

Karle, Heiko; Kirchsteiger, Georg; Peitz, Martin

**Conference Paper**

## Loss Aversion and Consumption Choice: Theory and Experimental Evidence

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2013: Wettbewerbspolitik und Regulierung in einer globalen Wirtschaftsordnung - Session: Public Goods and Reference Points, No. B05-V2

**Provided in Cooperation with:**

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Karle, Heiko; Kirchsteiger, Georg; Peitz, Martin (2013) : Loss Aversion and Consumption Choice: Theory and Experimental Evidence, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2013: Wettbewerbspolitik und Regulierung in einer globalen Wirtschaftsordnung - Session: Public Goods and Reference Points, No. B05-V2, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel und Hamburg

This Version is available at:

<https://hdl.handle.net/10419/79943>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

# Loss Aversion and Consumption Choice: Theory and Experimental Evidence\*

Heiko Karle<sup>†</sup>      Georg Kirchsteiger<sup>‡</sup>      Martin Peitz<sup>§</sup>

Version: May 9, 2013    (First Version: April 2011)

## Abstract

In this paper, we analyze a consumer choice model with price uncertainty, loss aversion, and expectation-based reference points. The implications of this model are tested in an experiment in which participants have to make a consumption choice between two sandwiches. We make use of the fact that participants differ in their reported taste difference between the two sandwiches and the degree of loss aversion which we measure separately. We find that more loss-averse participants are more likely to opt for the cheaper sandwich, in line with predictions from theory. The model with rational expectations provides a better fit than the model with naive expectations.

**Keywords:** Loss Aversion, Contextual Reference Points, Consumer Choice

**JEL Classification:** C91, D01, D11, D83

---

\*A previous version of this paper circulated under the title “The Impact of Contextual Reference Dependence on Purchase Decisions”. We are grateful to Larry Samuelson, three anonymous referees, Björn Bartling, Daniel Chen, Enrico Diecidue, Dirk Engelmann, Thomas Epper, Lorenz Götte, Paul Heidhues, Holger Herz, Rudolf Kerschbamer, Henrik Orzen, Ulrike Rangel, Lukas Wenner and various seminar audiences for helpful comments and suggestions. We gratefully acknowledge financial support from the National Bank of Belgium (Research Grant, “The Impact of Consumer Loss Aversion on the Price Elasticity of Demand”), the ARC Grant “Market Evolution, Competition and Policy: Theory and Evidence” and the German Science Foundation (SFB TR 15). *Correspondence to:* H. Karle

<sup>†</sup>ETH Zurich, Center for Law and Economics, 8092 Zurich - Switzerland. E-mail: hkarle@ethz.ch

<sup>‡</sup>ECARES, Université Libre de Bruxelles (ULB), B-1050 Brussels, Belgium. E-mail: gkirchst@ulb.ac.be

<sup>§</sup>University of Mannheim, Department of Economics, 68131 Mannheim, Germany. E-mail: martin.peitz@gmail.com. Also affiliated with CEPR, CERRE, CESifo, ENCORE, MaCCI, and ZEW.

## **1 Introduction**

Can consumers experience loss aversion even if they are not endowed with any good? A growing empirical and experimental literature provides evidence that loss aversion is based on expectations, as assumed by Kőszegi and Rabin (2006, 2007). In this paper, we investigate theoretically and experimentally the impact of expectation-based loss aversion with respect to price on purchase decisions.

Our main contribution is to highlight that expectations on uncertain prices influence indeed purchase decisions. This provides evidence of consumer behavior as postulated in recent work on imperfectly competitive markets (see Heidhues and Kőszegi, 2008 and Karle and Peitz, 2012). In our setting, consumers receive information which may shape their reference point towards their purchase decision, rendering earlier expectations immaterial. By conducting an experiment with exogenous, random prices we are able to investigate the impact of expectation-based reference prices on consumer choice.

We consider a situation in which consumers have to make a choice between two similar goods which differ with respect to prices as well as tastes. They know the tastes of both products, but they receive only stochastic information about the prices, forcing them to form price expectations. Ex-ante, there is an equal chance for each of the goods being the cheaper one. Then the agents learn the actual prices of both products. Afterwards, consumers make their choices. The theoretical analysis considers loss-averse agents who experience additional losses (gains) depending on whether the actually paid price is larger (smaller) than the expected one. Hence, the loss of paying a high price depends on the ex-ante probability with which she expects to pay the low price. We consider two different forms of expectation formation. On the one hand, an agent might be naive and think that her likelihood of choosing the cheaper sandwich is given by the population average, therefore disregarding her own personal taste and her own personal degree of loss aversion. On the other hand, agents might form rational expectations. For such an agent, the likelihood of choosing the cheaper good is bounded from below by  $(1/2)$ , since a rational consumer will always choose her preferred sandwich when it is cheaper. It could even be one if she expects to always eat the cheaper sandwich. Whether this is the case depends

crucially on consumer's personal characteristics, such as, for example, on her taste difference. Of course, these rational expectations must also be consistent with the agent's optimal behavior *ex post*, and the optimal behavior must be the one expected in the first place. In short, for a rational–expectation agent choices and expectations must form a personal equilibrium in the sense of Kőszegi and Rabin (2006, 2007).

The theoretical analysis demonstrates that for both forms of expectation formation more loss–averse consumers are more likely to eat the cheaper sandwich. More specifically, consumers who prefer the taste of the more expensive product are more likely to buy the cheap good if they exhibit a higher degree of loss aversion. This holds for consumers who assign a moderate importance to the taste difference—consumers for whom the taste difference is very important never buy the cheaper, but less tasty product, while those that assign little importance to the taste difference always buy the cheaper product.

We test this prediction experimentally. In the first part of the experiment, subjects had to choose between two different types of sandwiches. First, they tasted both sandwiches and reported how much they liked the taste of each sandwich. At this stage subjects were also informed about the set of possible prices, but not which of the two prices applied to which sandwich. They only learnt that both sandwiches were equally likely to become the cheaper sandwich. Afterwards, they were informed about the actual prices of the two sandwiches. Then they made their consumption choices. In the second part of the experiment, subjects made binary lottery choices which allowed us to measure individual parameters of loss aversion.<sup>1</sup>

As predicted by theory, subjects with a higher degree of loss aversion were more likely to choose the cheaper, but less tasty, sandwich. Such a choice was made by subjects that reported an intermediate level of taste difference. Subjects with a very large reported taste difference always chose the more liked good, and those with a very low reported taste difference always chose the cheaper sandwich. Hence, the evidence suggests that the purchase decision was indeed influenced by expectation–based loss aversion about prices

---

<sup>1</sup>This individual loss aversion elicitation followed Köbberling and Wakker (2005), Fehr and Goette (2007) and Gaechter, Johnson, and Herrmann (2007) and is based on cumulative prospect theory of Tversky and Kahneman (1992).

in the predicted way. Furthermore, the individual loss aversion parameters derived from results of the binary lottery choices had indeed the predicted impact on the consumption behavior.

For the empirical analysis we compare the two different versions of expectation formation (naive vs. rational expectations) and a specification which ignores the role of loss aversion altogether. In the regression analysis the degree of loss aversion turns out to be highly significant. Including loss aversion also increases the predictive power of the estimation by more than one third. The version with rational expectation-based consumer loss aversion performs slightly better than the version in which consumers hold naive beliefs about purchasing probabilities, which do not take individual consumer characteristics into account.

As far as we are aware, this is one of the first detailed theoretical and experimental investigations into expectation-based reference price dependence in a consumer choice setting.<sup>2</sup> The theoretical papers on that topic differ in the way reference points with respect to prices are formed. In Spiegel (2011), consumers sample prices for forming their reference point, while, in Zhou (2011), they use past prices. More closely related, in Heidhues and Köszegi (2008) and Karle and Peitz (2012) consumers form expectation-based reference points in a market with oligopolistic firms. In Heidhues and Köszegi (2008), consumers correctly anticipate *equilibrium* prices, while, in Karle and Peitz (2012), they observe announced prices but are uncertain about their tastes for the low- and high-price product (and this taste is drawn from a continuum of possible realizations). In our paper, consumers know the taste of the two products, but do not know which price applies.

