The Influence of Regret on Decision Making: Theory and Experiment

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Introduction

Most people experience regret when realizing that an alternative decision would have been the better one, retrospectively. They do not only care about what they actually get but also what they might have gotten had they chosen differently. So their utility is anything but independent from results of other previously possible decisions. Furthermore, people are able to anticipate regret (Zeelenberg, M., 1999). Therefore, regret is not only an emotion felt ex post, but is also able to influence decisions ex ante. The necessity to compare the present situation to a hypothetical situation makes regret a more complex emotion than the basic emotions like anger, fear or happiness. As a consequence, regret is developed relatively late in childhood namely at an age of approximately five to seven years (Guttentag, R. E. and J. M. Ferrell, 2004). In addition, regret is often influenced by culture and morality (Zeelenberg, M. and R. Pieters, 2007). Expected utility theory (EUT) ignores that decision makers usually compare what they could have gotten had they chosen differently to what they get. The standard model

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proposes that only the actually received outcome matters, and people will choose the alternative with the highest utility in expectation. However, several violations to EUT like the paradox of Allais, M. (1953) were observed in empirical studies casting doubt on the underlying assumptions. As a consequence, more descriptive theories like prospect theory (Kahneman, D. and A. Tversky, 1979; Tversky, A. and D. Kahneman, 1992) or regret theory (Loomes, G. and R. Sugden, 1982; Bell, D. E., 1982) were developed, able to explain a lot of the observed phenomena.

Regret theory takes into account that the well-being of a person is not independent of the results of decisions which were also possible. If another decision would have been better ex post people regret, otherwise they rejoice. So regret is a negative emotion whereby large intensities of regret are weighted disproportionally heavier than small ones (Zeelenberg, M. and R. Pieters, 2007). Decision makers try to avoid regret, especially large amounts. Hence, they are regret averse. The here discussed version of regret theory (Loomes, G. and R. Sugden, 1982) is based on two functions only - a common utility function and a regret function capturing the impact of regret. To answer the question whether this concept is in accordance with empirical evidence, an experiment was conducted in this work based on the parameter free approach of Bleichrodt, H., A. Cillo and E. Diecidue (2010). The measurement approach is parameter free in the sense that no assumptions on neither the utility nor the regret function are necessary. Furthermore, heterogeneity of preferences is considered, and so the method can be performed on an individual level.

Theory and Examples

Regret theory suggests that the utility of a decision maker depends on both, what he actually receives and what he could have received had he chosen in a different way. The outcome of the unchosen alternative now serves as a reference point to which the result of the chosen alternative is relatively evaluated. The following notation refers to Loomes, G. and R. Sugden (1982) and Loomes, G. and R. Sugden (1987). Let $A = \{A_1, ..., A_m\}$ be a set of possible actions which can be chosen. If the outcome of the selected action, say A_i, is smaller than the outcome of at least one unchosen action, say A_k, one regrets. Therefore, regret theory adjusts EUT regarding the influence of regret by proposing a two-dimensional, skew-symmetric and real-valued utility function $\Psi(x_{ij}, x_{kj})$. x_{ij} denotes the outcome of action A_i in state S_j whereby state $S_j \in \{S_1, ..., S_n\}$ occurs with probability p_j. Similarly, x_{kj} denotes the outcome of action A_k in state S_j. One regrets his decision for A_i if $x_{kj} > x_{ij}$ because he could have chosen A_k instead. Thus, $\Psi(\cdot, \cdot)$ should be decreasing in the second and increasing in the first argument. Since no regret can occur if both possible actions yield the same outcomes, $\Psi(\xi, \xi) = 0$ should follow. As a result of skew-symmetry ($\Psi(\xi, \phi) = -\Psi(\phi, \xi)$), an action A_i is preferred to A_k if the expected adjusted utility of choosing A_i and simultaneously rejecting A_k is positive:

$$A_i \succ A_k \Leftrightarrow \sum_{j=1}^{n} p_j \Psi(x_{ij}, x_{kj}) > 0$$

To make the estimation easier, a restricted form of $\Psi(\cdot, \cdot)$ was used with $\Psi(x_{ij}, x_{kj})$ $= Q(u(x_{ij}) - u(x_{kj}))$ where $Q(\cdot)$ is a strictly increasing function with the property of symmetry: $Q(-\xi) = -Q(\xi)$. $u(\cdot)$ denotes a concave Bernoulli utility function. Therefore, the intensity of regret only depends on the utility difference between chosen and rejected action. As mentioned earlier, most people are regret averse; they want to avoid large regrets in particular (Zeelenberg, M., 1999). This characteristic can be considered if $Q(\xi)$ is convex for all $\xi > 0$. If this holds, large differences between $u(x_{ij})$ and $u(x_{kj})$ are weighted heavier than small ones. It follows that large amounts of regret decrease the expected adjusted utility disproportionally more than small amounts due to $Q(-\xi) = -Q(\xi)$.

