermarkets, or plane tickets.

The form of loss aversion that is used in this paper is the same as described in Carbajal & Ely (2016), i.e. *two-dimensional* LA. Indeed, in the model we consider, any deviation from the (exogenous) reference point generates disutility. To illustrate this, let us take an example. Consider the market of opera tickets. The opera faces both rich and poor consumers and cannot identify a consumer's willingness to pay. The opera may therefore have an incentive to offer seats of different qualities and prices, such that rich customers would buy the better seats and poor customers would rather choose the cheaper ones. We assume that rich consumers aim to buy the premium seats, and that poor customers aim to buy the cheap seats. In our case, loss aversion will imply that any deviation from this expected product will generate some disutility. When considering to buy an opera ticket or not, the poor consumers will focus more on the loss of quality if they end up not buying anything and on the financial loss (due to the increased ticket price) if they end up buying a premium ticket. Similarly, the rich consumers that expect to buy a premium seat will face an additional source of disutility compared to the rational case if they switch to the standard ticket or does not buy any ticket. This is so because they attach more importance to the loss of quality than to the financial gain.

We show that with reference-dependence, the monopolist is more likely to offer a single good to the whole population rather than offering a menu of goods. This finding contributes to the literature on reference-dependence. Specifically, we answer the question of why we often observe simple contracts, although empirical observations report significant heterogeneity in buyers' willingness to pay. Indeed, the fact that price discrimination is not more widespread has been often attributed to the firms' costs of maintaining a large price price list (Dixit & Stiglitz, 1977). However, in practice, these costs often tend to be small, such that it is difficult to justify the observed lack of quality diversity.

Our contributions are twofold. First, we show that the optimality of pooling when consumers are loss-averse can be justified even when the demand is certain. The endowment effect can be sufficient to explain the prevalence of a pooling equilibrium, as in our mechanism, the environment is riskless. Indeed, we show that loss aversion distorts the benefits and costs of switching to menu pricing in such a way that it becomes more likely that a pooling equilibrium emerges. Second, we contribute to show why simple contracts are applied on markets for experience goods, despite significant heterogeneity observed in consumers' willingness to pay.

This paper also considers the effect of LA on welfare. We show that loss aversion exacerbates the welfare effects present in the standard model. That is, we show that menu pricing improves welfare even more if selling the low quality leads to an expansion of the market and that consumers are loss-averse. Otherwise, menu pricing deteriorates welfare even more than when consumers do not have reference-dependent preferences.

This paper also considers the effect of LA on welfare. We show that loss aversion enables the monopolist to extract more surplus from consumers, because loss aversion lowers their reservation point. However, there is no effect of loss aversion on the overall level of welfare.

The structure of the paper goes as follows. We first give an overview of the existing literature, in section 2. Because the model we are focused on is at the crossing of two very different topics in economics, we divide this section in three parts. First, we present the literature on screening and pricing strategies. Second, we show an overview of the —rapidly increasing— literature on reference-dependent preferences. Third, we review the papers that are combining loss aversion and menu pricing. Section 3 is the core of this paper and develops our model. After establishing the framework of the model and the different assumptions needed, we first recall the results of the profit maximization with standard preferences. We then show how the introduction of loss aversion impacts the results. In Section 4, we compute the welfare effects of menu pricing under loss aversion and discuss these results. We conclude in section 5 by encouraging possible extensions and briefly summarize our most important findings.

2 Literature Review

2.1 Screening and pricing strategies literature

The framework we present builds on the basic model of menu pricing by Mussa & Rosen (1978), who researched the optimal price and quality for a monopolist that cannot distinguish between consumers of different types. The monopolist has to offer a price/quality combination such that consumers self-select the product that is designed for them. In the model, product quality is endogenous, and the authors show that the product quality under a monopolistic setting is lower than under competition, except for the highest type of consumers. They also show that second degree price discrimination, i.e. menu pricing, leads to higher prices, and that the price differential increases with the quality level. As we will show, introducing bounded rationality strengthens these effects. They show that the strategy of inducing self-selection is likewise often strictly superior to any other strategy. This paper is the starting point of a large literature about screening. In the present paper, we will use a simplified version of this model. Indeed, we will consider binary types of consumers, and exogenous quality. However, the main difference we introduce lies in the addition of bounded rationality. Consumers are not assumed rational, they are loss-averse.

A second very influential paper by Spence (1977) examines the use of quantity dependent prices for a single commodity. He shows that the monopolist tends to use quantity discounts to raise revenues and that the unique optimal strategy for a monopolist is often to induce self-selection among heterogeneous customers by offering a menu of quantities, each requiring a different outlay. That paper paved to way for the standard menu pricing model that is widely used nowadays.

Stokey (1979) proposes a similar framework in continuous time. However, he shows that, under some assumptions, it is never profitable for a monopolist to discriminate by inducing self-selection. Instead, he shows that it is always optimal for the monopolist to pre-commit to a fixed price over time, thereby inducing those who would earn surplus at that given price to purchase at the first opportunity. These findings contradict the two papers mentioned above, which both find that price discrimination is optimal.

Salant (1989) unified the aforementioned papers to show that with Spence (1977) and Mussa & Rosen (1978)'s assumptions, a corner solution—where all consumers purchase the same product— needs not arise, but that whenever it does, price discrimination is not optimal. He then defines the condition under which the monopolist prefers to use menu pricing.

Maskin & Riley (1984) formalized the constraints faced by a monopolist under asymmetric information, and proposed a method to solve the profit maximization problem. They find that the optimal selling strategy involves pricing larger quantities at successively lower unit prices, in such a way to prevent high-type consumers to switch to a lower product.

Most of the existing literature on screening is based on the above papers. However, we introduce behavioral elements in our paper which were not present in any of those publications. Therefore, in the following subsection we review the literature about reference-dependent preferences. Within this literature, only a very limited subset combines both LA and screening.

2.2 Reference-dependent preferences literature

Many studies have covered reference-dependent preferences, initially introduced by Kahneman & Tversky (1991, 2013). They first formalized LA, and highlighted its implications through some experimental evidence. This model laid the foundations for modern analysis of LA in industrial organization, although implications on competition were not considered.

Ever since, several papers have showed how a retailer can maximize its profits when consumers present some form of deviation form rational preferences. DellaVigna & Malmendier (2004) analyze markets of goods with immediate costs but delayed benefits for consumers. They show that firms should price investment goods below marginal costs and leisure goods above marginal costs, so as to take maximal advantage of the consumer's overconfidence and underestimation of renewal. Moreover, firms facing such consumers charge back-loaded fees and offer contracts with automatic renewal and switching costs.

Eliaz & Spiegler (2006) also analyze this type of inconsistencies, but they do not generalize it: they design the optimal product that a principal offers depending on the degree of sophistication of the consumer. They show that more naive consumers are exploited by the retailer. Grubb (2009) highlights another bias: overconfidence. He shows that consumers may overestimate the precision of their demand forecasts, which creates an incentive for sellers to offer a price that involves a range of units offered at zero marginal price, followed by positive marginal prices for additional units. Within the literature on behavioral industrial organization, several studies are also looking at how a retailer can manipulate consumers choice, assuming bounded rationality. Salant & Siegel (2018) study a model of contracts in which a retailer can use framing to temporarily influence consumers choice. They design the optimal contract, considering that consumers may return the product after the framing effect wears off. However, as opposed to what we find in our paper, consumers do not experience a loss if they realize they overpaid for a product; they do not form reference points. All these papers aim to understand the implications of behavioral biases on a monopolist's behavior. In the present paper, we focus on a particular type of bias that is LA.

Rosato (2016) studies the optimal selling strategy when consumers are reference-dependent and that the retailer can limit the availability of a good. He demonstrates that the monopolist has an incentive to bait consumers with a cheap good that is however limited in availability, and offer an alternative more expensive product. The consumer is therefore left with the choice between purchasing a more expensive product or not purchasing at all. Facing the unavailability of the expected good, they will purchase the more expensive product to minimize their disappointment. This pricing strategy differs from ours, as we rather address the issue of price discrimination.