---

<sup>2</sup>There exists an extensive literature testing expectation-based loss aversion à la Köszegi and Rabin (2006, 2007, 2009). These works consist of exchange and valuation experiments (see Ericson and Fuster, 2011), experiments in which participants are compensated for exerting effort in a tedious and repetitive task (see Abeler, Falk, Goette, and Huffman, 2011), and of sequential-move tournaments (see Gill and Prowse, 2012). There is evidence that expectation-based reference dependence affects golf players' performance (see Pope and Schweitzer, 2011) and cabdrivers' labor supply decision (see Crawford and Meng, 2011). See also Camerer, Babcock, Loewenstein, and Thaler (1997), Farber (2005), and Farber (2008) for earlier work on cabdrivers' labor supply decision as well as Fehr and Goette (2007) for evidence on reference-dependence in labor supply from a field experiment with bike messengers. Further evidence on expectation-based reference points includes Loomes and Sugden (1987) and Choi, Fisman, Gale, and Kariv (2007) for choices over lotteries, Post, van den Assem, Baltussen, and Thaler (2008) for gambling behavior in game shows, and Card and Dahl (2011) for disappointment-induced domestic violence. Alternative theories which suggest that expectations act as reference points are provided by Bell (1985), Loomes and Sugden (1986) and Gul (1991).

The marketing literature hints at consumer choices being affected by loss aversion with respect to prices (for an overview see Mazumdar, Raj, and Sinha, 2005). One line of research (e.g. Putler (1992), or Kalyanaram and Winer (1995)) highlights the relevance of temporal reference prices that are derived from prices experienced in the past. Hardie, Johnson, and Fader (1993) provides an experimental study of brand choices under loss aversion in the price and in the quality dimension; in contrast to our setting, their experiment was designed such that reference points were based on the product previously purchased by a consumer. Another line of research such as Rajendran and Tellis (1994) suggests that the reference prices are based on the prices of similar products at the moment of purchase. We provide support to this second line by isolating the role of static reference prices within a set of similar products.

More generally, recent experimental contributions to the loss aversion literature such as Abeler, Falk, Goette, and Huffman (2011) and Gill and Prowse (2012) suggest that anticipated future disappointment or losses affect decisions, e.g. in the context of effort choices. Following a different approach, we show experimentally that unsatisfied expectations affect decisions. More precisely, expectation-based reference points affect consumption choices. Two features are worth mentioning. First, we add to this literature that expectation-based reference points depend on individual characteristics such as preferences. Second, we elicited the individual levels of loss aversion in an independent experimental test and show that the resulting loss aversion parameter can be used to predict individual behavior in consumption choice experiments.

The paper proceeds as follows. In Section 2, we provide a consumer choice model that includes consumer loss aversion and expectation-based reference points. We derive choice probabilities depending on the key variables of interest, namely the perceived taste difference and the degree of consumer loss aversion. In Section 3, we describe the design of the experiment. In Section 4, we present the experimental results. Section 5 concludes. In the Appendix, we provide some further descriptive statistics, an alternative specification of our measure of loss aversion, and the experimental instructions.

## 2 The Consumer Choice Model

In this section, we present a discrete choice model with loss-averse consumers who have expectation-based reference points. There are  $k = 1, \dots, n$  consumers with preferences over two products, which are sold at prices  $p_i$ . Consumer  $k$ 's gross utility for product  $i$  is  $\delta_i t_{ik}$ , with  $t_{ik}$  denoting  $k$ 's taste for product  $i$ . Abstracting from the effect of loss aversion, consumer  $k$ 's intrinsic net utility of buying good  $i$  is  $\delta_1 t_{ik} - \delta_2 p_i$ , with  $\delta_1$  and  $\delta_2$  being strictly positive parameters of the utility function.

The timing is the following:

1. Each consumer  $k$  learns her tastes for the two products,  $t_{ik}$ . She knows that the price of one product is low ( $p_L$ ) and that the price of the other product is high ( $p_H$ ). But she does not know which product is actually the cheaper one. We normalize  $p_H - p_L$  to be 1, and we assume that the a-priori probability of both possible price constellations is  $1/2$ .
2. Consumer  $k$  forms expectations how likely it is to buy at the low price  $p_L$  or at the high price  $p_H$ . This essentially means that consumers assign probabilities to prices. As will be explained in detail below, we will distinguish between two possible types of expectations: Naive expectations and rational expectations à la Kőszegi and Rabin (2006).
3. She observes the assignment of prices to products. Then she makes her purchase decision, based on her utility that includes realized gains and losses relative to her reference-point distribution. This decision is subject to errors (see below), in particular when the tastier good turns out to be the more expensive one.

Consumers may be loss averse in the price (or money) dimension. As usual the utility weight on gains are normalized to one, while losses receive weight  $\lambda_k$ , which denotes the degree of loss aversion of consumer  $k$ . Consumer  $k$  is loss averse if  $\lambda_k > 1$ . Since consumers learn their tastes at stage 1, they already know at this stage which product they

find less tasty. Denote the stage–2 expected probability of buying at the lower price by  $x_k^e$ , and the expected probability of buying at the higher price by  $1 - x_k^e$ . In stage 3, prices are determined. Denote the cheaper good by  $L$ , and the more expensive one by  $H$ . If the consumer buys  $L$ , she experiences a monetary gain compared to her stage–2 expectations. Taking into account that the price difference is 1, the consumer experiences a utility of

$$u_{Lk} = \underbrace{\delta_1 t_{Lk} - \delta_2 p_L}_{\text{intrinsic utility}} + \underbrace{\delta_3 (1 - x_k^e)}_{\text{gain in price}}.$$

On the other hand, when buying the more expensive product, the consumer experiences a monetary loss compared to her stage–2 expectations, resulting in a utility of

$$u_{Hk} = \underbrace{\delta_1 t_{Hk} - \delta_2 p_H}_{\text{intrinsic utility}} - \underbrace{\delta_3 \lambda_k x_k^e}_{\text{loss in price}}.$$

Denote the taste difference between the two products by  $\Delta t_k = t_{Hk} - t_{Lk}$ , and consumer  $k$ 's utility difference between buying  $L$  and  $H$  by  $-\Delta u_k = u_{Lk} - u_{Hk}$ . Using this notation, we get

$$\begin{aligned} -\Delta u_k &= (\delta_2 + \delta_3) - \delta_1 \Delta t_k + \delta_3 (\lambda_k - 1)x_k^e \\ &= \underbrace{\gamma_1}_{+} + \underbrace{\gamma_2}_{-} \Delta t_k + \underbrace{\gamma_3}_{+} (\lambda_k - 1)x_k^e, \end{aligned} \quad (1)$$

where  $\gamma_1 \equiv \delta_2 + \delta_3$ ,  $\gamma_2 \equiv -\delta_1$ , and  $\gamma_3 \equiv \delta_3$ . Obviously, consumer  $k$  chooses good  $L$  whenever  $-\Delta u_k > 0$ . If  $L$  is the tastier product,  $\Delta t_k$  is negative and consumer  $k$  will buy  $L$  for sure. However, if  $H$  is tastier, there is a tradeoff between price (including gain–loss utility) and taste. Due to gain–loss utility (see the third term on the RHS of (1)), a higher taste difference is required in order to induce the purchase of  $H$  by a loss–averse agent than by an agent without loss aversion—i.e., an agent with either  $\gamma_3 = 0$  or  $\lambda_k = 1$ .

As explained in the introduction, we distinguish between two possible ways how the stage–2 expectations  $x_k^e$  are formed: in the first setting, each consumer does not condition the expected purchasing probability on her individual characteristics such as the taste difference and the degree of loss aversion. We say that this setting is featuring *naïve*



expectation-based consumer loss aversion. To analyze this setting empirically, we will use population averages, denoted by  $\bar{x}$ . As discussed in the concluding section, any other empirical implementation would lead to similar results as long as the expectation formation does not depend on individual characteristics.

In the second setting, consumer  $k$ 's reference point distribution depends on the rational stage-2 expectations of the probability of choosing  $L$ , denoted by  $x_k^*$ . This rational expectation is of course affected by the consumer's characteristics. In particular, a consumer takes her tastes for the two products as well as her degree of loss aversion into account when thinking about how likely it is that she will buy  $L$ . We say that this setting is featuring *rational* expectation-based consumer loss aversion, as consumers understand that their personal characteristics affect the reference point.

