American Economic Journal: Microeconomics 2015, 7(2): 101–120
http://dx.doi.org/10.1257/mic.20130104

Loss Aversion and Consumption Choice: Theory and Experimental Evidence†

By Heiko Karle, Georg Kirchsteiger, and Martin Peitz*

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. Participants differ in their reported taste for the two sandwiches and in their 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 theoretical predictions. The estimates in the model with rational expectations are slightly more significant than those with naïve expectations. (*JEL* D11, D12, D84, M31)

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 proposed by Kőszegi and Rabin (2006, 2007). In this paper, we investigate theoretically and experimentally the impact of expectation-based loss aversion on purchase decisions.

Our main contribution is to highlight that expectations on uncertain prices do, indeed, influence purchase decisions. We provide evidence of consumer behavior as postulated in recent work on imperfectly competitive markets (see Heidhues and Kőszegi 2008 and Karle and Peitz 2014).

In our setting, consumers receive information that may shape their reference point towards their purchase decision, rendering earlier expectations immaterial. By

* Karle: Eidgenössische Technische Hochschule (ETH) Zurich, Center for Law and Economics, 8092 Zurich, Switzerland (e-mail: hkarle@ethz.ch); Kirchsteiger: European Centre for Advanced Research in Economics and Statistics (ECARES), Université Libre de Bruxelles (ULB), B-1050 Brussels, Belgium, Center for Economic and Policy Research (CEPR), Center for Economic Studies and ifo Institut (CESifo), and Vienna Center for Experimental Economics (VCEE) (e-mail: gkirchst@ulb.ac.be); Peitz: Department of Economics, University of Mannheim, 68131 Mannheim, Germany, CEPR, Centre on Regulation in Europe (CERRE), CESifo, Economics Network for Competition and Regulation (ENCORE), Mannheim Centre for Competition and Innovation (MaCCI), and Zentrum für Europäische Wirtschaftsforschung (ZEW) (e-mail: martin.peitz@gmail.com). A previous version of this paper was circulated under the title "The Impact of Contextual Reference Dependence on Purchase Decisions." We are grateful to three anonymous referees, Sofia Amaral Garcia, Björn Bartling, Daniel Chen, Enrico Diecidue, Dirk Engelmann, Thomas Epper, Lorenz Götte, Paul Heidhues, Fabian Herweg, Holger Herz, Rudolf Kerschbamer, Johannes Maier, Ulrike Rangel, Larry Samuelson, 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 Actions de Recherche Concertées (ARC) Grant "Market Evolution, Competition and Policy: Theory and Evidence" and the German Science Foundation Sonderforschungsbereich Transregio 15 (SFB TR 15).
† Go to http://dx.doi.org/10.1257/mic.20130104 to visit the article page for additional materials and author disclosure statement(s) or to comment in the online discussion forum.

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 that differ with respect to price and tastes. They know their own tastes for 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 to be the cheaper one. After the consumers learn the actual prices of both products, they make their choices. The theoretical analysis considers loss-averse agents who experience 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 the consumer expects to pay the low price. We consider two different forms of expectation formation. On the one hand, an agent might be naïve and think that her likelihood of choosing the cheaper sandwich is given by the population's average; thus, she disregards her own personal taste and her own personal degree of loss aversion. On the other hand, an agent 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 the consumer's personal characteristics, such as her tastes. Following Kőszegi and Rabin (2006, 2007), we assume that these rational expectations are consistent with the agent's optimal behavior ex post (i.e., for a rational-expectation agent, choices and expectations must form a personal equilibrium).

As the theoretical analysis shows, 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 cheaper product 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 tested 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. At this stage subjects were also informed about the set of possible prices, but not about which of the two prices applied to which sandwich. Subjects learned only that the sandwiches were equally likely to be the cheaper sandwich. Then, they found out actual prices of the two sandwiches and 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.[1]

As predicted by theory, subjects with a higher degree of loss aversion were more likely to choose the cheaper, but less tasty, sandwich. Subjects who reported an

[1] This individual loss-aversion elicitation followed Köbberling and Wakker (2005); Fehr and Götte (2007), and Gächter, Johnson, and Herrmann (2007) and is based on Tversky and Kahneman's (1992) cumulative prospect theory.

intermediate level of taste difference made this choice, while those with a very large reported taste difference always chose the tastier sandwich, 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 in the predicted way. Furthermore, the individual loss-aversion parameters derived from the results of the binary lottery choices had the predicted impact on the consumption behavior.

