Inflation Expectations and Behavior: Do Survey Respondents Act on their Beliefs?

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ABSTRACT

Inflation expectations surveys of individual consumers have become a key component of monetary policy. There is little evidence, however, i) that individual consumers act on their beliefs about future inflation, and ii) that the inflation expectations elicited with these surveys are informative about the respondents' beliefs. To address these two issues, we compare the inflation expectations reported by consumers in a survey with their behavior in a financially incentivized investment experiment in which inflation affects final payoffs. We find that, on average, the decisions of survey respondents are consistent, under risk neutrality, with theirs stated inflation beliefs. There is, however, substantial heterogeneity in behavior, and some of the subjects' decisions appear to be better explained by optimization errors than by risk attitude.

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1. Introduction

Inflation expectations are at the center of modern macro-economic models and monetary policy (Woodford 2005, Gali 2008, Sims 2009). If agents are forward looking, then beliefs about future inflation should influence present behavior and thereby impact realized inflation. Considerable attention has therefore been recently devoted to understand and measure inflation expectations. In particular, several central banks around the world are now conducting inflation expectations surveys of individual consumers.[1] These surveys, however, are only relevant to the extent that individual consumers indeed act on their inflation beliefs. In addition, one may question how informative the beliefs elicited through these surveys are, as no incentives are provided for truthful responses. In this paper, we attempt to shed light on these two issues by comparing the responses of individual consumers to an inflation expectations survey with their behavior in a financially incentivized investment experiment.

Many economic decisions are affected by future inflation. In particular, households should take into consideration future inflation when deciding on (e.g.) the timing of large purchases, wage demands, mortgage (re)financing, debt management, borrowing, saving and other financial decisions. Expectations about inflation should therefore have an effect on the real economy and in particular, on current prices. This transmission effect is now well recognized both in academia and in central banking circles (Bernanke 2004, 2007). It is therefore generally agreed that one of the first step to controlling inflation consists in

[1] Central banks that survey consumers about their inflation expectations include the Bank of England, the European Central Bank, the Bank of Australia, the Bank of Japan, the Sveriges Riksbank, and the Federal Reserve Bank of Cleveland.

actively managing the public's beliefs about future inflation.[2] The implementation of such a policy requires in particular accurate measurements of inflation expectations in order to calibrate monetary policy, but also to assess the central bank credibility and effectiveness of communications.

The measures of inflation expectations may be partitioned into two broad categories depending on whether they are direct or indirect. Direct measures are obtained from surveys in which consumers, businesses or professional forecasters are asked to self report their subjective beliefs about future inflation. In the U.S., such surveys include the monthly University of Michigan Survey of Consumers, the Livingston Survey, and the Survey of Professional Forecasters. Indirect measures are inferred from either financial instruments (such as TIPS, the Treasury Inflation-Protected Security), the term structure of interest rates, or past realizations of inflations rates. Both the direct and indirect approaches have potential weaknesses. While market based estimates often rely on strong modeling assumptions, survey measures may suffer from a lack of representativeness due to small samples.

Surveys aimed at eliciting expectations are also commonly criticized because of the absence of explicit incentives for truthful responses.[3] Indeed, because of the possibility for cheap talk, some economists are suspicious of non-incentivized belief elicitation techniques. In experimental economics for instance, subjects are almost systematically rewarded according to the accuracy of their stated beliefs (e.g. through a proper scoring

[2] In particular, Ben Bernanke (2004) argued that "an essential prerequisite to controlling inflation is controlling inflation expectations."
[3] See e.g. Keane and Runkle (1990), Manski (2004, 2006), or Pesaran and Weale (2006).

rule) in order to promote truthful and thoughtful predictions.[4] Economists have also played a central role in developing incentivized "information markets" which have been shown to have strong predictive power.[5] Despite a relatively large literature on the topic, the various accuracy comparisons of households' inflation surveys, forecasters' predictions and market based estimates have been mostly inconclusive.[6] So the question remains: how informative are the survey responses of individual consumers about their true inflation beliefs?