To obtain a testable model for our regression analysis, we introduce a noise variable  $\epsilon_k$  into consumer  $k$ 's choice problem in (1)—i.e.,  $-\Delta\tilde{u}_k \equiv -\Delta u_k + \epsilon_k$ . Following standard discrete choice theory,  $\epsilon_k$  is assumed to be additive, logistically distributed, and i.i.d. across consumers. If the less tasty product is cheaper ( $\Delta t_k > 0$ ), the probability of choosing  $L$  is  $Pr[\Delta u_k < \epsilon_k | \Delta t_k, \lambda_k] = Pr[\Delta\tilde{u}_k < 0 | \Delta t_k, \lambda_k]$ . For simplicity, we assume that, in the opposite case ( $\Delta t_k \leq 0$ ),  $\epsilon_k$  is distributed such that the consumer will choose product  $L$  for all possible realizations of  $\epsilon_k$ .<sup>3</sup>

We will use the following logit representation,

$$P_k = F\left(\underbrace{\gamma_1}_{+} + \underbrace{\gamma_2}_{-} \Delta t_k + \underbrace{\gamma_3}_{+} (\lambda_k - 1)x_k^e\right), \quad (2)$$

where  $P_k$  describes the probability that the cheaper product is chosen by consumer  $k$  who likes the other product better, and  $F(\cdot)$  is the logistic cdf.

We first turn to the impact of loss aversion on the choice of naive consumers.

---

<sup>3</sup>In our consumption choice experiment we did not observe a single participant choosing the product liked less when this product was also the more expensive one. We, therefore, consider it reasonable to assume that participants held expectations of zero about choosing a more expensive, less tasty product. Nevertheless, in our empirical analysis, we also considered a specification in which we took noise of this kind into account. The results were almost identical to those of the simpler specification, reported in columns (3) and (4) in Table 2 in Section 4. This was due to the fact that the out-of-the-sample predictions for the probabilities of choosing  $H$  were also very close to zero.

**Proposition 1.** *Suppose that consumers are subject to naive expectation-based loss aversion. The probability that consumer  $k$  chooses the cheaper, but less tasty product is increasing in the degree of loss aversion,  $\lambda_k$ .*

*Proof.* Since the expectations of a naive agent  $k$  do not depend on  $k$ 's individual characteristics, and in particular not on  $\lambda_k$ , the marginal effect of an increase in  $\lambda_k$  is given by  $\gamma_3 \bar{x}$ , which is strictly positive as long as some agents in the population buy good  $L$ . ■

This leads to the following testable hypothesis:

**Hypothesis 1:** *Suppose that consumers feature naive expectation-based loss aversion. Consumers who like the more expensive product better ( $\Delta t_k > 0$ ) and show a positive degree of loss aversion ( $\lambda_k > 1$ ) are more likely to choose the cheaper, less tasty product than otherwise identical participants with a lower degree of loss aversion.*

With rational expectation-based consumers, consumers' reference points are characterized by the expected probabilities of buying product  $L$ . Such consumers foresee that their tastes as well as their loss aversion affects these probabilities. Recall that we denote the probability of buying the cheaper product by  $x_k^*$ :

$$\begin{aligned} x_k^* &\equiv Pr[y_k = 1 | \Delta t_k, \lambda_k] \\ &= \frac{1}{2} Pr[y_k = 1 | \Delta t_k > 0, \lambda_k] + \frac{1}{2} Pr[y_k = 1 | \Delta t_k \leq 0, \lambda_k], \end{aligned} \quad (3)$$

where  $y_k$  describes  $k$ 's product choice, with  $y_k = 1$  referring to the choice of  $L$ . In this expression, the two probabilities are weighted with  $1/2$  as this is the ex-ante probability of the tastier product being cheaper.

We are now in the position to characterize consumer  $k$ 's personal equilibrium strategy  $x_k^*$  which completes the specification of her choice problem in (1). The concept of personal equilibrium requires that  $k$  holds rational expectations about her choice in equilibrium and that her choice in equilibrium is optimal given her expectations—see Kőszegi and Rabin (2006): If the tastier product is more expensive ( $\Delta t_k > 0$ ),  $k$  choose product  $L$  with

probability  $Pr[\Delta \tilde{u}_k < 0 | \Delta t_k, \lambda_k]$ . If the tastier product is more expensive,  $k$  always chooses  $L$ . Therefore,

$$x_k^* = \frac{1}{2} Pr[\Delta \tilde{u}_k < 0 | x_k^*, \Delta t_k > 0, \lambda_k] + \frac{1}{2}, \quad (4)$$

which implies that  $x_k^* \in [1/2, 1]$ . In our context, the interpretation of the error term  $\epsilon_k$  requires special attention. It models the assumption that consumers can make errors when choosing their goods. Consumers hold rational expectations about the possibility of an error, but they do not foresee the realisation of  $\epsilon_k$ . Hence,  $\epsilon_k$  cannot be interpreted as modeling those aspects of the decision process that are unknown to the econometrician. Such aspects should be known to the individual consumer already at the stage when the reference point is formed. The actual realisation of  $\epsilon_k$  would have to enter the expectation formation process, if it reflected aspects only unknown to the econometrician, but known to the consumer. Hence,  $\epsilon_k$  models a decision error, or any other random event that is unknown to the consumer when he forms his expectations. This assumption of choice errors forces many consumers to choose a mixed-strategy personal equilibrium, i.e.,  $x_k^* \in (1/2, 1)$  (which is also their preferred personal equilibrium under choice uncertainty), and this mixing is essential for the empirical analysis of expectation-based loss aversion.<sup>4</sup>

Our next theoretical result shows that the qualitative finding under naive expectation-based loss aversion also holds when expectation are formed rationally, provided that the degree of loss aversion is not too large.<sup>5</sup>

**Proposition 2.** *Suppose that consumers are subject to rational expectation-based loss aversion. The probability that consumer  $k$  chooses the cheaper, but less tasty product,  $P_k$ , is increasing in the degree of loss aversion,  $\lambda_k$ , if and only if*

$$(\lambda_k - 1) < \frac{2}{\gamma_3 \cdot f\left(\gamma_1 + \gamma_2 \Delta t_k + \gamma_3 (\lambda_k - 1) x_k^*\right)}, \quad (5)$$

---

<sup>4</sup>Without choice uncertainty, the prediction of the model of Kőszegi and Rabin (2006) would be that any consumer plays her pure-strategy preferred personal equilibrium—i.e., choose  $L$  whenever  $\Delta u_k < 0$  and  $H$  otherwise.

<sup>5</sup>It is also common in the theoretical literature on expectation-based loss aversion to require an upper bound on  $\lambda$  in order to avoid the dominance of the gain-loss utility terms, cf. de Meza and Webb (2007), Herweg and Mierendorff (forthcoming), and Karle (2013).

where  $f(\cdot)$  depicts the logistic density function.

*Proof.* We have to show that  $dP_k/d\lambda_k > 0$ . Note that, by (4) and  $P_k = Pr[\Delta\tilde{u}_k < 0|x_k^*, \Delta t_k > 0, \lambda_k]$ , this is equivalent to showing that  $dx_k^*/d\lambda_k > 0$ . Thus, applying the implicit function theorem on (4) using that  $P_k = Pr[\Delta\tilde{u}_k < 0|x_k^*, \Delta t_k > 0, \lambda_k]$  and, by (2),  $P_k = F(\gamma_1 + \gamma_2\Delta t_k + \gamma_3(\lambda_k - 1)x_k^*)$ , we receive

$$\frac{dx_k^*}{d\lambda_k} = \frac{\frac{1}{2}\gamma_3 x_k^* f(\cdot)}{1 - \frac{1}{2}\gamma_3(\lambda_k - 1)f(\cdot)}. \quad (6)$$

In (6),  $f(y)$  depicts the logistic density function at  $y = (\gamma_1 + \gamma_2\Delta t_k + \gamma_3(\lambda_k - 1)x_k^*)$ , the numerator depicts the effect of a marginal increase in  $\lambda_k$  with  $\partial x_k^*/\partial \lambda_k = 0$ , and the denominator the adjustment for  $\partial x_k^*/\partial \lambda_k \neq 0$ . The numerator is positive since, by (4),  $x_k^* \geq 1/2$  and since  $\gamma_3 = \delta_3 > 0$  by assumption. It remains to be shown that also the denominator is positive. Multiplying the denominator by 2 and rearranging leads to (5), the necessary and sufficient condition in the proposition. Thus, under (5),  $dx_k^*/d\lambda_k > 0$  which is equivalent to  $dP_k/d\lambda_k > 0$ . ■

In the empirical part, we will examine, whether or not the condition of Proposition 2 is fulfilled for all of our subjects. Our hypothesis with rational consumers contains the same prediction as Hypothesis 1:

**Hypothesis 2:** *Suppose that consumers feature rational expectation-based loss aversion and that condition (5) holds. Consumers who like the more expensive product better ( $\Delta t_k > 0$ ) and show a positive degree of loss aversion ( $\lambda_k > 1$ ) are more likely to choose the cheaper, less tasty product than otherwise identical participants with a lower degree of loss aversion.*

In the next section we describe the design we used in order to test the two hypotheses.