For the empirical analysis, we compare the two different versions of expectation formation (naïve versus rational expectations) with a specification that ignores the role of loss aversion altogether. In the regression analysis, the degree of loss aversion turns out to be 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 (in terms of pseudo R^2) than the version in which consumers hold naïve 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.[2] The theoretical papers on that topic differ in the way reference points with respect to prices are formed. In Spiegler (2012), consumers sample prices before forming their reference point, while in Zhou (2011), they use past prices. More closely related, in Heidhues and Kőszegi (2008) and Karle and Peitz (2014), consumers form expectation-based reference points in a market with oligopolistic firms. In Heidhues and Kőszegi (2008), consumers correctly anticipate the *equilibrium* price distribution, while in Karle and Peitz (2014), they observe posted prices but are uncertain about their tastes for the low- and high-priced product (which 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.[3]

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 quality dimensions; in contrast to our setting, their experiment was designed such that reference points were based on the

[2] There exists an extensive literature testing expectation-based loss aversion à la Kőszegi 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 et al. 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 et al. (1997); Farber (2005); and Farber (2008) for earlier work on cabdrivers' labor-supply decision, as well as Fehr and Götte (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 et al. (2007) for choices over lotteries; Post et al. (2008) for gambling behavior in game shows; and Card and Dahl (2011) for disappointment-induced domestic violence. Alternative theories that suggest that expectations act as reference points are provided by Bell (1985); Loomes and Sugden (1986); and Gul (1991).

[3] Hence, consumers know the price distribution, as in Heidhues and Kőszegi (2008), which is, however, exogenous in our consumer-choice setting.

product that a customer previously purchased. In another line of research, 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 et al. (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 by showing 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 I, 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: the perceived taste difference and the degree of consumer loss aversion. In Section II, we describe the design of the experiment. In Section III, we present the experimental results. Section IV concludes. In the Appendix, we provide some further descriptive statistics and an alternative specification of our measure of loss aversion. Our instructions for the participants in the experiment and the results of an alternative estimation of the model with rational expectations are contained in the online Appendix.

I. 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 $k = 1, \ldots, n$ consumers with preferences over two products, which are sold at prices p_i. Consumer k's gross utility for product i is $\delta_1 t_{ik}$, 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 δ_1 and δ_2 being strictly positive parameters of the utility function.

The timing is as follows:

- 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 $1/2$.
- Consumer k forms expectations of 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 we will explain in detail below, we will distinguish between two possible types of expectations: naïve expectations and rational expectations à la Kőszegi and Rabin (2006).
- Consumer k observes the assignment of prices to products. Then, she makes her purchase decision, based on her utility, which 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.[4] As usual, the utility weight on gains are normalized to one, while losses receive weight λ_k, which denotes consumer k's degree of loss aversion. 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 expected probability at stage 2 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 expectations at stage 2. Taking into account that the price difference is 1, the consumer experiences a utility of

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

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

$$(2) \qquad u_{Hk} = \underbrace{\delta_1 t_{Hk} - \delta_2 p_H}_{\text{intrinsic utility}} - \underbrace{\delta_3 \lambda_k x_k^e}_{\text{loss in price}}.$$

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

$$(3) \qquad \begin{aligned} -\Delta u_k &= (\delta_2 + \delta_3) - \delta_1 \Delta t_k + \delta_3 (\lambda_k - 1)x_k^e \\ &= \underbrace{\gamma_1}_{+} + \underbrace{\gamma_2}_{-} \Delta t_k + \underbrace{\gamma_3}_{+} (\lambda_k - 1)x_k^e, \end{aligned}$$

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, Δt_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 right-hand side of (3)), a loss-averse agent requires a greater taste difference to purchase H than 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 that the expectations at stage 2, x_k^e, are formed: in the first setting, each consumer does not condition the expected purchasing probability on her individual characteristics,

[4] In Section IV, we comment on the model in which consumers are loss averse also in the taste dimension.

such as taste difference and degree of loss aversion. We say that this setting features *naïve* expectation-based consumer loss aversion. To analyze this setting empirically, we use population averages, denoted by $\overline{x}$. 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 expectations at stage 2 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 into account her tastes for the two products and her degree of loss aversion when thinking about how likely it is that she will buy L. We say that this setting features *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 ϵ_k into consumer k's choice problem in (3), i.e., $-\Delta \tilde{u}_k \equiv -\Delta u_k + \epsilon_k$. Following standard discrete choice theory, ϵ_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 $\Pr[\Delta u_k < \epsilon_k \mid \Delta t_k, \lambda_k] = \Pr[\Delta \tilde{u}_k < 0 \mid \Delta t_k, \lambda_k]$. For simplicity, we assume that, in the opposite case ($\Delta t_k \leq 0$), ϵ_k is distributed such that the consumer will choose product L for all possible realizations of ϵ_k.[5]

We use the following logit representation,

$$P_k = F\Big(\underbrace{\gamma_1}_{+} + \underbrace{\gamma_2}_{-} \Delta t_k + \underbrace{\gamma_3}_{+} (\lambda_k - 1) x_k^e\Big), \tag{4}$$

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 cumulative distribution function.

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

PROPOSITION 1: *Suppose that consumers are subject to naïve expectation-based loss aversion. The probability that consumer k chooses the cheaper, but less tasty product is increasing in the degree of loss aversion,* λ_k.

PROOF:

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

[5] 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 III. This was due to the fact that the out-of-sample predictions for the probabilities of choosing H were also very close to zero.