A significant share of the behavioral industrial organization literature focuses on LA in a competitive setting. This is the case of Karle & Peitz (2010, 2014), who built a model *à la Salop (1979)* in which some reference-dependent consumers are initially uninformed about the location of the firm and form their reference point accordingly. They show that in the case of firms with identical costs, a larger share of uninformed consumers results in a less competitive market. Zhang & Li (2021) investigate the relationship between consumer LA and the choice of firms to disclose information, in a duopolistic setting. The presence of LA enables the firms to increase their profits at the expense of consumers, through more disclosure. Zhou (2011) approaches reference-dependent preferences through a model of imperfect competition. A prominent product is taken as a reference by consumers. In contrast with most papers, LA in price and in taste (or quality) are captured by two different parameters. He is therefore able to show that LA in the price dimension makes competition harsher, while LA in the product dimension softens competition. In Karle et al. (2021)'s competitive setting, not all consumers are loss-averse. Before inspecting all products, they can form consumption plans, and if the gain/loss sensations are too large relative to this plan's expected surplus, they skip the plan and stick to a default product.

The authors show that the presence of reference-dependent consumers reduces the competitive pressure and drives prices up. With a sufficiently large share of loss-averse consumers, firms can charge monopoly prices, regardless of the number of firms in the market. In our model, we start from monopolistic prices to show that LA increases optimal prices even more.

In a paper similar to Karle & Peitz (2010), Heidhues & Kőszegi (2008b) identify the optimal prices and equilibrium conditions with loss-averse consumers in a competitive environment. Here, consumers' tastes are heterogeneous, and the model then naturally builds on a Salop (1979) circle. They show the conditions under which all firms charge the same equilibrium price, and show how LA increases this price. Because consumers form their expectations before finding out their type (as opposed us), the prices will be sticky near these expectations, allowing for a single price to emerge on the market. These results are in line with ours, although the starting assumptions are different. A related paper by Courty & Nasiry (2018) show that charging the same price for products of different qualities may be optimal for a monopoly, when the reference point is formed by past purchases.

Fabrizi et al. (2016) study a model a model of market competition with vertical restraints between upstream manufacturers and downstream retailers. Here, LA is two dimensional. Moreover, not all consumers are assumed reference-dependent. Tramontana (2021) confronts reference-dependent consumers with a boundedly rational monopolist, who is not able to fully exploit consumers' bias. The firm must therefore guess a linear demand function with variable (or stochastic) slope in a dynamical process. He shows how LA and the level of the reference price affect the stability of the equilibrium.

Rosato (2016) and most of the recent literature on LA builds on the representation of preferences of Kőszegi & Rabin (2006), including this paper. They assume that a consumers' utility not only comes from the intrinsic consumption of a good, but also from a gain/loss compared to a reference point. They use this assumption on preferences to show that the more consumers anticipate to purchase, the higher their willingness to pay. They also introduce the concept of personal equilibrium, which is crucial when dealing with LA. Indeed, if reference points are based on expectations, then different expectations can lead for the same consumer to different equilibria. To solve that issue, they assume, as we did, that expectations are fully rational and that the consumer is able to compare ex-ante the different possible outcomes and form his expectations accordingly.

As the determination of this reference point is assumed exogenous by Kőszegi & Rabin (2006), several subsequent papers sought to make it endogenous. For instance, Mas (2006), Crawford & Meng (2011) and Abeler et al. (2011) have shown the role of expectations in the formation of such reference points. The latter show in an experimental design that with higher expectations, subjects work longer and earn more money. In a related paper by Orhun (2009), the reference point depends on the range of products sold by the retailer. This agent can therefore manipulate his product line so as to extract more profits from consumers.

2.3 Loss Aversion and Second Degree Price Discrimination Literature

Only a limited number of papers already analyzed the interaction between price discrimination and loss aversion. Moreover, there are divergences between the papers on the attributes of the reference point. Carbajal & Ely (2016) propose a model where a retailer screens loss-averse consumers, similarly to our model, but only consider LA with respect to quality. That is, if a consumer ends up purchasing a good that is more expensive but higher in quality, they will not experience LA. Consumers form their reference plan before they learn their type. Therefore, as in our model, there is no demand uncertainty and the novel effects they observe can be attributed to the endowment effect. They show that high reference plans for low-type consumers can generate allocative efficiency gains as optimal offers get closer to the efficient qualities. Alternatively, high reference plans for high-type consumers generate quality distortions above and beyond the efficient levels. Hence, they find that LA does not lead to more pooling, but rather leads to contracts with a certain degree of complexity. This comes from the finding that some consumers responds entirely to their reference consumption plan rather than to the cost functions or the distribution of types. In our model, consumers are also reference-dependent in the price dimension, therefore it is easier to convince low-types not to mimic the other type.

Hahn et al. (2018a) depart from the standard menu pricing model, but they assume that both quality and price may be a source of LA. They design the optimal product for heterogeneous loss-averse consumers, and show that LA increases the likelihood that the monopolist prefers to pool consumers. The difference with our model lies in the formation of the reference product. In their paper, consumers form their reference point before they learn their type, and when forming their reference point, they anticipate that their valuation of the good will be dependent of their type. It is therefore not clear whether the monopolist is able to extract more surplus from consumers because the demand is uncertain, or because of the endowment effect. This is a major distinction from our model, because in our setting, there is no uncertainty. Prices are therefore less sticky around expectations and this mitigates the optimality of pooling. Although our results align with these findings, our mechanism allows us to explain the small number of product types present in market for experience goods through the endowment effect only.

Herweg & Mierendorff (2013) explain the use of flat-rate tariffs by LA. Consumers prefer such a tariff to a measured tariff under which they would pay less in expectation. Here, consumers also learn their type after forming their expectations, hence resulting on an uncertain future demand. They show that for the monopolist, minimizing expected losses is more important than maximizing efficiency, and that flat-rate contracts are optimal when the marginal costs are small, when consumers are sufficiently loss-averse, and when demand is uncertain. This last point is crucial, as it generates the need for consumers to insure against fluctuations in their billing amounts. Once again, this differs from our model, as consumers face no uncertainty. As in Carbajal & Ely (2016), only deviations from expected prices are a source of LA. On the contrary, we argue that in some markets, consumers may also have expectations about quality levels, which may then also be a source of LA.

In a follow-up to their first paper, Hahn et al. (2018b) build a model of price discrimination under LA, when a monopolist faces horizontally differentiated consumers. They show that with such preferences, LA does not necessarily limit the benefits of screening. Instead, with such consumers, the optimal menu is similar to the standard case, without reference-dependent preferences.

Finally, the literature that relates most to our findings is the paper by Rezaei & De Jaegher (2015). This unpublished manuscript presents a framework that we develop even further. It builds on the papers by Carbajal & Ely (2016) and by Hahn et al. (2018a), and it designs the optimal products for a heterogeneous group of reference-dependent consumers. Both quality and price deviations from the reference good produce LA. This reference good is determined *after* consumers have learnt their type, as in Carbajal & Ely (2016). The authors are able to show that a condition weaker than the standard single-crossing property (SCP) is sufficient for menu pricing to emerge. However, because they do not assume the standard single-crossing property to hold, they fail to show clear-cut effects of LA on optimal prices and qualities, and hence on the optimal choice of the monopolist. We instead assume exogenous quality and SCP holding, which also allows us to show the welfare effects of LA in the model.

3 The Model

As previously mentioned, the aim of this paper is to analyze the effect of LA on the optimal decisions of the monopolist. To this end, we first present the basic model of menu pricing with rational agents, which builds on Mussa & Rosen (1978) and Maskin & Riley (1984). In a second subsection, we extend this model by introducing LA. After introducing those two models, we will introduce the welfare effects of loss aversion.

3.1 Introduction

The consumers: We consider two types of consumers for simplicity: θ_H, i.e. high-type consumers, and θ_L, low-type consumers. We assume $\theta_H > \theta_L$. Consumers only buy one good, and they are price-takers. Both consumers prefer higher quality and lower prices, but differ in their valuation of these attributes. The firm knows the proportion of each type of consumers in the population, but the type of a given consumer is private information. There is a proportion Q_H of high-type consumers and a proportion $1 - Q_H$ of low-type consumers. In the standard case, consumers' valuations $m(\theta, s, p)$ of a good only consists in the direct utility drawn from the purchased good. It can be represented as follows:

$$m(\theta, s, p) = \begin{cases} U(\theta_i, s_j) - p_j & \text{if a consumer of type } i \text{ purchases a product of quality } s_j \text{ at price } p_j, \\ 0 & \text{if he/she does not purchase} \end{cases}$$

Utility $U(\theta_i, s_j)$ is increasing in s_j, i.e. $U_s(\theta_i, s_j) > 0$. We also need to state the following assumption, that gives the retailer an incentive to discriminate:

$$U(\theta_H, s_j) > U(\theta_L, s_j) \quad \text{with } j \in \{L, H\} \tag{A1}$$

It stands that for any level of quality, higher-type consumers get more utility. This also implies that $U_\theta(\theta_i, s_j) > 0$.