### 3 Experimental Design

In the first part of the experiment, each subject had to choose between a ham and a camembert sandwich.<sup>6</sup> We used a perishable consumption good which was consumed on the spot. At the beginning of the experiment, subjects were endowed with 6 Euros, and they were told that one sandwich was to be sold at a price of 4 Euros and the other one at a price of 5 Euros. They were also informed that the prices were randomly assigned and equiprobable. Then the subjects had to taste both sandwiches and grade their tastes on a scale from 1 to 5 (very bad to excellent). Then it was announced which sandwich costed 4 and which sandwich costed 5 Euros. Finally, subjects made their choice of sandwich.

Our design allows for testing the impact of taste differences (rel. to a fixed price difference of 1 Euro) and loss aversion in price on consumption choice.<sup>7</sup> Yet, without appropriate controls, the use of personal taste information might cause structural biases in the variable taste difference—for example, due to students' heterogeneity in income or average expenditure for meals. In our empirical analysis, we find evidence for a structural difference of the impact of the variable taste difference for students with a low average meal expenditure and control for this.

In the second part of the experiment, we elicited each participant's individual degree of loss aversion (see Tversky and Kahneman, 1992). Subjects had to choose between lotteries and sure payments.<sup>8</sup> There were two series of choices, with 6 choices each. For series A, subjects had to make 6 choices between a lottery with 50% chance of winning 1 Euro and 50% chance of winning nothing, and a sure payment of  $S$ .  $S$  was either 10, 20, 30, 40, 50, or 60 Eurocents. In series B, subjects had to make six choices between a lottery that gave a  $1/3$  chance of winning 1 Euro and a  $2/3$  chance of losing  $R$  Euro,

---

<sup>6</sup>At the registration, participants were told that they were invited for a “lunch experiment” with sandwiches.

<sup>7</sup>In a former version of this paper, we also considered loss aversion in taste which did not change our theoretical predictions for sufficiently small taste differences. Due to a multi-collinearity problem between the variables taste difference and loss aversion in taste, however, we were not able to identify the additional effect of loss aversion in taste in our sample.

<sup>8</sup>A similar way of measuring loss aversion was used by Fehr and Goette (2007) and Gaechter, Johnson, and Herrmann (2007).

and a sure payment of zero.  $R$  was either 0, 10, 20, 30, 50, 70, or 100 Eurocents.

At the end of the experiment, one of the 12 choices was chosen randomly and implemented. To cover potential losses, each subject was endowed with a budget of 2 Euros for this second part of the experiment

For series A, a subject  $k$ 's choices should be characterized by a cut-off value  $S_k$  such that for any  $S < S_k$  the lottery is chosen and for any  $S \geq S_k$  the sure payment is preferred. Similarly, for series B subject  $k$ 's choices should be characterized by a cutoff value  $R_k \leq 0$  such that all lotteries with  $R > |R_k|$  are rejected and all lotteries with  $R \leq |R_k|$  are accepted. These cutoff values are used to derive the individual measures of loss aversion. More specifically, we use the exponential utility representation proposed by Tversky and Kahneman (1992)

$$u_k(z) = \begin{cases} z^{\beta_k} & \text{if } z \geq 0; \\ -\tilde{\lambda}_k(-z)^{\beta_k} & \text{o/w,} \end{cases},$$

where  $z$  denotes the monetary payoff,  $\tilde{\lambda}_k > 1$  represents loss aversion, and  $\beta_k \in (0, 1)$  diminishing sensitivity—i.e., risk aversion in gains and risk love in losses (and vice versa for  $\beta_k > 1$ ).

First,  $\beta_k$  is measured by using the cut-off values of results of series A. Take the exponential utility representation above. Using the condition that the utility of getting  $S_k$  for sure must be equal to the expected utility of getting 1 with a 50% chance, we receive as a measure for risk aversion

$$\beta_k = \ln(1/2) / \ln(S_k).$$

For given  $\beta$ , series B is used to derive the measure of loss aversion  $\tilde{\lambda}_k$ . From the cutoff condition  $0 = 1/3 + 2/3(-\tilde{\lambda}_k)(-R_k)^{\beta_k}$ , we receive the degree of loss aversion of participant  $k$

$$\tilde{\lambda}_k = \frac{1}{2(-R_k)^{\beta_k}} \quad \text{and } R_k < 0.^9$$

---

<sup>9</sup>If participants chose 0, we used 4 as a cutoff. Our results are robust to applying different cutoffs (maintaining significance at least at the 5% level).

Rabin (2000) argues that risk aversion cannot plausibly explain choice behavior in small-stake lotteries without implying absurd degrees of risk aversion in high-stake gambles. Therefore, in small-stake lotteries, people should be risk neutral. According to this view and in line with part of the experimental literature (see, e.g., Gaechter, Johnson, and Herrmann, 2007), we consider the specification that  $\beta_k$  is set equal to one in Appendix B. The results of our regression analysis are robust to this modification (see Table B1).<sup>10</sup>

Prospect theory suggests that, on top of loss aversion with diminishing sensitivity, subject's choices also exhibit probability weighting. We neglect this effect since probability weighting would only have a scale effect on our loss aversion measure but leave the ordering of the individual  $\tilde{\lambda}_k$ s unaffected.<sup>11</sup> We will only use the ranking of the individual  $\tilde{\lambda}_k$ s rather than their value, since we only test the hypothesis that participants who show a higher degree of loss aversion are more likely to choose the cheaper sandwich (see our hypothesis above). In addition, since participants make a riskless consumption choice, we decided to neglect diminishing sensitivity,  $\beta_k \neq 1$ , in the first part of the experiment.

The experiment was run at the experimental lab of the Department of Economics of the University of Mannheim in fall 2010. Students from all faculties and years participated. There were 6 sessions with up to 24 participants. Overall, 135 subjects participated. On average, they received a compensation of 7.56 Euros (at market prices) for spending about 45 minutes in the lab. Both sandwiches had a market value of 3.90 Euros.<sup>12</sup> On top, subjects received an average cash payment of 3.66 Euros, which was determined by their lottery choices and their residual budgets from their consumption choices.

---

<sup>10</sup>Alternatively, when monetary lottery choices are interpreted according to Kőszegi and Rabin (2006), we find that the ranking of  $\tilde{\lambda}_k$  is identical to that when  $\beta_k$  is set equal to one. A proof of this is available from the authors upon request.

<sup>11</sup>With probability weighting,  $\tilde{\lambda}_k$  would be multiplied by  $w^+(1/3)/w^-(2/3)$ , where  $w^+$  and  $w^-$  are the corresponding probability weights for gains and losses (for more detail, see Tversky and Kahneman (1992) as well as Gaechter, Johnson, and Herrmann, 2007, page 8)

<sup>12</sup>Sandwiches were ordered from a local sandwich restaurant. The sandwiches were warm and kept in isothermal transportation boxes.

## 4 Experimental Results

We had to rule out some observations because of inconsistent lottery choices in the second part of the experiment (8 observations out of 135) and because some participants were vegetarian although, in our invitation, it was announced that the experiment was not suitable for vegetarians (7 obs.). Furthermore, we had to drop the observations when participants liked the cheaper sandwich better (47 observations) as they are not suitable for identification in our analysis.<sup>13</sup> This left us with a sample of 73 participants. Two types of sandwiches were offered, ham sandwiches (alternative 1) and sandwiches with camembert (alternative 2).

Participants provided information on gender, age, field of study, number of terms, and average expenditure on meals (see Table A1 in Appendix A).

### 4.1 Degree of Loss Aversion

The second part of the experiment allowed us to separate the degree of loss aversion from the degree of risk aversion for each participant. We find a share of 76.7% of participants was slightly risk averse or risk neutral and the other subjects were slightly risk loving ( $mean(\beta_k) = 0.89$ ,  $\sigma(\beta_k) = 0.30$ ,  $\max(\beta_k) = 1.36$ ,  $\min(\beta_k) = 0.43$ ).