This leads to the following testable hypothesis:

HYPOTHESIS 1: *Suppose that consumers feature naïve 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 affect these probabilities. Recall that we denote the ex ante probability of buying the cheaper product by x_k^*:

$$x_k^* \equiv \Pr[y_k = 1 \mid \Delta t_k, \lambda_k] = \frac{1}{2}\Pr[y_k = 1 \mid \Delta t_k > 0, \lambda_k] + \frac{1}{2}\Pr[y_k = 1 \mid \Delta t_k \leq 0, \lambda_k], \tag{5}$$

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 a position to characterize consumer k's personal equilibrium strategy x_k^*, which completes the specification of her choice problem in (3). 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 chooses product L with probability $\Pr[\Delta \tilde{u}_k < 0 \mid \Delta t_k, \lambda_k]$. If the tastier product is less expensive, k always chooses L. Therefore,

$$x_k^* = \frac{1}{2}\Pr[\Delta \tilde{u}_k < 0 \mid x_k^*, \Delta t_k > 0, \lambda_k] + \frac{1}{2}, \tag{6}$$

which implies that $x_k^* \in [1/2, 1]$. In our context, the interpretation of the error term ϵ_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 realization of ϵ_k. On the contrary, if an error reflected aspects only unknown to the econometrician, but known to the consumer, the actual realization of ϵ_k would have to enter the expectation-formation process. Thus, we assume that ϵ_k models a decision error, or any other random event, such as a taste shock, the realization of which is unknown to the consumer when she forms her expectations. This assumption of choice errors forces consumers to condition their choice on the realization of ϵ_k. In expectations, their choice is probabilistic, i.e., $x_k^* \in (1/2, 1)$, which is also their preferred personal equilibrium under choice uncertainty. This probabilistic choice is essential for the empirical identification of the marginal effect of expectation-based loss aversion.[6]

[6] Without choice uncertainty, the prediction of Kőszegi and Rabin (2006) would be that any consumer chooses L whenever $\Delta u_k < 0$, and H otherwise.

Our next theoretical result shows that the qualitative finding under naïve expectation-based loss aversion also holds when expectations are formed rationally, provided that the degree of loss aversion is not too large.[7]

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, λ_k, if and only if*

$$(\lambda_k - 1) < \frac{2}{\gamma_3 \cdot f(\gamma_1 + \gamma_2\, \Delta t_k + \gamma_3(\lambda_k - 1)x_k^*)}, \tag{7}$$

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

PROOF:

We have to show that $dP_k/d\lambda_k > 0$. Note that, by (6) 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 (6) using that $P_k = \Pr[\Delta\tilde{u}_k < 0 | x_k^*, \Delta t_k > 0, \lambda_k]$ and, by (4), $P_k = F(\gamma_1 + \gamma_2\Delta t_k + \gamma_3(\lambda_k - 1)x_k^*)$, we receive

$$\frac{dx_k^*}{d\lambda_k} = \frac{\frac{1}{2}\gamma_3\, x_k^*\, f(\cdot)}{1 - \frac{1}{2}\gamma_3(\lambda_k - 1)\, f(\cdot)}. \tag{8}$$

In (8), $f(y)$ 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 λ_k with $\partial x_k^*/\partial\lambda_k = 0$; and the denominator depicts the adjustment for $\partial x_k^*/\partial\lambda_k \neq 0$. The numerator is positive since, by (6), $x_k^* \geq 1/2$ and since $\gamma_3 = \delta_3 > 0$ by assumption. It remains to be shown that the denominator also is positive. Multiplying the denominator by 2 and rearranging leads to (7), the necessary and sufficient condition in the proposition. Thus, under (7), $dx_k^*/d\lambda_k > 0$, which is equivalent to $dP_k/d\lambda_k > 0$. ∎

In the empirical section, 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 (7) 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.*

[7] It is also common in the theoretical literature on expectation-based loss aversion to require an upper bound on λ in order to avoid the dominance of the gain-loss utility terms; cf. de Meza and Webb (2007), Herweg and Mierendorff (2013), and Karle and Peitz (2014).

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

II. Experimental Design

In the first part of the experiment, each subject had to choose between a ham and a camembert sandwich.[8] We used a perishable consumption good which was consumed on the spot. At the beginning of the experiment, subjects were endowed with six euros, and they were told that one sandwich would be sold for four euros and the other for five euros. They were also informed that the prices were randomly assigned and equiprobable. 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 has the price of four euros and which five. Finally, subjects made their choice of sandwich.

Our design allows for testing the impact of taste differences (relative to a fixed price difference of one euro) and loss aversion in price on consumption choice. Yet, without appropriate controls, the use of personal taste information might cause structural biases in the variable taste difference due, for example, 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 taste differences among 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.[9] There were two series of choices, with six choices each. For series A, subjects had to make six choices between a lottery with a 50-percent chance of winning one euro and a 50-percent chance of winning nothing, and, on the other hand, a sure payment of S. S was $10, 20, 30, 40, 50$, or 60 eurocents. In series B, subjects had to make six choices between a lottery that gave a $1/3$ chance of winning one euro and a $2/3$ chance of losing R, and, on the other hand, a sure payment of zero. R was $0, 10, 20, 30, 50, 70$, 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 two euros for this second part of the experiment.