The firm: Let us assume a monopolist that is able to offer a menu of goods to consumers. There are two types of consumers, so the monopolist will offer a most two different products. Each good is a combination of a price p and a quality s. The two offered qualities are s_H and s_L, with $s_H > s_L$. This could also be understood as a measure of quantity for two goods of the same quality. We assume that the monopolist has the possibility to sell only a single product. In this case, we assume that he prefers to sell only the higher quality s_H. A sufficient condition for this is:

$$U(\theta_L, s_H) - U(\theta_L, s_L) > c_H - c_L \tag{HQ}$$

The cost of producing a good of quality s_j is $c(s_j) > 0$ with $j \in \{L, H\}$. For simplicity, we write $c(s_j) = c_j$. Moreover, we add that $c_H > c_L$, that there are no fixed cost of offering a good, and that $c(0) = 0$. The firm associates a quality with a price p_j so to maximize profits for both types of consumers. When the monopolist chooses to offer two products, he will design them such that high-type (resp. low-type) consumers choose the good with higher (resp. lower) quality and price.

Loss Aversion: The above representation of preferences is used in the first part of the model, where consumers do not have reference-dependent preferences. In the second part of the model, we will introduce LA. Its representation will be derived from that of Kőszegi & Rabin (2006). More specifically, consumers will draw intrinsic utility $m(\theta, s, p)$ from buying the good, as in the rational case, but they will also draw additional utility $n(\theta, s, p)$ from comparing the good they purchased with a type-contingent reference good (s_j^r, p_j^r). Total utility is additively separable between the two. This key feature on preferences explains the endowment effect which is regularly observed in empirical studies, but cannot be explained by the standard economic theory. Endowment effect refers to the difference between consumers' valuation of goods they own and their willingness to pay for the same good. This gain/loss valuation can be represented as follows:

$$n(\theta, s, p) = \eta[U(\theta_i, s_j) - U(\theta_i, s_j^r)] - \gamma[(p_j - p_j^r)] \tag{1}$$

where

$$\begin{cases} \eta = \lambda & \text{if } s_j < s_j^r \\ \eta = 1 & \text{if } s_j > s_j^r \end{cases} \qquad \begin{cases} \gamma = 1 & \text{if } p_j < p_j^r \\ \gamma = \lambda & \text{if } p_j > p_j^r \end{cases}$$

We see that when consumers expect to buy at a price p_j^r but end up buying a good of higher quality s_j and a higher price p_j, they experience an additional loss of $\lambda(p_j - p_j^r)$, as γ will be equal to λ. Conversely, when they end up buying a good at lower price and lower quality than expected, the consumers experience a loss of $\lambda[U(\theta_i, s_j) - U(\theta_i, s_j^r]$. The parameter $\lambda \geq 1$ therefore captures the degree of loss aversion of a consumer. It is assumed identical for all consumers. When $\lambda = 1$, consumers do not experience loss aversion. Note that a consumer can never experience loss aversion in price *and* in quality, as intuitively, it is never interesting to purchase a good with a higher price *and* a lower quality than the reference good. Moreover, a consumer that expected to purchase product (s_j^r, p_j^r) but eventually does not purchase experiences a loss of magnitude $\lambda U(\theta_i, s_j^r)$, since he/she expected to purchase the good but ends up buying nothing.

The model follows the rational expectations approach of Kőszegi & Rabin (2006). In this approach, consumers' expectations about what they will choose are also fulfilled. A consumer's expected optimal choice of product determines his reference point, and he/she then chooses his optimal product given this reference point. A Personal Equilibrium is defined as the situation where the optimal behavior of the consumer conditional on expectations coincides with the reference point. This might lead to complications, as there may be several Personal Equilibria for the same price/product combination, resulting of differences in expectations. Carbajal & Ely (2016) show that this can lead to complexities in the optimal contracts. Indeed, for the same price/product combination, a consumer might prefer not to purchase a product because he did not expect to buy it, or to purchase it because he expected to buy it. To limit such cases, we impose that consumers always expect to buy one of the goods. To limit such cases, we assume that consumers are able to ex-ante compare their different Personal Equilibria, and pick out the best for them. Kőszegi & Rabin (2006) refer the resulting choice as a Preferred Personal Equilibrium. Moreover, we assume that when the monopolist offers two products, rich consumers expect to receive the high quality and poor consumers expect to buy the low-quality. A way of interpreting this is to assume that the monopolist is able to use strategic framing to induce consumers to choose the Personal Equilibrium that they prefer the most. Relaxing those assumptions allows for coexisting Personal Equilibria. This case is similar to the one analyzed in Rezaei & De Jaegher (2015), and therefore not further discussed.

Structure of the game: Our framework can be interpreted as follows. There is a mass of ex-ante identical consumers that are interacting with a monopolist on a given time period. Before entering the market, consumers receive a signal that affect their willingness to pay. The monopolist only observes the distribution of signals and proposes a menu of goods accordingly, each good consisting in a combination of a price p and a level of quality s. Both can be observed by consumers. The seller is fully aware of consumers' behavioral bias when designing the product line. Moreover, when the seller proposes more than one product, he will design them such that lower-types choose the low-quality good and higher-type choose the high quality good. Consumers then choose to either buy one of the proposed goods or not buy anything.

3.2 Consumers with standard preferences

Before considering loss aversion, let us recall the standard menu pricing model. This is a reworking of the model presented in Belleflamme & Peitz (2015). In this section, we consider that utility only comes intrinsically from buying the good.

We first note that it is not necessarily optimal to offer a menu of goods. First, it could be more interesting for the monopolist to sell the same product to everyone if the proportion of low-type consumers is large enough. Second, it may also be more interesting to sell only to high-type consumers, and hence excluding low-types, if the proportion of high-types is large. The tradeoff between these options will crucially depend on Q_H, i.e. the propotionnal distribution of consumers across types. Optimal prices for each of these three cases are now studied separately, after which we derive the optimal choice for the monopolist given Q_H.

Let us first consider the cases were the monopolist only offers one product. The seller has two options: either selling a high quality product at price $p_H = U(\theta_H, s_H)$ to higher types only, or selling a (high quality) good at price $p_H = U(\theta_L, s_H)$ to all consumers. This trade-off will depend on the relative size of each group of consumers. If the proportion of low-types is too small, it will more interesting to sell to high-types only. The monopolist will therefore sell the product to high-types only if:

$$Q_H > \frac{U(\theta_L, s_H) - c_H}{U(\theta_H, s_H) - c_H} \equiv Q_0$$

yielding profits

$$\Pi_s = \begin{cases} Q_H[U(\theta_H, s_H) - c_H] & \text{if } Q_H \geq Q_0 \\ U(\theta_L, s_H) - c_H & \text{if } Q_H < Q_0 \end{cases}$$

Lets us now consider the case of menu pricing. The problem faced by the monopolist is described by:

$$\max_{(p_H, p_L)} (1 - Q_H)(p_L - c_L) + Q_H(p_H - c_H) \qquad s.t. \tag{2}$$

$$U(\theta_L, s_L) - p_L \geq 0$$

$$U(\theta_H, s_H) - p_H \geq 0$$

$$U(\theta_L, s_L) - p_L \geq U(\theta_L, s_H) - p_H$$

$$U(\theta_H, s_H) - p_H \geq U(\theta_H, s_L) - p_L$$

The monopolist maximizes profit for both types of consumers, subject to two participation constraints (PC) and two incentive-compatibility constraints (IC). The former ensure that consumers prefer to purchase over the outside option, which brings zero utility. The latter requires that each consumer type be (at least) as satisfied with the price and quality assigned to him/her as they would be with any other price and quality of product. All these constraints will be affected by the introduction of loss aversion in the next section. The results by Mussa & Rosen (1978), show that in such a menu, optimal prices are given by:

$$\begin{aligned} p_L^{NR} &= U(\theta_L, s_L) \\ p_H^{NR} &= U(\theta_H, s_H) - [U(\theta_H, s_L) - U(\theta_L, s_L)] \end{aligned} \tag{3}$$

hence profits amount to:

$$\Pi_m = (1 - Q_H)[U(\theta_L, s_L) - c_L] + Q_H[U(\theta_H, s_H) - U(\theta_H, s_L) + U(\theta_L, s_L) - c_H] \tag{4}$$

The superscript NR designates the optimal results when consumers have non reference-dependent preferences. Let us now compare under which conditions the monopolist would prefer to offer a menu.