In order to avoid that the results depend on outliers, we categorized the measured degree of loss aversion in four categories from “loss seeking or neutral” to “strongly loss averse”. More formally, we get

$$\lambda_k = \begin{cases} 1 \text{ “loss seeking or neutral”,} & \text{if } \tilde{\lambda}_k \leq 1; \\ 2 \text{ “weakly loss averse”,} & \text{if } \tilde{\lambda}_k \in (1, 1.8]; \\ 3 \text{ “loss averse”,} & \text{if } \tilde{\lambda}_k \in (1.8, 3]; \\ 4 \text{ “strongly loss averse”,} & \text{if } \tilde{\lambda}_k > 3, \end{cases}$$

---

<sup>13</sup>Any participant in our sample who had the choice between a cheaper, more tasty sandwich and a more expensive, less tasty sandwich, in fact chose the intrinsically better sandwich, irrespective of the set of explanatory variables such as the level of taste difference or the degree of loss aversion.



where 1.8 is equal to  $\text{median}(\tilde{\lambda}_k)$ .<sup>14</sup> Its *mean* is 2.63 (see Table A1 in Appendix A). The frequency of the categorized measure of loss aversion,  $\lambda_k$ , can be found at the bottom line in Table 1 (see below).<sup>15</sup>

We checked for correlation of  $\lambda_k$  with reported taste, age, gender and average expenditure for lunch of the subjects. The degree of loss aversion  $\lambda_k$  was found to be uncorrelated with all these individual characteristics.

## 4.2 Consumption Choice

About 80 percent of the participants liked the ham sandwich better (they were asked before learning the realized prices and, thus, their responses can be considered to be unbiased). In 5 out of 6 sessions, the ham sandwich turned out to be the more expensive sandwich, i.e. the ham sandwich is product  $H$ .<sup>16</sup>

Due to the price disadvantage of 1 Euro, 31.71% of the participants that liked the more expensive sandwich better actually chose the cheaper sandwich (36.26% for weakly better). Thus, the experimental setup induced a positive amount of choice reversals (with respect to the taste of the provided sandwiches) which we exploit for our empirical analysis.

We obtain results by first reporting choice outcomes and then estimating the discrete choice model with consumer loss aversion. Considering the sandwich choice of participants who liked the more expensive sandwich better, in our sample we find a positive monotonic relationship between loss aversion ( $\lambda_k$ ) and the choice of the cheaper sandwich ( $\text{mean}(y_k)$ ), see Table 1. For example, take all those subjects with a taste difference of  $\Delta t_k = 1$ . Only 1/3 of the participants with a low levels of loss aversion ( $\lambda_k = 1$  or 2)

---

<sup>14</sup>If we used 2 as a cut-off instead of the median, we would obtain qualitatively similar results.

<sup>15</sup>A reason why our measure of loss aversion is relatively high could be that, given that the winning probability in lottery series B was rather small ( $p = 1/3$ ), probability weighting (which we neglected) might have had an impact on lottery choices.

<sup>16</sup>We drew a price lottery on the evening before each experimental session, announced explicitly at the beginning of each session that prices were equiprobable and randomly drawn, and elicited the price realizations during each session. We drew price lotteries in advance in order to avoid too much waste, because we had to place our orders to the restaurant the evening before each session and our buffer stock was affected by realized prices.

Table 1: Impact of Loss Aversion on Sandwich Choice

$\Delta t_k$	$\lambda_k :$	1	2	3	4
0	$mean(y_k)$	-	0.5	1	1
	obs.	0	4	1	2
1	$mean(y_k)$	0.333	0.333	0.417	0.625
	obs.	3	15	12	8
2	$mean(y_k)$	0	0.111	0.1429	0.2
	obs.	2	9	7	5
3	$mean(y_k)$	-	0.333	0	0
	obs.	0	3	1	1
Total	$mean(y_k)$	0.2	0.290	0.333	0.5
	obs.	5	31	21	16

Table 1:  $y_k = 1$  means that the cheaper sandwich was chosen.  $\Delta t_k > 0$  means that the participant likes the more expensive sandwich better.

chose the cheaper and less tasty sandwich, while for  $\lambda_k = 3$  ( $\lambda_k = 4$ ) 42% (63%) went for the cheaper sandwich. This supports our hypothesis that participants with a higher degree of loss aversion are more likely to choose the cheaper sandwich. The monotone relationship between choice and degree of loss aversion holds for all levels of taste differences except for the category with the largest taste difference ( $\Delta t_k = 3$ ). In that category, which only contains 5 observations, the relationship is weaker and reversed.

To test the significance of expectation-based reference dependence (cf. equation (2)), we use a logit estimator, as outlined in Section 2.<sup>17</sup> To deal with the endogeneity issue under our null hypothesis, we apply a two-stage estimation procedure. The independent variable “Taste Diff.” resp. “Loss Price” equals  $\Delta t_k$  resp.  $(\lambda_k - 1)\hat{x}_k$ , where  $\hat{x}_k$  describes our first-stage estimate for participants’ ex ante expectations about choosing the cheaper sandwich.

Table 2 reports the second-stage logit estimation results (according to equation (2)). The even columns include the control variables age and a gender dummy (male = 1), which were obtained from a questionnaire. Columns (1) and (2) show the results of an estimate which allows for naive expectations of participants about their ex ante probability of

<sup>17</sup>We checked that the results of the logit estimation presented below are similar to the results of a corresponding OLS estimation.

Table 2: Probability of Choosing the Cheaper, Less Tasty Sandwich:  $P_k$ 

	Logit: Naive Expectations		Logit: Rational Expectations		Logit: No Loss Aversion	
	(1)	(2)	(3)	(4)	(5)	(6)
Loss Price	1.078** (0.037)	1.129** (0.033)	0.915** (0.032)	0.955** (0.028)		
Taste Diff.	-1.530*** (0.001)	-1.606*** (0.001)	-1.304*** (0.006)	-1.371*** (0.006)	-1.424*** (0.002)	-1.492*** (0.002)
Low Meal Ex. × Taste Diff.	1.184** (0.010)	1.246*** (0.009)	1.016** (0.019)	1.067** (0.017)	0.877** (0.033)	0.926** (0.029)
Age		0.056 (0.488)		0.054 (0.502)		0.056 (0.462)
Gender (M.)		0.626 (0.299)		0.647 (0.286)		0.517 (0.366)
Constant	-0.480 (0.546)	-2.200 (0.299)	-0.537 (0.502)	-2.227 (0.293)	0.743 (0.178)	-0.851 (0.653)
N. Obs.	73	73	73	73	73	73
Pseudo $R^2$	0.1994	0.2188	0.2029	0.2225	0.1482	0.1649

Table 2: Loss Price equals  $(\lambda_k - 1)\hat{x}_k$ , where  $\hat{x}_k$  describes the first-stage estimate for participants' ex ante probability of choosing the cheaper sandwich. In the logit regressions with naive expectations, the sample mean is used as first-stage estimate for  $\hat{x}_k$ , i.e.,  $\hat{x}_k = 1/2 \cdot \text{mean}(y_k) + 1/2$ , while in the second specification an individual-specific estimate is used (see main text). The third specification does not consider loss aversion. P-values are in parentheses. Significance at the 1%, 5%, and 10% level is denoted by \*\*\*, \*\*, and \*, respectively.

choosing the cheaper sandwich,  $\hat{x}_k$ :  $\hat{x}_k$  was replaced by the price-lottery-weighted sample mean of the choice variable  $y_k$ , i.e.,  $\hat{x}_k = \bar{x} = 1/2 \cdot \text{mean}(y_k) + 1/2$ . This presumes that, before observing the price realization, each participant expects to end up buying the cheaper product with identical probability (which is equal to  $\hat{x}_k = 0.671$  in our sample) although participants vary in characteristics.<sup>18</sup> This logit estimator essentially examines the marginal effect of the independent variables taste difference and degree of loss aversion as in a standard-textbook procedure since  $\hat{x}_k = 1/2 \cdot \text{mean}(y_k) + 1/2$  is simply a constant multiplied by the independent variable  $(\lambda_k - 1)$ . In line with our predictions, we find a

<sup>18</sup>See Table A1 in Appendix A for descriptive statistics of all independent variables.

positive effect of loss aversion and a negative effect of taste difference on the probability of choosing the cheaper, less tasty sandwich (at a significance level of 5%).