For series A, a subject k's choices should be characterized by a cutoff 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)

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

[8] At registration, participants were told that they were invited for a "lunch experiment" with sandwiches.

[9] Fehr and Götte (2007) and Gächter, Johnson, and Herrmann (2007) used a similar way of measuring loss aversion.

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

First, β_k is measured by using the cutoff 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 one with a 50 percent chance, we receive as a measure for risk aversion

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

For given β, 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

$$\tilde{\lambda}_k = \frac{1}{2(-R_k)^{\beta k}} \quad \text{and} \quad R_k < 0.$$[10]

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., Gächter, Johnson, and Herrmann 2007), we consider, in Appendix B, the specification that β_k is set equal to one. The results of our regression analysis are robust to this modification (see Table B1).[11]

Prospect theory suggests that, in addition to loss aversion with diminishing sensitivity, subjects' choices also exhibit probability weighting. We neglect this effect since probability weighting would have a scale effect only on our loss-aversion measure but would leave the ordering of the individual $\tilde{\lambda}_k$s unaffected.[12] We will use only the ranking of the individual $\tilde{\lambda}_k$s rather than their value, since we test only 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 six 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

[10] 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 percent level).

[11] 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 β_k is set equal to one. A proof of this is available from the authors upon request.

[12] 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 and Gächter, Johnson, and Herrmann 2007).

value of 3.90 euros and were consumed on the spot.[13] In addition, 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.

III. Experimental Results

We had to rule out some observations because of inconsistent lottery choices in the second part of the experiment (eight observations out of 135) and because some participants were vegetarian even though our invitation stated that the experiment was not suitable for vegetarians (seven observations). Furthermore, we had to drop the observations when participants liked the cheaper sandwich better (47 observations), as they were not suitable for identification in our analysis.[14] This left us with a sample of 73 participants. Two types of sandwiches were offered: ham (alternative 1) and 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).

A. *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 found that a share of 76.7 percent of participants were slightly risk-averse or risk-neutral and the other subjects were slightly risk-loving ($\text{mean}(\beta_k) = 0.89$, $\sigma(\beta_k) = 0.30$, $\max(\beta_k) = 1.36$, $\min(\beta_k) = 0.43$).

In order to avoid the results depending 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

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

where 1.8 is equal to $\text{median}(\tilde{\lambda}_k)$.[15] Its mean is 2.63 (see Table A1 in Appendix A). The frequency of the categorized measure of loss aversion, λ_k, can be found in the bottom line in Table 1.[16]

[13] Sandwiches were ordered from a local sandwich restaurant and kept warm in isothermal transportation boxes.

[14] 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.

[15] If we used 2 as a cutoff instead of the median, we would obtain qualitatively similar results.

[16] 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.

Table 1—Impact of Loss Aversion on Sandwich Choice

Δt_k	λ_k:	1	2	3	4
0	mean(y_k)	—	0.5	1	1
	Observations	0	4	1	2
1	mean(y_k)	0.333	0.333	0.417	0.625
	Observations	3	15	12	8
2	mean(y_k)	0	0.111	0.1429	0.2
	Observations	2	9	7	5
3	mean(y_k)	—	0.333	0	0
	Observations	0	3	1	1
Total	mean(y_k)	0.2	0.290	0.333	0.5
	Observations	5	31	21	16

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

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

B. *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 five of six sessions, the ham sandwich turned out to be the more expensive sandwich—i.e., the ham sandwich is product H.[17]

Because of the price disadvantage of one euro, 31.71 percent of the participants that preferred the taste of the more expensive sandwich actually chose the cheaper sandwich (36.26 percent for weakly preferred). Thus, the experimental setup induced a positive number of choice reversals (with respect to the taste of the 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 (λ_k) and the choice of the cheaper sandwich (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 level of loss aversion ($\lambda_k = 1$ or 2) chose the cheaper, less tasty sandwich, while for $\lambda_k = 3$ ($\lambda_k = 4$), 42 percent (63 percent) 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 contains only five observations, the relationship is weaker and reversed.

[17] 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.

To test the significance of expectation-based reference dependence (cf. equation (4)), we use a logit estimator, as outlined in Section I.[18] To deal with the endogeneity issue under our null hypothesis, we apply a two-stage estimation procedure. The independent variable "Taste Diff." (respectively "Loss Price") equals Δt_k (respectively $(\lambda_k - 1)\hat{x}_k$), 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 (4)). The even columns include the control variable age and a gender dummy (male $=$ 1), which were obtained from a questionnaire. Columns 1 and 2 show the results of an estimate that allows for participants' naïve expectations about their ex ante probability of 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., $\hat{x}_k = \overline{x} = 1/2 \cdot \text{mean}(y_k) + 1/2$. This presumes that, before observing the realized price, 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.[19] 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 positive effect of loss aversion and a negative effect of taste difference on the probability of choosing the cheaper, less tasty sandwich (at a five-percent significance level).