Let us first compare the profits yielded by menu pricing and with those yielded by selling the high quality to high-types only. The monopolist chooses to offer the menu only if $\Delta\Pi = \Pi_m - \Pi_s > 0$, which is equal to:

$$\Delta\Pi = (1 - Q_H)[U(\theta_L, s_L) - c_L] - Q_H[U(\theta_H, s_L) - U(\theta_L, s_L)] \tag{5}$$

This term is positive if and only if:

$$\begin{aligned} (1 - Q_H)(U(\theta_L, s_L) - c_L) &> Q_H(U(\theta_H, s_L) - U(\theta_L, s_L)) \\ \Leftrightarrow U(\theta_L, s_L) - c_L &> Q_H(U(\theta_H, s_L) - U(\theta_L, s_L) + U(\theta_L, s_L) - c_L) \\ \Leftrightarrow Q_H &< \frac{U(\theta_L, s_L) - c_L}{U(\theta_H, s_L) - c_L} \equiv Q^*_{NR} \end{aligned} \tag{6}$$

The two conflicting effects involved are called by Belleflamme & Peitz (2015) *market expansion* and *cannibalization*. Market expansion, captured by the first term of (5), states that because of the introduction of the menu, lower types are now consuming, leading to higher profits. Cannibalization designates the fact that high-type consumers now consume the high-type product at lower price, hence reducing profits. The effect is captured by the second term of equation (5). Equation (6) shows the condition under which market expansion is stronger than cannibalization: the share of high-type consumers should not be too large. The monopolist will prefer to offer a single product to high-types only rather than to offer a menu if $Q_H > Q^*_{NR}$.

Let us now consider the second case and show under which conditions the monopolist prefers menu pricing over selling the high-type product to the whole population. That is, we compare Π_m and Π_s under $Q_H < Q_0$. In this case, the change induced by menu pricing is given by:

$$\begin{aligned} \Delta\Pi = (1 - Q_H)[(U(\theta_L, s_L) - c_L) - (U(\theta_H, s_L) - c_L)] + \\ Q_H[(U(\theta_H, s_H) - U(\theta_H, s_L)) - (U(\theta_L, s_H) - U(\theta_L, s_L))] \end{aligned} \tag{7}$$

There are again two conflicting effects. The first part of equation (7) is negative and captures the fact that low-type consumers now buy the low-quality good instead of the high quality, diminishing the profits of the monopolist. The second part of equation (7) shows that profits increase because higher types now pay a higher price than in the pooling case. For the second term not to be ambiguous, one often assumes a single-crossing property, which states that high-type consumers value any increase in quality more than low-type consumers do. Formally the SCP states that for any $s_H > s_L$,

$$U(\theta_H, s_H) - U(\theta_H, s_L) > U(\theta_L, s_H) - U(\theta_L, s_L) \tag{SC}$$

The monopolist will choose menu pricing over pooling if $\Delta\Pi > 0$, which is possible if and only if:

$$Q_H > \frac{U(\theta_L, s_H) - U(\theta_L, s_L) - (c_H - c_L)}{U(\theta_H, s_H) - U(\theta_H, s_L) - (c_H - c_L)} \equiv Q_{NR}^{**} \tag{8}$$

This shows that menu pricing is chosen only if the proportion of high-type is large enough.

Let us summarize the above results: for $Q_H \in [Q_{NR}^{**}; Q_{NR}^{*}]$ it is optimal for the seller to offer a menu of goods. For $Q_H < Q_{NR}^{**}$ the monopolist chooses to offer a single product to all consumers, while for $Q_H > Q_{NR}^{*}$, he proposes a product such that only high-valuation consumers purchase.

Note that for these conditions to be compatible with our starting point, we need $Q_{NR}^{**} < Q_0$ and $Q_0 < Q_{NR}^{*}$. After some manipulations, it appears that both these conditions are equivalent to:

$$\frac{U(\theta_H, s_H) - c_H}{U(\theta_H, s_L) - c_L} > \frac{U(\theta_L, s_H) - c_H}{U(\theta_L, s_L) - c_L} \tag{9}$$

which states that going from low to high quality increases *proportionally more* the surplus of high-type consumers. In the following section, we show how loss aversion affects the conditions for the optimality of menu pricing.

3.3 Loss-averse consumers

Let us now introduce loss aversion in the model. The monopolist faces the same three options as in the case without reference-dependent preferences. However, the constraints in the different maximization problems are different. Let us first consider the case in which the monopolist offers one single product of quality s_H. In this case, as in the standard case, the monopolist has two solutions: either offering the high quality good to high-types only, or offering the high quality good to the whole population. Let us first focus on the first setting. In this case, the low-valuation consumers are excluded, and the monopolist would be facing the following problem:

$$\max_{p_H} \quad Q_H(p_H - c_H) \tag{10}$$

subject to

$$0 \geq U(\theta_L, s_H) - p_H + U(\theta_L, s_H) - \lambda p_H \tag{11}$$

$$U(\theta_H, s_H) - p_H \geq -\lambda U(\theta_H, s_H) + p_H \tag{12}$$

Constraint (11) captures the fact that low-types do not expect to buy and eventually do not buy. If they would purchase, they would experience the standard intrinsic utility attached to the good, but they would put more weight on the financial loss of purchasing the good than on the satisfaction brought by the good.

Similarly, with condition (12), the monopolist ensures that high-valuation consumers expect to buy the good. A deviation from this expectation, i.e. to the outside option, does not bring more utility, because the loss of utility resulting from not purchasing the good is larger than the utility gain stemming from not having to pay its price.

Let us solve this problem. Note first that the two constraints can be rewritten as:

$$p_H \geq \frac{2}{1+\lambda} U(\theta_L, s_H)$$
$$p_H \leq \frac{1+\lambda}{2} U(\theta_H, s_H)$$

Because assuming that assumption A1 holds and $\lambda \geq 1$, it also holds that $\frac{1+\lambda}{2} U(\theta_H, s_.) > \frac{2}{1+\lambda} U(\theta_L, s_.)$. The monopolist therefore sets p_H^{RD} at the highest possible price such that high-type consumers still prefer to purchase, hence leading to the following prices and profits:

$$p_H^{RD} = \frac{1+\lambda}{2} U(\theta_H, s_H) \qquad \Pi_s = Q_H \left(\frac{1+\lambda}{2} U(\theta_H, s_H) - c_H \right)$$

where the superscript RD designates the optimal results with referent-dependent preferences. We observe that the offered price is increasing with the level of loss aversion. This is because the buyer wants to avoid the loss from non-participation and therefore, is willing to pay more for a given amount of consumption.

Similarly, if the monopolist chooses to offer a single product to the whole population, he will face the following problem:

$$\max_{p_H} \quad (p_H - c_H) \tag{13}$$

subject to:

$$U(\theta_L, s_H) - p_H \geq -\lambda U(\theta_L, s_H) + p_H \tag{14}$$

$$U(\theta_H, s_H) - p_H \geq -\lambda U(\theta_H, s_H) + p_H \tag{15}$$

Again recalling assumption A1, the first constraint will be binding. Hence, optimal prices and profits are given by:

$$p_H^{RD} = \frac{1+\lambda}{2} U(\theta_L, s_H) \qquad \Pi_s = \left(\frac{1+\lambda}{2} U(\theta_L, s_H) - c_H \right)$$

Once again, the monopolist is able to charge higher prices when consumers are loss-averse because they want to avoid the loss resulting from not buying. Note that in this case, the monopolist is not able to extract all the surplus from high-type consumers.

How will the monopolist choose to whom offer this single product? The trade-off between selling a unique product to high-types only or to all types depends, as in the standard-preferences case, on the relative size of each group. The monopolist will sell to high-types if and only if the profit from selling to these consumers only is larger than the profit yielded by selling to the whole population. Formally, the monopolist will sell to high-valuation consumers if:

$$Q_H > \frac{\frac{1+\lambda}{2}U(\theta_L, s_H) - c_H}{\frac{1+\lambda}{2}U(\theta_H, s_H) - c_H} \equiv Q_1 \tag{16}$$

We note that $\frac{\partial Q_1}{\partial \lambda} > 0$ (Appendix 1.), i.e. the range of the parameter Q_H below which the monopolist prefers to offer a single product to the whole population increases with loss aversion.

Proposition 1: *When the monopolist only offers a single product and cannot distinguish between different types of consumers, then the threshold proportion of high-type consumers above which the monopolist prefers to sell to high-type consumers only, is higher when consumers are loss-averse.*

A larger aversion to the loss resulting from non-participation enables the seller to charge more. However, when the seller chooses to exclude low-type consumers, the additional profit coming from loss aversion is weighted by the proportion of high-type consumers. Therefore, with loss-averse consumers, it gets more interesting for the seller to offer the good with a relatively smaller mark-up, but to all consumers rather than a subset of them only.