On the right-hand side of the estimation we have included an interaction term of a dummy variable for low average expenditure per meal (Low Meal Ex.= 1 if meal expenditure  $\leq$  3 Euros) and the variable taste difference,  $\mathbb{I}_{\{\text{Meal Ex}_k \leq 3\}} \cdot \Delta t_k$ .<sup>19</sup> This interaction term is supposed to capture that, for participants who spend less money for their meals on average, the fixed price difference of 1 Euro is more important than for other participants relative to any given taste difference. We find that this interaction term has a positive impact on choice reversals and is highly significant.<sup>20</sup>

The estimates in columns (1) and (2) support Hypothesis 1, the hypothesis under *naive* expectation-based loss aversion. Yet, these estimates show an endogeneity bias if consumers experience *rational* expectation-based loss aversion instead, since the interdependence between the actual choice probability  $P_k$  and the ex-ante choice probability  $x_k^e$  is not taken into account. In columns (3) and (4),  $\hat{x}_k$  reports the estimate which accounts for participants' characteristics, i.e., participants hold rational expectations about their ex ante choice probability given their characteristics:  $\hat{x}_k = x_k^* = 1/2 \cdot \hat{P}r[\Delta \tilde{u}_k < 0 | \lambda_k, \Delta t_k, \Delta p \geq 0] + 1/2$ . We estimated  $\hat{x}_k$  and  $\hat{P}_k$  iteratively (according to equation (2) with  $\hat{P}_k = \hat{P}r[\Delta \tilde{u}_k < 0 | \lambda_k, \Delta t_k, \Delta p \geq 0]$ ), and in order to minimize endogeneity issues for the joint estimation of the second-stage coefficients and  $\hat{x}_k$ , we used the price-lottery-weighted sample mean,  $1/2 \cdot \text{mean}(y_k) + 1/2$ , as an unconditional estimate for the lagged value of  $\hat{x}_k$ .<sup>21</sup>

$$\hat{x}_{k,t+1} = \frac{1}{2} F\left(\hat{\gamma}_{1,t} + \hat{\gamma}_{2,t} \Delta t_k + \hat{\gamma}_{3,t} (\lambda_k - 1) \frac{\text{mean}(y_k) + 1}{2}\right) + \frac{1}{2}, \quad (7)$$

where  $F(\cdot)$  is the logistic cdf and  $(\hat{\gamma}_{1,t}, \hat{\gamma}_{2,t}, \hat{\gamma}_{3,t})$  are the second-stage logit coefficients

<sup>19</sup>One third of our population has such a low level of average expenditure per meal. Our results are robust to perturbations of the cutoff of 3 Euros per meal.

<sup>20</sup>When the dummy variable Low Meal Expenditure is added to the regression, it is non-significant, while it is significant at a 3.9% to 5.7% level when being included instead of the interaction term.

<sup>21</sup>An alternative specification in which we used  $\hat{x}_{k,t}$ , the conditional estimate for the lagged value of  $\hat{x}_k$ , instead of  $1/2 \cdot \text{mean}(y_k) + 1/2$  leads to almost identical results as those reported in columns (3) and (4). Convergence of the iterative estimation was reached after 11 to 12 iterations.

estimated according to equation (2) in iteration  $t$ . As an initial value of  $\hat{x}_k$ , we also used the price–lottery–weighted sample mean, i.e.,  $\hat{x}_{k,0} = 1/2 \cdot \text{mean}(y_k) + 1/2$ . Convergence of the iterative estimation was reached after 21 to 23 iterations. We denote this estimate by  $\hat{x}_{k,\infty}$ . The mean of  $\hat{x}_{k,\infty}$  is equal to 0.666 (which is close to  $1/2 \cdot \text{mean}(y_k) + 1/2$ ) and individual  $\hat{x}_{k,\infty}$  varies between 0.511 and 0.893. Columns (3) and (4) in Table 2 show the second–stage estimation results according to equation (2) with  $\hat{x}_k = \hat{x}_{k,\infty}$ .<sup>22</sup>

Results in columns (3) and (4), together with the test result of condition (5) from Proposition 2, provide support for Hypothesis 2. As predicted by equation (4), in all regressions which include the degree of loss aversion as an independent variable, we find a significant, negative effect of the reported taste difference ( $\hat{\gamma}_2 < 0$ ) and a significant, positive effect of the degree of loss aversion ( $\hat{\gamma}_3 > 0$ ), both significant at least at the 5 percent level. In addition, we found that all participants in our sample satisfied the condition for the degree of loss aversion having a positive impact on the probability of choosing the cheaper, less tasty sandwich (cf. (5) in Proposition 2): In our sample, the lowest upper bound on  $(\lambda_k - 1)$  (right-hand side of (5)) is predicted to equal 8.795 (resp. 8.377) for column (3) (resp. (4)), while  $(\lambda_k - 1)$  only varies from 0 to 3.

To document the importance of loss aversion, we report the logit regressions in columns (5) and (6), which exclude measures of loss aversion. They show a notably lower  $R$  squared; for instance compared to columns (1) and (2). This indicates that measures of loss aversion add explanatory power to the estimation beyond those of standard preferences.

The logit regressions with rational expectations in columns (3) and (4) show the highest significance level for loss aversion (3.2% without and 2.8% with controls). With rational expectations, the estimates for loss aversion in price are lower than those without rational expectations (columns (1), (2)). This indicates that using rational expectations (i.e., expectations which incorporate individual characteristics) reduces the endogeneity issue in

---

<sup>22</sup>Alternatively, it could be assumed that individual expectations are simply shaped by the price–lottery–weighted sample mean of  $y_k$  conditional on participants' taste difference and degree of loss aversion as presented in Table 1, i.e.,  $\hat{x}_k = \text{mean}(y_k | \Delta t_k, \lambda_k) / 2 + 1/2$ . This also leads to similar second–stage estimation results as those reported in columns (3) and (4).

our sample. Furthermore, with rational expectations, the estimates for taste difference are lower in absolute terms than those with naive expectations and with standard consumers (columns (1), (2) and (5), (6)). This suggests that estimators that do not account for loss aversion based on rational expectations overestimate the sensitivity of choice probabilities to taste differences. Control variables are not significant which might be due to the fact that characteristics such as gender and age do not systematically affect choice behavior when controlling for, in particular, the taste and average meal expenditures variables.

To summarize, our findings with respect to both, the choice outcomes and the discrete choice model provide support for Hypotheses 1 and 2. Our analysis suggests that the rational expectation-based model is preferred over the naive expectation-based model. In the alternative specification where participants are treated as risk neutral ( $\beta_k = 1$  for all  $k$ ), our results are confirmed. They are reported Appendix B.

## **5 Conclusion**

Our experimental evidence suggests that information on the degree of loss aversion extracted from lotteries has predictive power for consumption behavior. By presenting participants a one-shot consumption decision problem and by implementing a pre-consumption blind tasting, our experiment has successfully excluded the possibility that participants' consumption choice has been influenced by reference points based on past purchases. Through tasting and the announcement of the price distribution, participants formed contextual reference points which affected participants' consumption choice after they had learnt the realized price allocation.

Our empirical analysis is informed by a theory of consumer choice which distinguishes between naive and rational expectation-based loss aversion. Our findings provide strong support that expectation-based loss aversion affects consumption choices. With respect to the naive model, we acknowledge that our estimation results do not distinguish between different ways expectations are formed. Our parameters are obtained when expectations are formed according to expectation averages. Alternatively, consumers may believe to

buy the better tasting product with probability one.<sup>23</sup> However, our results suggest that rational expectations–based loss aversion better explains the data than naive expectations–based loss aversion and, thus, it does not really matter which interpretation of naive expectations is to be preferred.

The requirement to not only pay money but also to compensate participants in a product dimension has been a challenge designing this experiment which we solved by inviting participants to a lunch experiment with sandwiches. Each participant’s degree of loss aversion has been identified through the choice of lotteries. Our analysis supports the idea that an individual’s parameter of loss aversion is similar in different choice environments. Otherwise, we should not have obtained a relationship between the degree of loss aversion identified through the choice among lotteries and observed choices in our lunch experiment.

Our paper suggests a way how to combine experimental data with real–world consumption data since the experimentally identified degree of loss aversion may well be correlated with the degree of loss aversion outside the lab as it applies to consumption choices. However, real–world consumption data are often generated in a dynamic choice context such that consumers can form temporal reference points. While our experimental design deliberately excluded this temporal aspect, the use of real–world consumption data may complement the present study to evaluate the relative importance of expectation–based loss aversion in a setting that includes the possibility to form temporal reference points.

---

<sup>23</sup>This would only affect the value of parameter  $\gamma_3$ .