A vivid example when regret has influence on decisions is the reluctance to exchange lottery tickets observed by van de Ven, N. and M. Zeelenberg (2011). In their experiment participants were endowed with lottery tickets all of them having an equal chance to win a voucher. One group obtained the tickets in sealed envelopes not knowing their ticket number whereas participants of another group knew their ticket numbers. The subjects were then asked to exchange their tickets with a member of their group. As an incentive they received a pen when exchanging. Now it appeared that significantly more participants from the sealed envelope group were willing to exchange their ticket. If one assumes that the pen exceeds the transaction costs of the exchange, this behavior is not explainable by EUT. Every participant should be willing to trade. If regret about their decisions is considered, such a behavior is understandable, though. Subjects knowing their number are able to anticipate possible regret in case they had exchanged and their former ticket number is drawn. As a consequence to regret aversion, they are reluctant to exchange. In contrast, the attendants of the control group will never gain information about their former number after having exchanged. They will not be able to regret their decisions, and so they are consistently more willing to trade their tickets.

A further example is the experimentally observed tendency of bidders in first-price sealed-bid auctions to bid more than predicted by theory (Cox, J. C., V. L. Smith and J. M. Walker, 1988). In a first-price auction the subject with the highest bid wins and has to pay his own bid. The other bidders pay nothing. To gain profit, bidders have to provide bids lying under their true valuations for the auctioned good. Solving the implied game an unambiguous Bayesian-Nash-Equilibrium is found. Nevertheless, empirical evidence shows that offered bids often lie above the predicted ones if it is common knowledge that the winning bid will be revealed afterwards. If so, a bidder may regret his decision having offered a bid lying way under his valuation in case the winning bid was only slightly higher than his own (Filiz-Ozbay, E. and E. Y. Ozbay, 2007). If he had only bidden little more, he would have won while still making profit. The possible regret can be anticipated if it is known that the winning bid will be common knowledge afterwards. Consistently, observed bids in first-price auctions, with ex post information about the winning bid, lie slightly above the predicted ones.

Experimental Design

The problem in quantitatively measuring regret theory is the composition of regret and utility function. A first feasible method was developed by Bleichrodt, H., A. Cillo and E. Diecidue (2010). The following refers to their work. The foundation of their parameter free approach is the so called trade-off method originally proposed by Wakker, P. P. and D. Deneffe (1996) to measure the value function of cumulative prospect theory (Tversky, A. and D. Kahneman, 1992). In a first step this method is applied to elicit a standard sequence of outcomes $x_0, ..., x_k$ to infer a participant's utility function u. The second step consists of constructing a second sequence $z_1, ..., z_l$ to measure the regret function Q. Consistency with regret theory would imply that the obtained utility functions are concave whereas the elicited regret functions are convex.

To determine the standard sequence of outcomes, the participants were asked which amount of money x_i would lead to indifference between the two binary actions $A_{i-1} = x_{i-1_p} G_{1-p}$ and $B_i = x_{i_p} g_{1-p}$ for $i = 1, ..., k$. The elicitation of x_i was accomplished by an iterative algorithm. x_{i-1}, obtained with probability p, denotes the outcome determined in the previous stage. Therefore, the elicitation of each x_i depends on the prior determination of x_{i-1} resulting in a chained structure of the standard sequence. G and g denote two gauge outcomes obtained with probability $1-p$ each. They can be arbitrarily chosen as long as $x_0 > G > g \geq 0$ holds to ensure that the sequence increases. x_0 denotes the starting value of the sequence. It can be assumed that a participant will choose $x_i > x_{i-1}$ due to $g < G$. Expressed by regret theory the indifference between A_{i-1} and B_i and between A_i and B_{i+1} yields:

$$B_i \sim A_{i-1} \Leftrightarrow pQ(u(x_i) - u(x_{i-1})) + (1-p)Q(u(g) - u(G)) = 0$$

$$B_{i+1} \sim A_i \Leftrightarrow pQ(u(x_{i+1}) - u(x_i)) + (1-p)Q(u(g) - u(G)) = 0$$