Consider now the case where the monopolist offers a menu of products and is subject to the same maximization as in the case without reference-dependent preferences, but now faces the following constraints:

$$U(\theta_L, s_L) - p_L \geq -\lambda U(\theta_L, s_L) + p_L \tag{PC1}$$

$$U(\theta_H, s_H) - p_H \geq -\lambda U(\theta_H, s_H) + p_H \tag{PC2}$$

$$U(\theta_L, s_L) - p_L \geq U(\theta_L, s_H) - p_H + [U(\theta_L, s_H) - U(\theta_L, s_L)] - \lambda(p_H - p_L) \tag{IC1}$$

$$U(\theta_H, s_H) - p_H \geq U(\theta_H, s_L) - p_L - \lambda[U(\theta_H, s_H) - U(\theta_H, s_L)] + (p_H - p_L) \tag{IC2}$$

Constraints (PC1) and (PC2) are the loss aversion participation constraints. If a consumer of type θ does not buy any good, given that $U(\theta, 0) = 0$, they do not obtain any direct utility. However, because he/she expected to buy some good, he/she experiences a loss of not obtaining the quality he/she expected, and a gain of not having to pay its price, captured by the right-hand side of the inequality.

Constraint (IC1) prevents low-type consumers to switch to the higher quality product. The additional terms on the right-hand side of the equation are the result of loss aversion: by switching to a higher quality product, low-types put more valuation on the loss caused by the increase in prices than on the gain brought by the increase in quality, as $\lambda \geq 1$. Similarly, constraint (IC2) prevents high-valuation consumers to switch to the low-quality product. Loss aversion causes these consumers to attach more weight to the downgrade in quality than to the price reduction induced by the change.

We can solve this problem and derive the optimal prices. We find the following results (Appendix 2):

$$p_L^{RD} = \frac{1+\lambda}{2} U(\theta_L, s_L)$$
$$p_H^{RD} = \frac{1+\lambda}{2} U(\theta_H, s_H) - \frac{1+\lambda}{2} [U(\theta_H, s_L) - U(\theta_L, s_L)] \tag{17}$$

As in the standard-preferences case, the monopolist is not able to extract the full surplus of high-type consumers, since they would otherwise switch to the low-quality product. We also observe that loss aversion allows the monopolist to increase both prices proportionally. The intuition for this comes from the fact that the monopolist knows that consumers do not like to deviate from their reference point. Therefore, the seller can charge a higher price, the additional mark-up corresponding to the cost faced by consumers to switch to another option. Moreover, we note that $\frac{\partial p_{.}^{RD}}{\partial \lambda} > 0$, hence the more loss-averse the consumers are, the more the prices increase.

Note that the single crossing property is needed to ensure that $p_H^{RD} > p_H^{NR}$. Rezaei & De Jaegher (2015) are able to show that under loss aversion, self-selection is possible under a condition that is less strict that the SCP (with endogenous quality). Formally, they show that the monopolist is able to make consumers self-select the contracts if:

$$\frac{1+\lambda}{2} \left[U\left(\theta_H, s_H\right) - U\left(\theta_H, s_L\right)\right] > \frac{2}{1+\lambda} \left[U\left(\theta_L, s_H\right) - U\left(\theta_L, s_L\right)\right] \tag{18}$$

This condition is also sufficient to achieve self-selection when quality levels are exogeneous. When λ is large enough, it is always possible to incur self-selection, even if the SCP is violated. However, the above condition is not sufficient to derive a clear-cut impact of loss aversion on optimal prices, and hence on the optimal menu. Without the SCP, one cannot tell if $p_H^{RD} - p_H^{NR}$ is positive — because of higher types having a larger reservation price — or negative — because the monopolist has to offer a larger discount to high-types to prevent them from buying the low-quality product. In order to derive the welfare effect and the optimal menu, we therefore need to assume that the SCP still holds.

When is menu pricing optimal?

To determine when menu pricing is optimal for the monopolist, we need to compare profits yielded by menu pricing with profits under other settings. If the monopolist chooses to offer a screening menu, the profits will be larger than when consumers have non reference-dependent preferences and will be given by:

$$\Pi_m = (1 - Q_H) \left[\frac{1+\lambda}{2} U(\theta_L, s_L) - c_L\right] + Q_H \left[\frac{1+\lambda}{2} U(\theta_H, s_H) - \frac{1+\lambda}{2} [U(\theta_H, s_L) - U(\theta_L, s_L)] - c_H\right] \tag{19}$$

Let us first assume that the proportion of high-valuation consumers is large enough, such that, if the seller was to offer a single product, he would only sell to high-type consumers. That is we have

$Q_H > Q_1$. The change induced by switching to menu pricing would be given by:

$$\Delta\Pi = \Pi_m - \Pi_s = (1 - Q_H)\left(\frac{1+\lambda}{2}U(\theta_L, s_L) - c_L\right) - Q_H\left(\frac{1+\lambda}{2}[U(\theta_H, s_L) - U(\theta_L, s_L)]\right) \tag{20}$$

The net effect of menu pricing is positive if there are not too many high-type consumers, i.e. if:

$$Q_H < \frac{\frac{1+\lambda}{2}U(\theta_L, s_L) - c_L}{\frac{1+\lambda}{2}U(\theta_H, s_L) - c_L} \equiv Q^*_{RD} \tag{21}$$

We note that $\frac{\partial Q^*_{RD}}{\partial \lambda} > 0$ (Appendix 3.). This implies that menu pricing is more attractive than selling to high-types only when the low-type consumers are more abundant. Indeed, by introducing the menu, low-type consumers now buy the low-quality product, whose price is marked up by $\frac{\lambda-1}{2}U(\theta_L, s_L)$. On the other hand, introducing the menu decreases profits coming from high-valuation consumers even more because the seller now must offer a larger price differential than in the case where preferenes are not reference-dependent to prevent high-type consumers from switching. It is straightforward to infer that the change in profits induced by menu pricing now entails a additional benefit of $(1 - Q_H)\frac{\lambda-1}{2}U(\theta_L, s_L)$, which is counterbalanced by an additional cost of $Q_H\frac{\lambda-1}{2}U(\theta_H, s_L) - Q_H\frac{\lambda-1}{2}U(\theta_L, s_L)$. The net effect of loss aversion on the change in profits induced by menu pricing is therefore given by:

$$\frac{\lambda - 1}{2}(U(\theta_L, s_L) - Q_H U(\theta_H, s_L)) \tag{22}$$

We observe that the additional benefits brought by menu pricing are not weighted by the proportion of high-type consumers, while the additional costs are. This implies that loss aversion strengthens the market expansion effect more than the cannibalization effect of menu pricing, hence increasing the likelihood that the seller prefers to offer a menu.

Let us now consider the second case, where the proportion of high-type consumers is not large enough, such that if the monopolist would offer a single product, he would sell it to the whole population. In this case, the change in profits induced by switching to menu pricing is given by:

$$\begin{aligned}\Delta\Pi = \Pi_m - \Pi_s = (1 - Q_H)\left[\left(\frac{1+\lambda}{2}U(\theta_L, s_L) - c_L\right) - \left(\frac{1+\lambda}{2}U(\theta_L, s_H) - c_H\right)\right] \\ +Q_H\frac{1+\lambda}{2}\Big([U(\theta_H, s_H) - U(\theta_H, s_L)] - [U(\theta_L, s_H) - U(\theta_L, s_L)]\Big)\end{aligned} \tag{23}$$

When the SCP holds, as in the case with standard preferences, the second term of the right-hand side is positive. The net effect of switching to menu pricing is positive if:

$$\Delta\Pi > 0 \Leftrightarrow Q_H > \frac{\frac{1+\lambda}{2}\left[U(\theta_L, s_H) - U(\theta_L, s_L)\right] - (c_H - c_L)}{\frac{1+\lambda}{2}\left[U(\theta_H, s_H) - U(\theta_H, s_L)\right] - (c_H - c_L)} \equiv Q^{**}_{RD} \tag{24}$$

Again, it holds that $\frac{\partial Q^{**}_{RD}}{\partial \lambda} > 0$ (Appendix 4.). This implies that screening is less attractive compared to pooling when low-type consumers are more abundant. Indeed, relying on the previously-described reasoning, we obtain the following net effect of loss aversion on the change induced by switching to menu pricing:

$$\frac{\lambda - 1}{2}\left[Q_H\big(U(\theta_H, s_H) - U(\theta_H, s_L)\big) - \big(U(\theta_L, s_H) - U(\theta_L, s_L)\big)\right] \tag{25}$$

These results indicate that loss aversion distorts the benefits and costs of switching to menu pricing, such that it becomes less profitable to offer a menu when consumers are more loss-averse. Indeed, we observe that the increase in profits coming from high-type consumers paying now paying a larger price is weighted by the proportion of high-types. Conversely, the decrease in profits coming from low-type consumers now buying the low quality is not weighted. This causes the screening menu to be relatively less profitable than the pooling menu when consumers are more loss-averse.