## References

- ABELER, J., A. FALK, L. GOETTE, AND D. HUFFMAN (2011): "Reference Points and Effort Provision," *American Economic Review*, 101(2), 470–492.
- BELL, D. E. (1985): "Disappointment in Decision Making under Uncertainty," *Operations Research*, 33(1), 1–27.
- CAMERER, C., L. BABCOCK, G. LOEWENSTEIN, AND R. THALER (1997): "Labor Supply of New York City Cabdrivers: One Day at a Time," *Quarterly Journal of Economics*, 112(2), 407–441.
- CARD, D., AND G. B. DAHL (2011): "Family Violence and Football: The Effect of Unexpected Emotional Cues on Violent Behavior," *Quarterly Journal of Economics*, 126(1), 103–143.
- CHOI, S., R. FISMAN, D. GALE, AND S. KARIV (2007): "Consistency and Heterogeneity of Individual Behavior under Uncertainty," *American Economic Review*, 97(5), 1921–1938.
- CRAWFORD, V. P., AND J. MENG (2011): "New York City Cabdrivers' Labor Supply Revisited: Reference-Dependent Preferences with Rational-Expectations Targets for Hours and Income," *American Economic Review*, 101(5), 1912–32.
- DE MEZA, D., AND D. C. WEBB (2007): "Incentive Design under Loss Aversion," *Journal of the European Economic Association*, 5(1), 66–92.
- ERICSON, K. M. M., AND A. FUSTER (2011): "Expectations as Endowments: Evidence on Reference-Dependent Preferences from Exchange and Valuation Experiments," *Quarterly Journal of Economics*, 126(4), 1879–1907.
- FARBER, H. S. (2005): "Is Tomorrow Another Day? The Labor Supply of New York City Cabdrivers," *Journal of Political Economy*, 113(1), 46–82.
- (2008): "Reference-Dependent Preferences and Labor Supply: The Case of New York City Taxi Drivers," *American Economic Review*, 98(3), 1069–1082.
- FEHR, E., AND L. GOETTE (2007): "Do Workers Work More if Wages Are High? Evidence from a Randomized Field Experiment," *American Economic Review*, 97(1), 298–317.
- GAECHTER, S., E. J. JOHNSON, AND A. HERRMANN (2007): "Individual-Level Loss Aversion in Riskless and Risky Choices," *Discussion Paper, University of Nottingham*.
- GILL, D., AND V. PROWSE (2012): "A Structural Analysis of Disappointment Aversion in a



- Real Effort Competition,” *American Economic Review*, 102(1), 469–503.
- GUL, F. (1991): “A Theory of Disappointment Aversion,” *Econometrica*, 95(3), 667–686.
- HARDIE, B. G. S., E. J. JOHNSON, AND P. S. FADER (1993): “Modeling Loss Aversion and Reference Dependence Effects on Brand Choice,” *Marketing Science*, 12(4), 378–394.
- HEIDHUES, P., AND B. KŐSZEGI (2008): “Competition and Price Variation when Consumers are Loss Averse,” *American Economic Review*, 98(4), 1245–1268.
- HERWEG, F., AND K. MIERENDORFF (forthcoming): “Uncertain Demand, Consumer Loss Aversion, and Flat-Rate Tariffs,” *Journal of the European Economic Association*.
- KALYANARAM, G., AND R. S. WINER (1995): “Empirical Generalizations from Reference Price Research,” *Marketing Science*, 14(3), 161–169.
- KARLE, H. (2013): “Creating Attachment through Advertising: Loss Aversion and Pre-Purchase Information,” *CER-ETH Zurich Working Paper*, 13/177.
- KARLE, H., AND M. PEITZ (2012): “Competition under Consumer Loss Aversion,” *University of Mannheim Working Paper Series*, 12–8.
- KÖBBERLING, V., AND P. P. WAKKER (2005): “An Index of Loss Aversion,” *Journal of Economic Theory*, 122(1), 119 – 131.
- KŐSZEGI, B., AND M. RABIN (2006): “A Model of Reference-Dependent Preferences,” *Quarterly Journal of Economics*, 121(4), 1133–1165.
- (2007): “Reference-Dependent Risk Attitudes,” *American Economic Review*, 97(4), 1047–1073.
- (2009): “Reference-Dependent Consumption Plans,” *American Economic Review*, 99(3), 909–936.
- LOOMES, G., AND R. SUGDEN (1986): “Disappointment and Dynamic Consistency in Choice under Uncertainty,” *Review of Economic Studies*, 53(2), 271–282.
- (1987): “Testing for Regret and Disappointment in Choice under Uncertainty,” *Economic Journal*, 97, 118–129.
- MAZUMDAR, T., S. RAJ, AND I. SINHA (2005): “Reference Price Research: Review and Propositions,” *Journal of Marketing*, 69(4), 84–102.
- POPE, D. G., AND M. E. SCHWEITZER (2011): “Is Tiger Woods Loss Averse? Persistent Bias in the Face of Experience, Competition, and High Stakes,” *American Economic*

*Review*, 101, 129–157.

POST, T., M. J. VAN DEN ASSEM, G. BALTUSSEN, AND R. H. THALER (2008): “Deal or No Deal? Decision Making under Risk in a Large-Payoff Game Show,” *American Economic Review*, 98(1), 38–71.

PUTLER, D. S. (1992): “Incorporating Reference Price Effects into a Theory of Consumer Choice,” *Marketing Science*, 11(3), 287–309.

RABIN, M. (2000): “Risk Aversion and Expected-Utility Theory: A Calibration Theorem,” *Econometrica*, 68(5), 1281–1292.

RAJENDRAN, K. N., AND G. J. TELLIS (1994): “Contextual and Temporal Components of Reference Price,” *Journal of Marketing*, 58(1), 22–34.

SPIEGLER, R. (2011): “Monopoly Pricing when Consumers are Antagonized by Unexpected Price Increases: A “Cover Version” of the Heidhues-Kőszegi-Rabin Model,” *Economic Theory*, April, 1–17.

TVERSKY, A., AND D. KAHNEMAN (1992): “Advances in Prospect Theory: Cumulative Representation of Uncertainty,” *Journal of Risk and Uncertainty*, 5, 297–323.

ZHOU, J. (2011): “Reference Dependence and Market Competition,” *Journal of Economics and Management Strategy*, 20(4), 1073–1097.

## Appendix

### A Descriptive Statics

Table A1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Choice (cheaper Sandw.), $y_k$	73	0.342	0.478	0	1
Taste Difference, $\Delta t_k$	73	1.356	0.752	0	3
Loss Aversion Parameter, $\lambda_k$	73	2.658	0.901	1	4
Age	73	23.932	3.509	18	35
Gender (Male= 1)	73	0.562	0.500	0	1
Meal Expenditure	73	4.333	1.935	2	15
Low Meal Ex.	73	0.329	0.473	0	1
$\hat{x}_k$ , Naive, col.(1)	73	0.671	0	0.671	0.671
$\hat{x}_k$ , Rat. Exp., col. (3)	73	0.666	0.103	0.511	0.893

Table A1: Meal Expenditure measures participants' reported average expenditure for lunch per week, Low Meal Ex. is a dummy variable which is equal to one for Meal Expenditure  $\leq 3$ , and Gender is a gender dummy which is equal to one for male. The two last rows present the first-stage estimate of the ex ante probability of choosing the cheaper sandwich  $\hat{x}_k$  used in the regressions in Table 2.

### B Alternative Specification

In this appendix, we consider the specification that participants' degree of loss aversion is measured without taking diminishing sensitivity into account ( $\beta_k = 1$ ). As a consequence,  $\tilde{\lambda}_k$  is skewed upwards. This indicates that the measure of loss aversion used in the main text is preferable for our analysis. Nevertheless, we can take advantage of the ranking of participants' degrees of loss aversion in this case and apply a categorization with the following quantiles of  $\lambda_k(\beta_k = 1) \in \{1, 2, 3, 4\}$ ,

$$\lambda_k(\beta_k = 1) = \begin{cases} 1 \text{ "loss seeking or neutral",} & \text{if } \tilde{\lambda}_k \leq 1; \\ 2 \text{ "weakly loss averse",} & \text{if } \tilde{\lambda}_k \in (1, 2.5]; \\ 3 \text{ "loss averse",} & \text{if } \tilde{\lambda}_k \in (2.5, 5]; \\ 4 \text{ "strongly loss averse",} & \text{if } \tilde{\lambda}_k > 5. \end{cases}$$

This leads to the following results of our regression analysis which are very similar to the former results (see Table B1).