We control for heterogeneity in participants' price sensitivity, which could be an alternative explanation to loss aversion for the observed choice reversals. 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, $I_{\{\text{Meal Ex}_k \leq 3\}} \cdot \Delta t_k$, as well as the control variable average expenditure per meal (Meal Ex.) itself.[20] This interaction term captures that, for participants who spend less money for their meals, on average, the fixed price difference of one euro may be 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 significant, while the control variable average expenditure per meal is never significant. In addition, we find that the coefficient of the variable "Taste Diff." does not systematically vary across other observable subject characteristics, such as age and gender, i.e., the coefficients of the corresponding interaction terms all turn out to be insignificant. Overall, we observe that controlling for heterogeneity in participants' price sensitivity leads to a higher significance level of loss aversion in explaining choice reversals.

The estimates in columns 1 and 2 support Hypothesis 1, the hypothesis under *naïve* expectation-based loss aversion. Yet, if consumers experience *rational* expectation-based loss aversion instead, these estimates suffer from an endogeneity bias,

[18] We checked that the results of the logit estimation presented below are similar to the results of a corresponding OLS estimation.

[19] See Table A1 in Appendix A for descriptive statistics of all independent variables.

[20] 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.

TABLE 2—PROBABILITY OF CHOOSING THE CHEAPER, LESS TASTY SANDWICH: P_k

	Logit: naïve expectations		Logit: rational expectations		Logit: no loss aversion	
	(1)	(2)	(3)	(4)	(5)	(6)
Loss Price	1.063**	1.114**	0.877**	0.918**		
	(0.040)	(0.035)	(0.033)	(0.028)		
Taste difference	−1.632***	−1.675***	−1.370***	−1.406***	−1.544***	−1.585***
	(0.002)	(0.002)	(0.009)	(0.010)	(0.002)	(0.002)
Low meal expectations × taste difference	1.340**	1.349**	1.139**	1.139**	1.073**	1.077**
	(0.013)	(0.015)	(0.028)	(0.032)	(0.033)	(0.035)
Meal expectations	0.101	0.072	0.090	0.064	0.124	0.102
	(0.557)	(0.701)	(0.602)	(0.738)	(0.459)	(0.571)
Age		0.049		0.046		0.047
		(0.550)		(0.575)		(0.543)
Gender (male)		0.624		0.654		0.520
		(0.299)		(0.282)		(0.362)
Constant	−0.837	−2.291	−0.865	−2.273	0.276	−1.029
	(0.400)	(0.281)	(0.381)	(0.283)	(0.739)	(0.591)
Observations	73	73	73	73	73	73
Pseudo R^2	0.2029	0.2203	0.2080	0.2258	0.1536	0.1681

Notes: 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 naïve expectations, the sample mean is used as the 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.

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

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 that accounts for participants' characteristics, i.e., participants hold rational expectations about their ex ante choice probability given their characteristics: $\hat{x}_k = x_k^* = 1/2 \cdot \hat{\Pr}[\Delta\tilde{u}_k < 0 \mid \lambda_k, \Delta t_k, \Delta p \geq 0] + 1/2$. We estimated $\hat{x}_k$ and $\hat{P}_k$ iteratively (according to equation (4) with $\hat{P}_k = \hat{\Pr}[\Delta\tilde{u}_k < 0 \mid \lambda_k, \Delta t_k, \Delta p \geq 0]$):

$$\hat{x}_{k,t+1} = \frac{1}{2} F(\hat{\gamma}_{1,t} + \hat{\gamma}_{2,t}\,\Delta t_k + \hat{\gamma}_{3,t}(\lambda_k - 1)\hat{x}_{k,t}) + \frac{1}{2}, \tag{9}$$

where $F(\,\cdot\,)$ is the logistic cumulative distribution function and $(\hat{\gamma}_{1,t}, \hat{\gamma}_{2,t}, \hat{\gamma}_{3,t})$ are the second-stage logit coefficients estimated according to equation (4) in iteration t. As an initial value of $\hat{x}_k$, we 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 11 to 12 iterations. We denote this estimate by $\hat{x}_{k,\infty}$. The mean of $\hat{x}_{k,\infty}$ is equal to 0.671, which coincides with the sample mean $1/2 \cdot \text{mean}(y_k) + 1/2$, and individual $\hat{x}_{k,\infty}$ varies between 0.509 and 0.944. Columns 3 and 4 in Table 2 show the second-stage estimation results according to equation (4) with $\hat{x}_k = \hat{x}_{k,\infty}$.[21]

[21] 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,

Results in columns 3 and 4, together with the test result of condition (7) from Proposition 2, provide support for Hypothesis 2. As predicted by equation (6), in all regressions that 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, using our categorization, we find 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. (7) in Proposition 2): In our sample, the lowest upper bound on $(\lambda_k - 1)$ (right-hand side of (7)) is predicted to equal 9.132 (respectively, 8.719) for column 3 (respectively, (4)), while $(\lambda_k - 1)$ varies only 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 pseudo R^2, compared, for example, 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 a high significance level for loss aversion (3.3 percent without and 2.8 percent 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 that incorporate individual characteristics) reduces the endogeneity issue in our sample. Furthermore, with rational expectations, the estimates for taste difference are lower in absolute terms than those with naïve 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 results are confirmed in the alternative specification, reported in Appendix B, where participants are treated as risk-neutral ($\beta_k = 1$ for all k). Furthermore, we note that using rational expectations leads to a larger pseudo R^2 compared to naïve expectations—this is also confirmed in our alternative specification.