Note that we obtain this result when the standard SCP holds. Condition (18) is not sufficient to derive clear-cut effect of loss aversion on the optimal decision of the monopolist.

Also note that for the optimality of menu pricing to be compatible with our starting point, we need $Q^{**}_{RD} < Q_1$ and $Q_1 < Q^{*}_{RD}$. Both conditions are equivalent to:

$$\frac{\frac{1+\lambda}{2}U(\theta_H, s_H) - c_H}{\frac{1+\lambda}{2}U(\theta_H, s_L) - c_L} > \frac{\frac{1+\lambda}{2}U(\theta_L, s_H) - c_H}{\frac{1+\lambda}{2}U(\theta_L, s_L) - c_L} \tag{26}$$

This condition requires that going from low to high quality increases surplus *proportionally more* for high-type loss-averse consumers than for low-type loss-averse consumers. The above results are summarized in the following proposition:

Proposition 2: *Menu pricing is optimal under loss aversion if the proportion of high-valuation is neither too small nor too large and that going from low to high quality increases surplus proportionally more for high-type consumers than for low-type consumers. That is, there exists Q^{**}_{RD} and Q^{*}_{RD} such that if $Q^{**}_{RD} < Q_H < Q^{*}_{RD}$, the monopolist prefers to offer a menu. Moreover, we have $\frac{\partial Q^{**}_{RD}}{\partial \lambda} > 0$ and $\frac{\partial Q^{*}_{RD}}{\partial \lambda} > 0$.*

Let us assume linear utility of the form $U = \theta s$, and constant marginal costs of production $c > 0$ such that $c(s_j) = c_j s_j$ with $j \in \{L, H\}$. Under these conditions, loss aversion increases the chances that offering the same product to all consumers is the optimal choice. Appendix 5 graphically illustrates how the choice of the optimal menu varies with different parameter values.

3.4 Ex-ante versus Ex-post Consistent Reference Points

At this point, it may be useful to compare optimal products in our model with those obtained if consumers form their reference point before learning their type, as in Hahn et al. (2018a). In both papers, the main message is the optimality of pooling. This is shown in our model by the fact that with a larger λ, Q^{**}_{SB} increases, so pooling is the optimal choice for a larger range of the parameter Q_H. However, unlike in Hahn et al. (2018a), we show that loss aversion strengthens the domination of pooling over screening even in a riskless environment. In Hahn et al. (2018a), consumers learn their type after they formed their reference point. In the mechanism they describe, the optimality of pooling stems from both the buyer's insurance motive and the endowment effect. Prices are then sticky around consumer's expectations, which makes it more likely that the sellers prefers to offer a single price. In our model, the optimality of pooling only stems from the endowment effect, since consumers do not need to insure against the risk of not having their expected type. Loss aversion impacts the optimal choice of the monopolist through distortions of the standard effects of switching to menu pricing. LA strengthens the costs of offering the menu more than its benefits, hence increasing the likelihood that pooling is optimal.

4 Welfare effects

Because we were able to derive the profits and and consumer surplus from the previous computations, we are now able to analyze the welfare deriving from menu pricing. Social welfare is computed as the sum of the consumer surplus (with reference-dependent preferences) and the profits of the monopolist. In the case were the monopolist sells to high-type consumers only, prices are set so as to make their participation constraint binding. Social welfare is therefore given by:

$$\begin{aligned} W_s &= 0 && \text{Low-type's surplus} \\ &+ Q_H[U(\theta_H, s_H) - \frac{1+\lambda}{2}U(\theta_H, s_H)] && \text{High-type's surplus} \\ &+ Q_H[\frac{1+\lambda}{2}U(\theta_H, s_H) - c_H] && \text{Profits} \\ &= Q_H[U(\theta_H, s_H) - c_H] && \text{Social welfare when } Q_H > Q^*_{RD} \end{aligned} \tag{27}$$

A first interesting feature we observe is that high-type's surplus is *negative*. This comes from the fact that these consumers are expecting to buy some product. Consumer surplus is computed as the difference between their willingness to pay and the price they actually pay. Without loss aversion, low type's surplus would be equal to 0. However, when they are loss averse and would decide not to purchase eventually, they would not only get no direct utility, but also experience some disutility of not having the quality they expected. Because the monopolist is aware of the consumer's bias and can fix prices accordingly, he can extract this spare utility as well. This results in these consumers purchasing at a larger price, the difference between the two coming directly from loss aversion.

A second feature is that although consumer surplus and profits are both affected by loss aversion, social welfare is not. This comes from the fact that all the consumers' disutility that is generated by loss aversion can be captured by the monopolist.

In the case were the monopolist sells one product to all types of consumers, i.e. $Q_H < Q_1$, he sets prices so as to satisfy low-types participation constraints. This allows high-type consumers to extract some surplus equivalent to $U(\theta_H, s_H) - \frac{1+\lambda}{2}U(\theta_L, s_H)$. Social welfare in this case amounts to:

$$
\begin{aligned}
W_s &= (1-Q_H)[U(\theta_L,s_H) - \frac{1+\lambda}{2}U(\theta_L,s_H)] && \text{Low-type's surplus} \\
&+ Q_H[U(\theta_H,s_H) - \frac{1+\lambda}{2}U(\theta_L,s_H)] && \text{High-type's surplus} \\
&+ \frac{1+\lambda}{2}U(\theta_L,s_H) - c_H && \text{Profits} \\
&= U(\theta_L,s_H) - c_H + Q_H[U(\theta_H,s_H) - U(\theta_L,s_H)] && \text{Social welfare when } Q_H < Q^{**}_{RD}
\end{aligned} \tag{28}
$$

In this case, it is the low-type consumers that experience a negative surplus. When consumers do not have reference-dependent preferences, high-types are able to get some surplus. In this case however, it is not clear if their surplus will be positive or negative. For high levels of loss aversion, it might well be the case that $U(\theta_H,s_H) < \frac{1+\lambda}{2}U(\theta_L,s_H)$, and in this case, both types of consumers would have a negative surplus. In any case, the additional surplus generated is also fully captured by the monopolist, hence leaving unchanged the social welfare compared to the case without referent-dependent preferences.

When the monopolist prefers to offer a menu rather than a single product, he must also leave them an information rent, because he must prevent those high-price customers from switching to the lower-end product. The surplus these consumers are able to extract is $U(\theta_H,s_H) - \frac{1+\lambda}{2}U(\theta_H,s_H) + \frac{1+\lambda}{2}[U(\theta_H,s_L) - U(\theta_L,s_L)]$, the last term capturing the information rent they can extract. Therefore, the computation of the social welfare results in the following:

$$
\begin{aligned}
W_m &= (1-Q_H)[U(\theta_L,s_L) - \frac{1+\lambda}{2}U(\theta_L,s_L)] && \text{Low-type's surplus} \\
&+ Q_H\big[U(\theta_H,s_H) - \frac{1+\lambda}{2}U(\theta_H,s_H) + \frac{1+\lambda}{2}[U(\theta_H,s_L) - U(\theta_L,s_L)]\big] && \text{High-type's surplus} \\
&+ Q_H\big[\frac{1+\lambda}{2}U(\theta_H,s_H) - \frac{1+\lambda}{2}[U(\theta_H,s_L) - U(\theta_L,s_L)] - c_H\big] + (1-Q_H)\big[\frac{1+\lambda}{2}U(\theta_L,s_L) - c_L\big] \\
&= Q_H[U(\theta_H,s_H) - c_H] + (1-Q_H)[U(\theta_L,s_L) - c_L] && \text{Social welfare when } Q^{**}_{RD} < Q_H < Q^{*}_{RD}
\end{aligned} \tag{29}
$$

Once again, the low-types get have a negative surplus, and it is not clear whether high-types' surplus is positive or negative. On the one hand, an higher level of loss aversion increases the informational rent that high types can get, hence increasing their surplus. On the other hand, a higher loss aversion level lowers the value of the outside option, making those consumers worse-off. These consumers'surplus will be positive if $\frac{1+\lambda}{2}U(\theta_H,s_L) > \frac{\lambda-1}{2}U(\theta_H,s_H) + \frac{1+\lambda}{2}U(\theta_L,s_L)$. The welfare effects are nonetheless unchanged by loss aversion since the seller is able to capture the disutility brought by loss aversion. The main results of this section can be summarized in the following proposition:

Proposition 3: *Loss aversion decreases consumers' surplus and increases the seller's profits, but it does not affect social welfare.*

5 Conclusion

In this paper, we explored the optimal pricing design by a revenue-maximizing monopolist facing two vertically differentiated types of loss-averse consumers. Consumers are loss-averse *à la* Kőszegi & Rabin (2006), i.e. their utility function is the sum of an intrinsic utility and a gain-loss utility, which depends on their reference point. This reference point is set by rational expectations that are assumed fulfilled. We derived the conditions over which the monopolist prefers to offer a single product to the whole population rather than selling to high willingness-to-pay consumers only, and we highlighted the impact of loss aversion on the conditions for a separating equilibrium.