Table B1: Probability of Choosing the Cheaper, Less Tasty Sandwich:  $P_k$

	Logit: Naive Expectations		Logit: Rational Expectations		Logit: No Loss Aversion	
	(1)	(2)	(3)	(4)	(5)	(6)
Loss Price	1.152** (0.049)	1.346** (0.029)	1.027** (0.041)	1.200** (0.022)		
Taste Diff.	-1.606*** (0.001)	-1.737*** (0.001)	-1.392*** (0.003)	-1.491*** (0.003)	-1.424*** (0.002)	-1.492*** (0.002)
Low Meal Ex. × Taste Diff.	1.169** (0.011)	1.257*** (0.009)	1.023** (0.019)	1.085** (0.018)	0.876** (0.033)	0.926** (0.029)
Age		0.054 (0.506)		0.054 (0.512)		0.056 (0.462)
Gender (M.)		0.848 (0.176)		0.900 (0.158)		0.517 (0.366)
Constant	-0.238 (0.745)	-2.118 (0.314)	-0.350 (0.639)	-2.276 (0.285)	0.743 (0.178)	-0.851 (0.653)
N. Obs.	73	73	73	73	73	73
Pseudo $R^2$	0.1954	0.2243	0.2027	0.2337	0.1482	0.1649

Table B1: Loss Price equals  $[\lambda_k(\beta_k = 1) - 1]\hat{x}_k$ , where  $\hat{x}_k$  describes the first-stage estimate for participants' ex ante probability of choosing the cheaper sandwich and  $\lambda_k(\beta_k = 1)$  the categorized measure of loss aversion when diminishing sensitivity is not taken into account. In the logit regressions with naive expectations, the sample mean is used as first-stage estimate for  $\hat{x}_k$ , i.e.,  $\hat{x}_k = 1/2 \cdot \text{mean}(y_k) + 1/2$ , while in the second specification an individual-specific estimate is used (see main text). The third specification does not consider loss aversion. P-values are in parentheses. Significance at the 1%, 5%, and 10% level is denoted by \*\*\*, \*\*, and \*, respectively.

## C Instructions

Dear participants

first, we would like to thank you for your participation in this experiment. The experiment won't last longer than 50 minutes. All of your information provided will be treated strictly anonymously. Therefore, please do not put your name on the questionnaire.

The experiment consists of two parts. In the **first part** you will be served two sandwich samples of the same quality. After tasting both of them, you will have to choose the one you would like to have for lunch after the experiment is finished. One sandwich will cost you 4 Euro, whereas the other sandwich will cost 5 Euro. As a participant, you will receive the total amount of 6 Euro for the first part of this experiment, i.e. in the end you will receive the sandwich you choose and the money left from your budget, either 1 or 2 Euro.

PART ONE procedure:

- a) Please taste both sandwich samples
- b) Please evaluate the taste of each sandwich
- c) The experimenter will announce the prices of the sandwiches
- d) Please choose the sandwich you like

In the **second part** of the experiment you are required to fill in the questionnaire attached and to specify which lotteries (out of a series of lotteries) you would like to play. For your participation in the second part of the experiment you will receive 2 Euro. It depends then on the lottery you choose and their outcomes, whether you gain up to an additional Euro or lose up to one. So, your payoff in the second part will be between 1 and 3 Euro.

PART TWO procedure:

- e) Please fill in the questionnaire
- f) Please decide which lotteries you would like to play
- g) One lottery will be randomly selected and played out
- h) You will receive the sandwich you chose in part one and your payoff in both part one and part two by submitting a payoff receipt
- i) Enjoy your sandwich!

If you still have questions on how you should proceed, please ask the experimenter. Otherwise, please turn and start with part one.

## PART ONE

Please keep the experimental lab clean. Thank you!

a)

1. Please taste the sandwich 1.

2. Please taste the sandwich 2.

b)

1. How did you like the sandwich 1? Please put a cross in a box below according to your preferences.

strongly dislike   ☐   ☐   ☐   ☐   ☐   strongly like  
                                 1            2            3            4            5

2. How did you like the sandwich 2? Please put a cross in a box below according to your preferences.

strongly dislike   ☐   ☐   ☐   ☐   ☐   strongly like  
                                 1            2            3            4            5

c)

1. The price of the sandwich 1 is \_\_\_\_ Euro. Please fill in the price.

2. The price of the sandwich 2 is \_\_\_\_ Euro. Please fill in the price.

d) Please decide on which of the two sandwiches you would like to buy. Keep in mind that you can buy only one sandwich, i.e. either sandwich 1 or sandwich 2.

I would like to buy sandwich \_\_\_\_.

## PART TWO

e) Please fill in the questionnaire:

### Personal information:

1. Prices being equal, which sandwich would you have chosen?  
Sandwich \_\_\_\_
2. Did you have a sandwich for lunch yesterday? (No/Yes. If yes, which kind of?)  
No ☐ Yes ☐ \_\_\_\_\_
3. How much do you spend on average for lunch (on a weekday) in case you eat out (i.e. in case you don't cook by yourself)?  
\_\_\_\_ Euro
4. How often do you have lunch out per week?  
\_\_\_\_ times
5. How old are you?  
\_\_\_\_
6. What is your sex?  
female ☐ male ☐
7. In which semester are you?  
\_\_\_\_ semester
8. Do you work during your studies in order to earn some money?  
(No/Yes. If yes, how much do you earn a month?)  
No ☐ Yes ☐ approx. \_\_\_\_\_ euros

**Risk attitude:**

9. Every time I make a decision, I ask myself what would have happened in case I would have made an alternative decision.

Strongly disagree   ☐1   ☐2   ☐3   ☐4   ☐5   ☐6   ☐7   Strongly agree

10. Once I have made a decision, I try to figure out what the outcomes of the other alternatives would have been.

Strongly disagree   ☐1   ☐2   ☐3   ☐4   ☐5   ☐6   ☐7   Strongly agree

11. I regard a good decision as a failure in case I find out that an alternative would have been better.

Strongly disagree   ☐1   ☐2   ☐3   ☐4   ☐5   ☐6   ☐7   Strongly agree

12. Missed opportunities often come to my mind, when I look back on my life.

Strongly disagree   ☐1   ☐2   ☐3   ☐4   ☐5   ☐6   ☐7   Strongly agree

13. Once I have made a decision, I do not question it.

Strongly disagree   ☐1   ☐2   ☐3   ☐4   ☐5   ☐6   ☐7   Strongly agree



f) Decision about playing a lotteries:

In the following a number of lotteries will be presented to you each of which you can either play or not. The lotteries of one series differ in the amount of money you may lose. The series of lotteries, in turn, differ in the probability of winning or losing. By the end of part two, one lottery will be randomly selected and played in order to determine your payoff. For the second part of the experiment you have 2 Euro at your disposal. The maximal amount of Euros you can win or loose is 1 Euro. Thus, your payoff in this part will be either 1 or 3 Euro.

Here is an **example**:

**Example: Lottery series Z**

Gains **1,00 euro**

Winning probability **50%**

Losses **see below**

Loss probability **50%**

Losses	X	X	□	□	□	□
	-0,10 euro	-0,20 euro	-0,30 euro	-0,50 euro	-0,70 euro	-1,00 euro

- ➔ The crosses above indicate that you would play a lottery of series Z until a loss 20 cents.
- ➔ If the lottery with a loss of -0,10 Euro was randomly selected, then you would win an additional 1 Euro with the probability of 50% or loose -0,10 Euro with the probability of, again, 50%. Hence, your payoff in this case would be either 3 Euro or 1,90 Euro.
- ➔ If the lottery with a loss of -0,30 Euro was randomly selected, you would not win or lose anything as you decided not to play in this case, i.e. your payoff would remain 2 Euro.

Please ask the experimenter if there is something unclear about how you should proceed. If the instructions are clear, please consider the following lotteries, as it has been described in the example above.

In the following please decide between the **lottery A** and a **secure payment**:

**Lottery A:**

Gains    **1,00 euro**

Winning probability    **50%**

Losses    **0,00 euro**

Loss probability        **50%**

**Secure payment:**

Payment A (see the table below)

Please decide between lottery A and a secure payment A line by line. Please cross one alternative per line!

<b>Table</b>	<b>Lottery A</b>	<b>Secure payment</b>
Line 1	Lottery A <input type="checkbox"/>	A=0,10 euro <input type="checkbox"/>
Line 2	Lottery A <input type="checkbox"/>	A=0,20 euro <input type="checkbox"/>
Line 3	Lottery A <input type="checkbox"/>	A=0,30 euro <input type="checkbox"/>
Line 4	Lottery A <input type="checkbox"/>	A=0,40 euro <input type="checkbox"/>
Line 5	Lottery A <input type="checkbox"/>	A=0,50 euro <input type="checkbox"/>
Line 6	Lottery A <input type="checkbox"/>	A=0,60 euro <input type="checkbox"/>

**Lottery series B**

Gains    **1,00 euro**

Winning probability    **33,3%**

Losses    **see below**

Loss probability        **66,7%**

Please cross every lottery of the series **B** that you would like to play!  
(0 to 6 crosses are possible)

	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Losses</b>	-0,10 euro	-0,20 euro	-0,30 euro	-0,50 euro	-0,70 euro	-1,00 euro

Congratulations! You have completed the second part of the experiment. Please wait till your questionnaire will be collected by the experimenter and sign your payoff receipt. Thank you for your patience/participation!

Please feel free to express any kind of comments you have on this experiment. Thank you!

---

---