Since the regret function is assumed to be strictly increasing, Q is invertible. Thus, the two foregoing equations put together result in:

$$u(x_{i+1}) - u(x_i) = u(x_i) - u(x_{i-1}), i = 1, ..., k-1$$

By setting $u(x_0) = 0$ and $u(x_k) = 1$, it follows: $u(x_{i+1}) - u(x_i) = 1/k$. Therefore, the points $(x_0, 0), ..., (x_j, \frac{j}{k}), ..., (x_k, 1)$ can be obtained. In the conducted experiment the gauge outcomes $G = 16, g = 11$, the starting value $x_0 = 20$ and the probabilities $p = 1/3, 1-p = 2/3$ were used. Overall, six points were elicited, hence $k = 5$. The experiment was programmed and conducted with 'z-Tree' (Fischbacher 2007). To determine x_1, the participants were iteratively asked which outcome would make them indifferent between $A = 20_{1/3}16_{2/3}$ and $B = {x_1}_{1/3}11_{2/3}$ beginning with $x_1 = 45$ and then slightly modifying x_1 to find the true value. Therefore, the subjects always just had to choose a lottery A or B instead of directly indicating the sought value because a direct method might result in massive response errors due to the large cognitive demands. A screenshot of the first elicitation part can be found in Figure 1. Overall, 27 subjects, mainly economics undergraduates, participated. Two of them were randomly chosen playing for real money in two of their choices to motivate truthful answers. One experimental unit was worth 0.10 euros resulting in an average payment of 13.20 euros. The subjects knew that the outcomes of the unchosen alternatives would be revealed afterwards. Therefore, they were able to anticipate regret.

In the second step the elicited standard sequence of outcomes was used to determine a further sequence $z_1, ..., z_l$. In contrast to the first step, now the probabilities were altered for each outcome. Firstly, the subjects were asked which outcome z_1 would make them indifferent between $A_1 = x_{4_{p_1}} x_{0_{1-p_1}}$ and $B_{z_1} = x_{3_{p_1}} z_{1_{1-p_1}}$ with x_4, x_0, x_3 as outcomes belonging to the standard sequence and $p_1 = 1/4, 1 - p_1 = 3/4$ denoting the corresponding probabilities. The elicitation of z_1 was done by an iterative algorithm, so the subjects only had to choose one out of two lotteries again. Generally the subjects were asked for outcomes z_j making them indifferent between $A_j = x_{4_{p_j}} x_{0_{1-p_j}}$ and $B_{z_j} = x_{3_{p_j}} z_{j_{1-p_j}}$. Expressing this indifference via regret theory gives:

$$p_j Q(u(x_4) - u(x_3)) + (1 - p_j) Q(u(x_0) - u(z_j)) = 0, j = 1, ..., l$$

Scaling the regret function via $Q(u(x_4) - u(x_3)) = Q(1/k) = 1$ and because of $u(x_0) = 0$ together with $Q(0) = 0$, this results in:

$$Q(u(z_j)) = \frac{p_j}{1 - p_j}, j = 1, ..., l$$

By using the probabilities $p_1 = 1/4, p_2 = 2/5, p_3 = 3/5, p_4 = 3/4$ the six points $(0, 0), (u(z_1), 1/3), (u(z_2), 2/3), (1/5, 1), (u(z_3), 3/2), (u(z_4), 3)$ were obtained. Since only the outcomes $z_1, ..., z_4$ were determined in the procedure, the corresponding utilities had to be inferred to elicit the function $Q(\cdot)$ instead of eliciting the composition function $Q(u(\cdot))$. This was done by linear interpolation using the previously estimated utility functions.