We found that that the empirical observation of sellers offering menus with small number of goods is consistent with the profit-maximization of a firm facing loss-averse consumers. Indeed, we showed that loss aversion eases the emergence of a pooling equilibrium where all consumers are offered the same good. In contrast with Hahn et al. (2018a), the optimal menus described in our analysis are realized in a (hypothetical) fully certain environment, hence showing that the lack of diversity observed in markets does not fully result from the insurance motive of consumers. Loss aversion rather tends to intensify the effects that are already present in the standard price discrimination model. It distorts the benefits and costs of offering a menu, such that it increases the likelihood that the seller prefers to offer a single product to all consumers, assuming that the single crossing property holds.

The model we present makes abstraction of many elements which could arise in real-life settings. First, we assumed fixed quality levels. Although this could indeed capture well markets for experience goods where quality cannot be changed easily, it is very likely that a monopolist is concerned about the quality level of its products, and that loss aversion induces distortions of these optimal levels.

In addition, the degree of loss aversion can vary across and within consumers types. The ability of the monopolist to discriminate consumers with different degrees of loss aversion could allow him to better screen consumers. In this case, analyzing the optimal contracts in this case would be interesting although mathematically demanding since it would make the analysis multidimensional. Moreover, while the behavioral implications of our model seem to be consistent with empirical observations, some of the underlying parameters remain difficult to measure. Measuring precisely the "degree" of a person's loss aversion is not straightforward[1].

[1] Ordaz (2007) provides a survey for estimates of the parameter λ from different studies using field and experimental data. Estimates range from 1.3 to 2.71.

6 References

Abeler, J., Falk, A., Goette, L., & Huffman, D. (2011). Reference points and effort provision. *American Economic Review*, 101(2), 470–92.

Belleflamme, P. & Peitz, M. (2015). *Industrial organization: markets and strategies.* Cambridge University Press.

Carbajal, J. C. & Ely, J. C. (2016). A model of price discrimination under loss aversion and state-contingent reference points. *Theoretical Economics*, 11(2), 455–485.

Courty, P. & Nasiry, J. (2018). Loss aversion and the uniform pricing puzzle for media and entertainment products. *Economic Theory*, 66(1), 105–140.

Crawford, V. P. & Meng, J. (2011). New york city cab drivers' labor supply revisited: Reference-dependent preferences with rational-expectations targets for hours and income. *American Economic Review*, 101(5), 1912–32.

DellaVigna, S. & Malmendier, U. (2004). Contract design and self-control: Theory and evidence. *The Quarterly Journal of Economics*, 119(2), 353–402.

Dixit, A. K. & Stiglitz, J. E. (1977). Monopolistic competition and optimum product diversity. *The American economic review*, 67(3), 297–308.

Eliaz, K. & Spiegler, R. (2006). Contracting with diversely naive agents. *The Review of Economic Studies*, 73(3), 689–714.

Fabrizi, S., Lippert, S., Puppe, C., & Rosenkranz, S. (2016). Manufacturer suggested retail prices, loss aversion and competition. *Journal of Economic Psychology*, 53, 141–153.

Grubb, M. D. (2009). Selling to overconfident consumers. *American Economic Review*, 99(5), 1770–1807.

Hahn, J.-H., Kim, J., Kim, S.-H., & Lee, J. (2018a). Price discrimination with loss averse consumers. *Economic Theory*, 65(3), 681–728.

Hahn, J.-H., Kim, J., Kim, S.-H., Lee, J., et al. (2018b). Price discrimination with loss averse and horizontally differentiated consumers. *Korean Economic Review*, 34, 117–129.

Heidhues, P. & Kőszegi, B. (2008a). Competition and price variation when consumers are loss averse. *American Economic Review*, 98(4), 1245–68.

Heidhues, P. & Kőszegi, B. (2008b). Competition and price variation when consumers are loss averse. *American Economic Review*, 98(4), 1245–68.

Herweg, F. & Mierendorff, K. (2013). Uncertain demand, consumer loss aversion, and flat-rate tariffs. *Journal of the European Economic Association*, 11(2), 399–432.

Kahneman, D. & Tversky, A. (1991). Loss aversion in riskless choice: A reference-dependent model. *The quarterly journal of economics*, 106(4), 1039–1061.

Kahneman, D. & Tversky, A. (2013). Prospect theory: An analysis of decision under risk. In *Handbook of the fundamentals of financial decision making: Part I* (pp. 99–127). World Scientific.

Karle, H. & Peitz, M. (2010). Consumer loss aversion and the intensity of competition.

Karle, H. & Peitz, M. (2014). Competition under consumer loss aversion. *The RAND Journal of Economics*, 45(1), 1–31.

Karle, H., Schumacher, H., & Vølund, R. (2021). Consumer loss aversion and scale-dependent psychological switching costs. *SSRN Electronic Journal*.

Kőszegi, B. & Rabin, M. (2006). A model of reference-dependent preferences. *The Quarterly Journal of Economics*, 121(4), 1133–1165.

Mas, A. (2006). Pay, reference points, and police performance. *The Quarterly Journal of Economics*, 121(3), 783–821.

Maskin, E. & Riley, J. (1984). Monopoly with incomplete information. *The RAND Journal of Economics*, 15(2), 171–196.

Mussa, M. & Rosen, S. (1978). Monopoly and product quality. *Journal of Economic theory*, 18(2), 301–317.

Ordaz, J. A. (2007). Advances in economics and econometrics: Theory and applications, ninth world congress, vol. ii.

Orhun, A. Y. (2009). Optimal product line design when consumers exhibit choice set-dependent preferences. *Marketing Science*, 28(5), 868–886.

Rezaei, B. & De Jaegher, K. (2015). Screening loss averse consumers. *Unpublished Manuscript*.

Rosato, A. (2016). Selling substitute goods to loss-averse consumers: Limited availability, bargains, and rip-offs. *The RAND Journal of Economics*, 47(3), 709–733.

Salant, S. W. (1989). When is inducing self-selection suboptimal for a monopolist? *The Quarterly Journal of Economics*, 104(2), 391–397.

Salant, Y. & Siegel, R. (2018). Contracts with framing. *American Economic Journal: Microeconomics*, 10(3), 315–46.

Salop, S. C. (1979). Monopolistic competition with outside goods. *The Bell Journal of Economics*, (pp. 141–156).

Spence, M. (1977). Nonlinear prices and welfare. *Journal of public economics*, 8(1), 1–18.

Stokey, N. L. (1979). Intertemporal price discrimination. *The Quarterly Journal of Economics*, (pp. 355–371).

Tramontana, F. (2021). When a boundedly rational monopolist meets consumers with reference dependent preferences. *Journal of Economic Behavior & Organization*, 184, 30–45.

Zhang, J. & Li, K. J. (2021). Quality disclosure under consumer loss aversion. *Management Science*, 67(8), 5052–5069.

Zhou, J. (2011). Reference dependence and market competition. *Journal of Economics & Management Strategy*, 20(4), 1073–1097.

7 Appendices

Appendix 1. The derivative of Q_1 with respect to λ is:

$$\frac{\partial Q_1}{\partial \lambda} = \frac{\frac{1}{2}(U(\theta_H, s_H) - U(\theta_L, s_H))c_H}{(\frac{1+\lambda}{2}U(\theta_H, s_H) - c_H)^2} > 0 \tag{30}$$

Appendix 2. Here, we derive the optimal prices when the seller offers a menu of products.