IV. Discussion and 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 with a one-shot consumption decision problem and by implementing a preconsumption blind tasting, our experiment successfully excluded the possibility that participants' consumption choice was influenced by reference points

i.e., $\hat{x}_k = \text{mean}(y_k \mid \Delta t_k, \lambda_k)/2 + 1/2$. This leads to second-stage estimation results similar to those reported in columns 3 and 4. We present these alternative results in columns 3' and 4' of Table W1 in the online Appendix.

based on past purchases. Through tasting and the announcement of the price distribution, participants formed contextual reference points that affected their consumption choice after they had learned the realized price allocation.

Our empirical analysis is informed by a theory of consumer choice that distinguishes between naïve and rational expectation-based loss aversion. Our findings strongly support the view that expectation-based loss aversion affects consumption choices. With respect to the naïve model, we acknowledge that our estimation results do not distinguish between the different ways in which uniform expectations are formed. Our parameters are obtained when uniform expectations are formed according to expectation averages. Alternatively, all consumers may expect to buy the better tasting product with probability one.[22] However, as our results suggest that rational expectation-based loss aversion better explains the data than naïve expectation-based loss aversion does, it does not really matter which interpretation of naïve expectations is preferred.

In our consumption experiment, participants were not only paid money, but also in kind. To be as true as possible to our theoretical model, our goal was to exclude the possibility of resale (and, thus, of monetizing the in-kind payment) and to make sure that revealed tastes remained constant between the point of reporting them and the actual purchase. For this purpose, we designed an experiment in which consumption takes place on the spot—a lunch experiment with sandwiches.

Each participant's degree of loss aversion has been identified separately through the choice among lotteries. A priori, it is not clear whether the derived values are related to consumer-choice behavior in a consumer-choice environment. In particular, one may suspect that an individual's degree of loss aversion identified through the choice among lotteries is unrelated to observed choices in our lunch experiment. Our analysis, however, shows that these two are related: an individual's parameter of loss aversion positively correlates with choice probabilities, as predicted by our consumer-choice model in which consumers are loss-averse in the price dimension.

In our framework, we postulated that consumers are loss-averse in the price dimension, but not in the taste dimension. Following Kőszegi and Rabin (2006), one may alternatively postulate that consumers are also loss-averse in the taste dimension. To allow for loss aversion in the taste dimension, the theoretical model and the empirical specification need to be augmented. Consumer k's utility of choosing the cheaper but less tasty product then equals $u'_{Lk} = u_{Lk} - \delta_4 \lambda_k (1 - x_k^e) \Delta t_k$, which is u_{Lk} from equation (1) augmented by the loss in the taste dimension, where $\delta_4 > 0$. Analogously, consumer k's utility of buying the more expensive and tastier product equals $u'_{Hk} = u_{Hk} + \delta_4 x_k^e \Delta t_k$, where u_{Hk} has been defined in equation (2), and the additional term captures the gain in the taste dimension since the consumer buys the product she likes better. The utility difference is then $-\Delta u'_k = -\Delta u_k - \delta_4(\lambda_k - 1)(1 - x_k^e)\Delta t_k$, where $-\Delta u_k$ is as defined in equation (3), subtracting $\delta_4 \Delta t_k$. A loss-averse consumer k has a net gain in the price dimension and a net loss in the taste dimension when deciding in favor of the cheaper, less liked product. In the regression analysis, one can then use the logit

[22] This would affect only the value of parameter γ_3 but not its significance.

representation, $P_k' = F(-\Delta u_k')$, where P_k' describes the probability that the cheaper product is chosen by consumer k, who likes the other product better, $\Pr[y_k = 1 \mid \Delta t_k, \lambda_k, \Delta p = 1]$, and $F(\cdot)$ is the logistic cumulative distribution function.

The theoretical results obtained in this model are the same as those considered in the main body of this paper for all consumers with a sufficiently small taste difference.[23] Due to multicollinearity between taste difference, Δt_k, and loss aversion in taste, $(\lambda_k - 1)(1 - x_k^e)\Delta t_k$, however, we could not identify the additional effect of loss aversion in the taste dimension. This was due to the fact that the variation of $(\lambda_k - 1)(1 - x_k^e)$ was insufficient in our sample. Since the theoretical predictions obtained in both models are the same for consumers who do not have a large taste difference, we decided to follow the simpler framework in which consumers are loss averse only with respect to price. Future work may want to return to this issue by empirically discriminating between a model in which consumers are loss averse only in the price dimension and one in which consumers are loss averse in both dimensions.[24]

Our paper suggests a way to combine experimental data with real-world consumption data: 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 of forming temporal reference points.