Results

The obtained utility functions u of the first five subjects and the utility function based on the mean data can be found in Figure 2. On the horizontal axis the estimated outcomes are located. The vertical axis shows the corresponding utilities. The slightly dotted line is drawn for comparison to the case of a linear utility function. Consistency with regret theory would imply concave functions. To test for concavity, two classifications were used which were also applied by Bleichrodt, H., A. Cillo and E. Diecidue (2010) – a parametrical and a non-parametrical one. In the parametrical classification non-linear regressions were conducted for every participant estimating the coefficients α, β of the power function $y = \alpha(x - 20)^{\beta}$ by non-linear least squares. Afterwards, it was tested whether β was significantly smaller (larger) than 1 corresponding to a concave (convex) function. Overall, 17 concave and 3 convex functions were found. Thus, a one-tailed binomial test showed that there were significantly more concave than convex utility functions ($p = 0.001$). The estimated power coefficient based on the mean data was $\hat{\beta} = 0.832$ ($SE = 0.025$). Therefore, the function based on the mean was classified concave as well (see Figure 3). The non-parametrical classifications were more technical. For each function twenty differences $\Delta_{gh,lm} = (x_g - x_h) - (x_l - x_m),\ g > h,\ g > l,\ g - h = l - m$ for all outcomes x_i with $g,\ h,\ l,\ m \in \{0, ..., 5\}$ were calculated. Since $u(x_g) - u(x_h) = u(x_l) - u(x_m)$ holds if $g - h = l - m$, it follows that the corresponding part is concave if $\Delta_{gh,lm}$ is positive. If $\Delta_{gh,lm}$ is negative, however, this corresponds to a convex part. Larger getting distances between the determined outcomes imply concavity because the difference between two contiguous utilities is always the same: $1/k$. A function was already classified concave if only 50% of the calculated values were positive due to response errors. By this method, 23 concave and 3 convex functions were found. Again, significant evidence for concavity showed up ($p = 0.000$, one-tailed binomial test). The utility function based on the mean was equally classified concave.

Figure 4 shows the elicited regret functions Q of the first five participants and the one based on the mean data. On the horizontal axis the utility difference between chosen and unchosen action can be found. On the vertical axis the value of Q is shown. The dotted line is drawn for comparison representing a linear function. If the subjects behaved according to regret theory, the estimated regret functions should be convex because large differences between chosen and unchosen actions carry disproportionally more weight than small ones. Again a parametrical and a non-parametrical classification were used. For the first one the coefficients α, β of the power function $y = \alpha x^{\beta}$ were calculated. Afterwards, it was tested whether β was significantly greater (smaller) than 1 corresponding to a convex (concave) shape of the regret function. As can already be supposed by Figure 4, the estimation of Q revealed more noise than the elicitation of u probably due to the more complex lotteries faced in the second part. Thus, the standard errors were generally greater. Only 10 functions exhibited a significant convex and 2 functions a significant concave shape. For the regret function based on the mean data a power coefficient $\hat{\beta} = 1.376$ ($SE = 0.187$) was computed being only weakly significant greater than 1 (see Figure 5). However, the non-parametrical method revealed more evidence for convexity. For each subject twenty values $\nabla_{gh,lm} = (Q(g/5) - Q(h/5)) - (Q(l/5) - Q(m/5)),\ g > h,\ g > l,\ g - h = l - m,\ g,\ h,\ l,\ m \in \{0, ..., 5\}$ were calculated whereby positive values now corresponded to convex parts. A regret function was said to be convex if only 50% of the differences were positive. Hereby 22 convex and 3 concave functions were found. Therefore, the proportion of convex to concave shapes was highly significant in support of convex functions ($p = 0.000$, one-tailed binomial test). Likewise, the regret function based on the mean data was classified convex.

Thus, despite more noise in the estimation of the regret functions, evidence for regret aversion was found.

Summarizing, the results of Bleichrodt, H., A. Cillo and E. Diecidue (2010) as well as the results presented in this work showed that most subjects take the feeling of regret into account when making a decision. They compare retrospectively what they could have gotten to what they actually get, but they are also able to anticipate regret ex ante. Regret occurs if an alternative decision would have been the better one whereas subjects are disproportionally averse to large regrets. The data revealed evidence for this because mainly convex regret functions were found corresponding to regret aversion. Furthermore, evidence for concave utility functions showed up. So overall the assumptions of regret theory could be experimentally verified.

References

Allais, M. (1953): "Le comportement de l'homme rationel devant le risque, critique des postulates et axiomes de l'ecole americaine," *Econometrica*, 21, 503–546.

Bell, D. E. (1982): "Regret in Decision Making Under Uncertainty," *Operations Research*, 30, 961–981.

Bleichrodt, H., A. Cillo and E. Diecidue (2010): "A Quantitative Measurement of Regret Theory," *Management Science*, 56, 161–175.