(IC1) and (IC2) can be rewritten as

$$p_H - p_L \geq \frac{2}{1+\lambda}[U(\theta_L, s_H) - U(\theta_L, s_L)] \tag{31}$$

$$p_H - p_L \leq \frac{1+\lambda}{2}[U(\theta_H, s_H) - U(\theta_H, s_L)] \tag{32}$$

In order to achieve self-selection, it is required that the two proposed price-quality combinations are not equal, i.e. we need the following condition to hold:

$$\frac{1+\lambda}{2}[U(\theta_H, s_H) - U(\theta_H, s_L)] > \frac{2}{1+\lambda}[U(\theta_L, s_H) - U(\theta_L, s_L)] \tag{33}$$

Note that this condition is weaker than the standard single crossing condition. Indeed, for a sufficiently large λ, it is possible for the monopolist to discriminate even is the standard single crossing condition does not hold. We assume that λ is not sufficiently small, such that the single crossing condition holds. We know that

$$\frac{1+\lambda}{2}[U(\theta_H, s_H) - U(\theta_H, s_L)] > \frac{2}{1+\lambda}[U(\theta_H, s_H) - U(\theta_H, s_L)] \tag{34}$$

and that

$$\frac{2}{1+\lambda}[U(\theta_H, s_H) - U(\theta_H, s_L)] > \frac{2}{1+\lambda}[U(\theta_L, s_H) - U(\theta_L, s_L)] \tag{35}$$

By the single crossing condition, which implies that either (IC1) or (IC2) is not binding, we now prove that (IC2) is binding and that (IC1) is not.

From (IC2) and (A1), we obtain:

$$U(\theta_H, s_H) - p_H \geq U(\theta_L, s_L) - p_L - \lambda[U(\theta_H, s_H) - U(\theta_H, s_L)] + (p_H - p_L) \tag{36}$$

Because PC1 holds, we can build on (36) to infer that:

$$U(\theta_H, s_H) - p_H \geq -\lambda U(\theta_L, s_L) + p_L - \lambda[U(\theta_H, s_H) - U(\theta_H, s_L)] + (p_H - p_L) \tag{37}$$

which gives us after simplification

$$U(\theta_H, s_H) - p_H \geq -\lambda U(\theta_H, s_H) - \lambda[U(\theta_L, s_L) - U(\theta_H, s_L)] + p_H \tag{38}$$

Given (A1), it holds that $U(\theta_L, s_L) - U(\theta_H, s_L) < 0$, and PC2 is therefore not binding.

Let us now write the Kuhn-Tucker conditions applicable to our problem. Let γ_1, ϕ_1 and ϕ_2 be the multipliers attached to (PC1), (IC1) and (IC2) respectively. Because we showed that PC2 is not binding, its multiplier is equal to zero and does not need to be considered. The two remaining conditions for the problem are therefore

$$(1 - Q_H) - 2\gamma_1 - \phi_1(1 + \lambda) + 2\phi_2 = 0 \tag{39}$$

$$Q_H + \phi_1(1 + \lambda) - 2\phi_2 = 0 \tag{40}$$

Because either (IC1) or (IC2) is not binding, it must be that either $\phi_1 = 0$ or $\phi_2 = 0$ is binding. If $\phi_2 = 0$, it must hold, building on (40) that $\phi_1 < 0$, which is not possible. Therefore $\phi_2 > 0$ must hold, implying that (IC2) is binding, and that (IC1) is not. We can now solve the system given by (39) and (40) to get $\gamma_1 = \frac{1}{2}$, showing that (PC1) must be binding.

Given that (PC1) and (IC2) are binding, the profit maximizing monopolist sets prices such that:

$$p_L = \frac{1 + \lambda}{2} U(\theta_L, s_L) \tag{41}$$

and:

$$p_H = \frac{1 + \lambda}{2} U(\theta_H, s_H) - \frac{1 + \lambda}{2} [U(\theta_H, s_L) - U(\theta_L, s_L)] \tag{42}$$

We know that $\frac{1+\lambda}{2} > 1$, which means that when consumers are loss averse, the monopolist is able to increase both prices.

Appendix 3. The derivative of Q^* with respect to λ is :

$$\frac{\partial Q^*}{\partial \lambda} = \frac{\frac{1}{2}(U(\theta_H, s_L) - U(\theta_L, s_L))c_L}{(\frac{1+\lambda}{2} U(\theta_H, s_L) - c_H)^2} > 0 \tag{43}$$

Appendix 4. The derivative of Q^{**} with respect to λ is

$$\frac{\partial Q^{**}}{\partial \lambda} = \frac{\frac{1}{2}\big([U(\theta_H, s_H) - U(\theta_H, s_L)] - [U(\theta_L, s_H) - U(\theta_L, s_L)]\big)(c_H - c_L)}{(\frac{1+\lambda}{2}[U(\theta_H, s_H) - U(\theta_H, s_L)] - (c_H - c_L))^2} > 0 \tag{44}$$

Appendix 5. Figure 1 divides the space of (λ, Q_H) into three regions and illustrates the type of optimal menu in each region, for different values of the parameters. Here direct utility takes the form $m(\theta, s, p) = \theta_i s_j - p_j$ and marginal costs are assumed constant. The dotted line represents Q_1. We directly observe that since the straight lines do not cross the dotted line, condition (26) holds. It can be shown that in the region A, the optimal type of menu is to offer a single product to all the consumers. In region B, it is rather optimal for the monopolist to offer a menu of goods and to let consumers self-select the best product for them. In region C, the monopolist finds it optimal to exclude low-type consumers and to offer a product to high-types only.

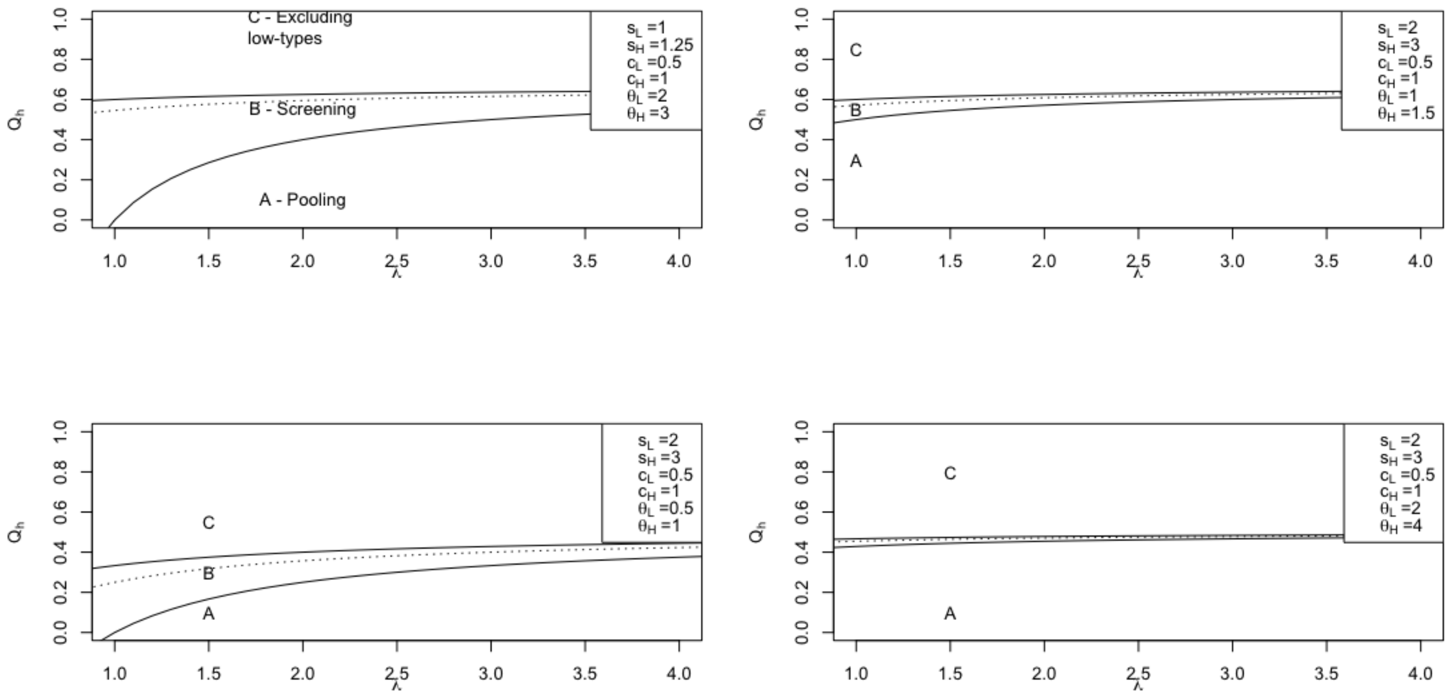

Figure 1: Optimal Menus