[23] This is formally established in an earlier discussion paper version: Karle, Kirchsteiger, and Peitz (2013).

[24] As mentioned in Section I, the error term ϵ_k can also be interpreted as a taste shock. In particular, feelings such as hunger or thirst may affect the taste, and consumers may have problems predicting them. If consumers are loss averse only in the price dimension, this applies without further qualification. If consumers are also loss averse in taste but not with respect to the taste shock ϵ_k, our present setting applies. If, however, consumers also include this shock in the gain-loss utility they experience in the taste dimension, the reference point would need to be adjusted, resulting in an adaptation of the consumer-choice model proposed by Heidhues and Kőszegi (2008).

Appendix

A. *Descriptive Statistics*

Table A1—Descriptive Statistics

Variable	Observations	Mean	Standard deviation	Min.	Max.
Choice (cheaper sandwich), y_k	73	0.342	0.478	0	1
Taste difference, Δt_k	73	1.356	0.752	0	3
Loss aversion parameter, λ_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 Expenditure	73	0.329	0.473	0	1
$\hat{x}_k$, naïve, column 1	73	0.671	0	0.671	0.671
$\hat{x}_k$, rational expenditure, column 3	73	0.671	0.119	0.509	0.944

Notes: Meal Expenditure measures participants' reported average expenditure for lunch per week. Low Meal Expenditure is a dummy variable which is equal to one for meal expenditures ≤ 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 when participants' degree of loss aversion is measured without taking diminishing sensitivity into account ($\beta_k = 1$). As a consequence, $\tilde{\lambda}_k$ turns out to be skewed upwards, while the ranking of participants' degree of loss aversion turns out to be almost identical to that used in the main text.[25] We 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).

[25] The latter finding also indicates that, in our sample, participants' choices in gain lotteries are consistent with those in mixed lotteries, which, otherwise, could have been a reason for concern with respect to our identification of risk preferences in the main text.

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

	Logit: naïve expectations		Logit: rational expectations		Logit: no loss aversion	
	(1)	(2)	(3)	(4)	(5)	(6)
Loss Price	1.116*	1.327**	0.985**	1.171**		
	(0.058)	(0.033)	(0.045)	(0.024)		
Taste difference	−1.678***	−1.769***	−1.432***	−1.481***	−1.544***	−1.585***
	(0.002)	(0.002)	(0.006)	(0.006)	(0.002)	(0.002)
Low meal expectation × taste difference	1.277**	1.304**	1.100**	1.092**	1.073**	1.077**
	(0.016)	(0.017)	(0.032)	(0.040)	(0.033)	(0.035)
Meal expectation	0.075	0.036	0.063	0.020	0.124	0.102
	(0.667)	(0.854)	(0.725)	(0.923)	(0.459)	(0.571)
Age		0.051		0.051		0.047
		(0.541)		(0.546)		(0.543)
Gender (male)		0.844		0.913		0.520
		(0.178)		(0.154)		(0.362)
Constant	−0.485	−2.156	−0.571	−2.293	0.276	−1.029
	(0.599)	(0.306)	(0.538)	(0.284)	(0.739)	(0.591)
Observations	73	73	73	73	73	73
Pseudo R^2	0.1973	0.2247	0.2068	0.2370	0.1536	0.1681

Notes: 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 diminshing sensitivity is not taken into account. In the logit regressions with naïve expectations, the sample mean is used as the 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.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

REFERENCES

Abeler, Johannes, Armin Falk, Lorenz Götte, and David Huffman. 2011. "Reference Points and Effort Provision." *American Economic Review* 101 (2): 470–92.

Bell, David E. 1985. "Disappointment in Decision Making under Uncertainty." *Operations Research* 33 (1): 1–27.

Camerer, Colin, Linda Babcock, George Loewenstein, and Richard Thaler. 1997. "Labor Supply of New York City Cabdrivers: One Day at a Time." *Quarterly Journal of Economics* 112 (2): 407–41.

Card, David, and Gordon B. Dahl. 2011. "Family Violence and Football: The Effect of Unexpected Emotional Cues on Violent Behavior." *Quarterly Journal of Economics* 126 (1): 103–43.

Choi, Syngjoo, Raymond Fisman, Douglas Gale, and Shachar Kariv. 2007. "Consistency and Heterogeneity of Individual Behavior under Uncertainty." *American Economic Review* 97 (5): 1921–38.

Crawford, Vincent P., and Juanjuan Meng. 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.

Ericson, Keith M., and Andreas Fuster. 2011. "Expectations as Endowments: Evidence on Reference-Dependent Preferences from Exchange and Valuation Experiments." *Quarterly Journal of Economics* 126 (4): 1879–1907.

de Meza, David, and David C. Webb. 2007. "Incentive Design under Loss Aversion." *Journal of the European Economic Association* 5 (1): 66–92.