Cox, J. C., V. L. Smith and J. M. Walker (1988): "Theory and Individual Behavior of First-Price Auctions," *Journal of Risk and Uncertainty*, 1, 61–99.

Filiz-Ozbay, E. and E. Y. Ozbay (2007): "Auctions with Anticipated Regret: Theory and Experiment," *American Economic Review*, 97, 1407–1418.

Fischbacher, U. (2007): "z-Tree: Zurich Toolbox for Ready-made Economic Experiments," *Experimental Economics*, 10, 171–178.

Guttentag, R. E. and J. M. Ferrell (2004): "Reality Compared With Its Alternatives: Age Differences in Judgments of Regret and Relief," *Developmental Psychology*, 40, 764–775.

Kahneman, D. and A. Tversky (1979): "Prospect Theory: An Analysis of Decision Under Risk," *Econometrica*, 47, 263–291.

Loomes, G. and R. Sugden (1982): "Regret Theory: An Alternative Theory of Rational Choice Under Uncertainty," *The Economic Journal*, 92, 805–824.

——— (1987): "Some Implications of a More General Form of Regret Theory," *Journal of Economic Theory*, 41, 270–287.

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

van de Ven, N. and M. Zeelenberg (2011): "Regret Aversion and the Reluctance to Exchange Lottery Tickets," *Journal of Economic Psychology*, 32, 194–200.

Wakker, P. P. and D. Deneffe (1996): "Eliciting von Neumann-Morgenstern Utilities when Probabilities are Distorted or Unknown," *Management Science*, 42, 1131–1150.

Zeelenberg, M. (1999): "Anticipated Regret, Expected Feedback and Behavioral Decision Making," *Journal of Behavioral Decision Making*, 12, 93–106.

Zeelenberg, M. and R. Pieters (2007): "A Theory of Regret Regulation 1.0," *Journal of Consumer Psychology*, 17, 3–18.

Appendix

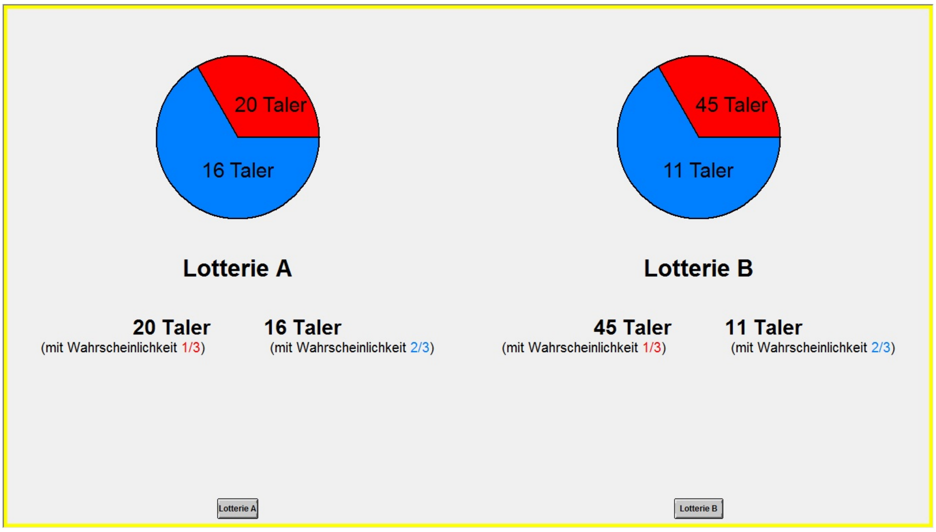

Figure 1: Example of a screen faced in the first part

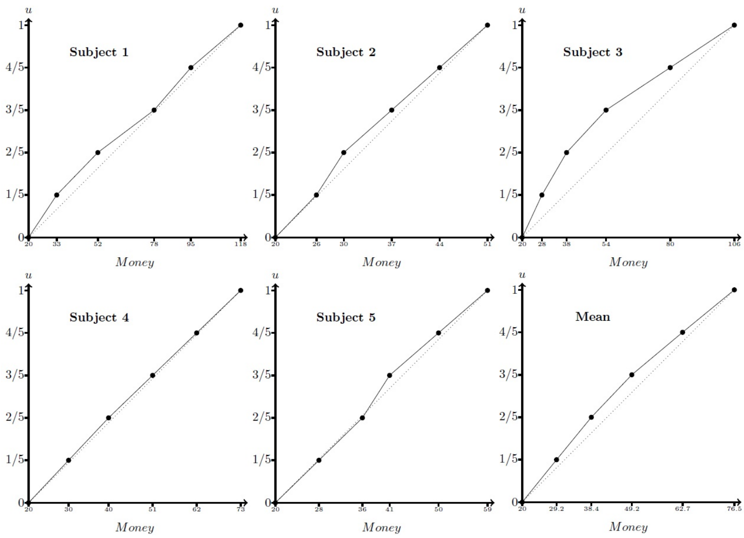

Figure 2: Utility functions of the first five subjects and based on the mean data

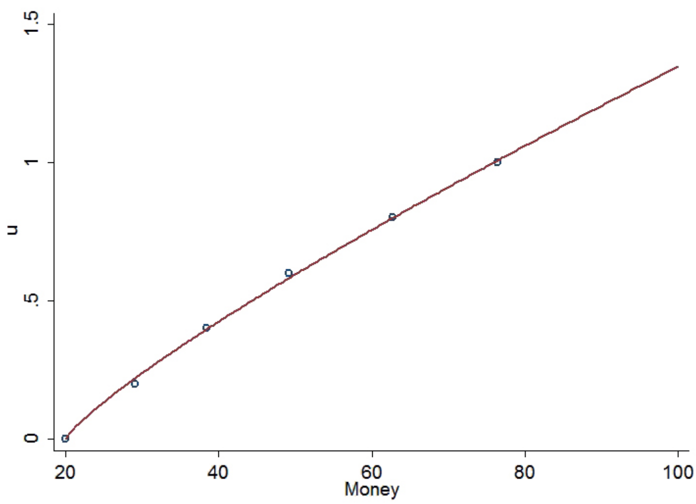

Figure 3: Non-linear regression of the utility function based on the mean data

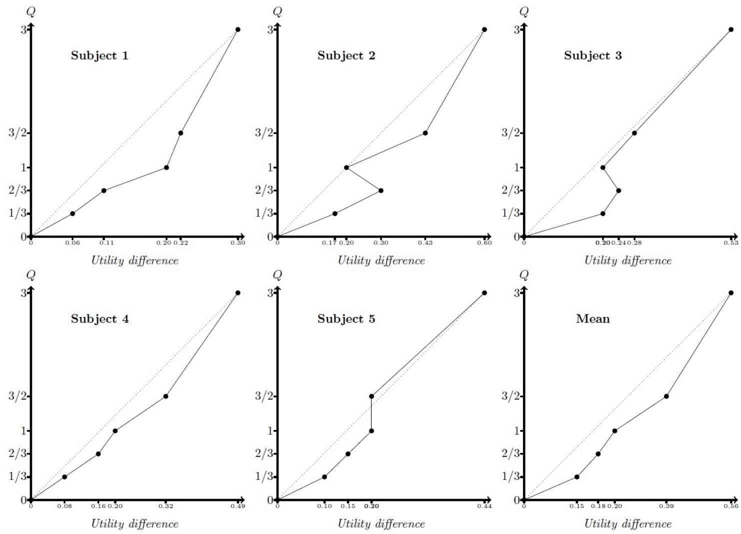

Figure 4: Regret functions of the first five subjects and based on the mean data

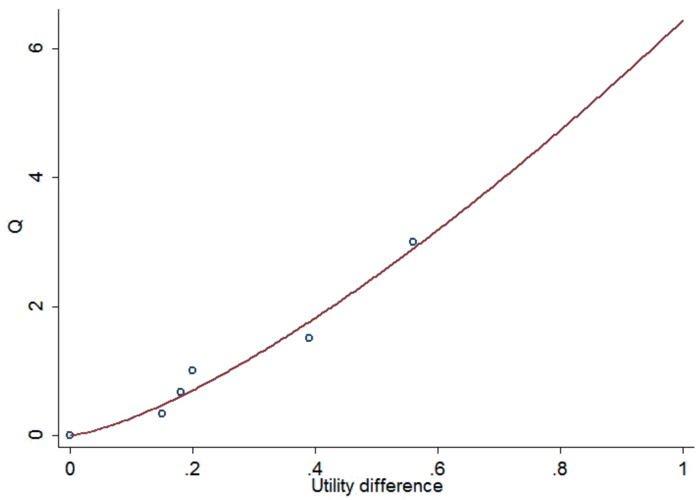

Figure 5: Non-linear regression of the regret function based on the mean data