Farber, Henry S. 2005. "Is Tomorrow Another Day? The Labor Supply of New York City Cabdrivers." *Journal of Political Economy* 113 (1): 46–82.

Farber, Henry S. 2008. "Reference-Dependent Preferences and Labor Supply: The Case of New York City Taxi Drivers." *American Economic Review* 98 (3): 1069–82.

Fehr, Ernst, and Lorenz Götte. 2007. "Do Workers Work More if Wages Are High? Evidence from a Randomized Field Experiment." *American Economic Review* 97 (1): 298–317.

Gächter, Simon, Eric J. Johnson, and Andreas Herrmann. 2007. "Individual-Level Loss Aversion in Riskless and Risky Choices." http://www.nottingham.ac.uk/cedex/documents/papers/2010-20.pdf.

Gill, David, and Victoria Prowse. 2012. "A Structural Analysis of Disappointment Aversion in a Real Effort Competition." *American Economic Review* 102 (1): 469–503.

Gul, Faruk. 1991. "A Theory of Disappointment Aversion." *Econometrica* 95 (3): 667–86.

Hardie, Bruce G. S., Eric J. Johnson, and Peter S. Fader. 1993. "Modeling Loss Aversion and Reference Dependence Effects on Brand Choice." *Marketing Science* 12 (4): 378–94.

Heidhues, Paul, and Botond Kőszegi. 2008. "Competition and Price Variation when Consumers are Loss Averse." *American Economic Review* 98 (4): 1245–68.

Herweg, Fabian, and Konrad Mierendorff. 2013. "Uncertain Demand, Consumer Loss Aversion, and Flat-Rate Tariffs." *Journal of the European Economic Association* 11 (2): 399–432.

Kalyanaram, G., and R. S. Winer. 1995. "Empirical Generalizations from Reference Price Research." *Marketing Science* 14 (3): 161–69.

Karle, Heiko, Georg Kirchsteiger, and Martin Peitz. 2013. "Loss Aversion and Consumption Choice: Theory and Experimental Evidence." Center for Economic and Policy Research (CEPR) Discussion Paper 9183.

Karle, Heiko, Georg Kirchsteiger, and Martin Peitz. 2015. "Loss Aversion and Consumption Choice: Theory and Experimental Evidence: Dataset." *American Economic Journal: Microeconomics* 7 (2). http://dx.doi.org/10.1257/mic.20130104.

Karle, Heiko, and Martin Peitz. 2014. "Competition under Consumer Loss Aversion." *RAND Journal of Economics* 45 (1): 1–31.

Köbberling, Veronika, and Peter P. Wakker. 2005. "An Index of Loss Aversion." *Journal of Economic Theory* 122 (1): 119–31.

Kőszegi, Botond, and Matthew Rabin. 2006. "A Model of Reference-Dependent Preferences." *Quarterly Journal of Economics* 121 (4): 1133–65.

Kőszegi, Botond, and Matthew Rabin. 2007. "Reference-Dependent Risk Attitudes." *American Economic Review* 97 (4): 1047–73.

Kőszegi, Botond, and Matthew Rabin. 2009. "Reference-Dependent Consumption Plans." *American Economic Review* 99 (3): 909–36.

Loomes, Graham, and Robert Sugden. 1986. "Disappointment and Dynamic Consistency in Choice under Uncertainty." *Review of Economic Studies* 53 (2): 271–82.

Loomes, Graham, and Robert Sugden. 1987. "Testing for Regret and Disappointment in Choice under Uncertainty." *Economic Journal* 97: 118–29.

Mazumdar, Tridib, S. P. Raj, and Indrajit Sinha. 2005. "Reference Price Research: Review and Propositions." *Journal of Marketing* 69 (4): 84–102.

Pope, Devin G., and Maurice E. Schweitzer. 2011. "Is Tiger Woods Loss Averse? Persistent Bias in the Face of Experience, Competition, and High Stakes." *American Economic Review* 101 (1): 129–57.

Post, Thierry, Martijn J. van den Assem, Guido Baltussen, and Richard 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, Matthew. 2000. "Risk Aversion and Expected-Utility Theory: A Calibration Theorem." *Econometrica* 68 (5): 1281–92.

Rajendran, K. N., and Gerard J. Tellis. 1994. "Contextual and Temporal Components of Reference Price." *Journal of Marketing* 58 (1): 22–34.

Spiegler, Ran. 2012. "Monopoly Pricing when Consumers are Antagonized by Unexpected Price Increases: A 'Cover Version' of the Heidhues-Kőszegi-Rabin Model." *Economic Theory* 51 (3): 695–711.

Tversky, Amos, and Daniel Kahneman. 1992. "Advances in Prospect Theory: Cumulative Representation of Uncertainty." *Journal of Risk and Uncertainty* 5 (4): 297–323.

Zhou, Jidong. 2011. "Reference Dependence and Market Competition." *Journal of Economics and Management Strategy* 20 (4): 1073–97.