Furthermore, although several papers have recently studied how individuals form and update their inflation beliefs,[7] the correspondence between inflation expectations and individual consumers' behavior is still not well understood. One can argue convincingly that, in part because of the high stakes involved, professional investors, firms and other large economic actors do take future inflation into consideration when making decisions. At a more micro-economic level, however, it is unclear how agents' behavior is affected by their beliefs about future inflation.[8] In particular, several lab experiments suggest that, in contrast with standard economic theory, subjects do not necessarily best-respond to their stated beliefs (e.g. Costa-Gomez and Weizsaker 2008).[9] In addition, because of the

[4] Wagner (2009) identifies more than 40 economic experiments using incentivized beliefs elicitation techniques. Manski (2004) also discusses the possibility of using scoring rules to elicit expectations in surveys.

[5] See Hahn and Tetlock (2005), Manski (2006) or Ledyard (2006). Such information markets include the Iowa Electronic Markets, Betfair, Intrade, TradeSports, the Hollywood Stock Exchange, or NewsFutures.

[6] For recent contributions see Lloyd (1999), Carroll (2003), Ang, Bekaert and Wei (2005), or Nunes (2010). In a more general context, Manski (2004) concludes that the beliefs elicited in non incentivized surveys appear to be informative. Note also that we take no position as to whether or not the beliefs elicited from consumers' surveys should be considered objective, as in a rational expectation model, or subjective.

[7] Bryan and Venkatu, (2001a,b), Souleles (2004), Döhring. and Mordonu (2007), Bruine de Bruin et al. (2010).

[8] For instance, it often seems that wage negotiations are primarily driven by recent past inflation, rather than by what workers expect future inflation to be.

[9] Armantier and Treich (2010) argue that these failures could be explained by stakes and hedging effects.

delay between the decision and the realization of the random event, it is not clear whether future inflation prospects are sufficiently salient to influence the present behavior of a consumer in any meaningful way. If inflation is shown to be irrelevant for behavior, then consumers would have no incentives to acquire, process and store information about future inflation, and their predictions should therefore be considered essentially uninformative.

In this paper, we compare self reported beliefs in an inflation expectations survey with the behavior of the respondents in a financially incentivized investment experiment. The objective is twofold: First, we want to investigate how agents behave when faced with an investment decisions whose payoffs depend on future inflation. Second, we want to explore the extent to which the beliefs the respondents express in the inflation expectations survey are informative about the decisions they make in the experiment.

The results reveal that stated beliefs and experimental behavior are on average consistent under the assumption of risk neutrality. There is, however, a substantial amount of heterogeneity across subjects. In particular, 41% of the subjects behaved as if risk averse, while 28% of the subjects behaved as if risk loving. Further analysis suggests that the behavior of these subjects cannot be fully explained by risk attitude, and that choices may have also been driven by optimization errors.

2. The Survey and the Subjects

The survey is part of an ongoing effort by the Federal Reserve Bank of New York, with support from the Federal Reserve Bank of Cleveland and other research institutions, to better understand how the public forms and updates beliefs about future inflation, and to develop better tools to measure consumers' inflation expectations. The object of the survey discussed in this paper was twofold: To study how individual consumers revise their inflation expectations after being exposed to new information, and to investigate the link between behavior and self reported beliefs.

The survey and the experiment were conducted over the internet with RAND's American Life Panel. The respondents were randomly selected among participants in the Michigan Survey of Consumers at the University of Michigan's Survey Research Center conducted in the year 2007. A Total of 745 respondents accepted our invitation to complete the survey. The survey was fielded between July 20, 2010 and August 17, 2010, with 87% completed before August 1st. Fifty percent of the respondents completed the survey within 25 minutes, while the average completion time was 41 minutes. Respondents reported an average age of 52.8, with a median of 53. In total, 57% were female, 57.5% were married or living with a partner, 50% had at least a bachelor's degree, and 90% were white. The median reported income range was $60-$75K, with 42% of the respondents reporting incomes over $75k.

Respondents received $20 for answering the entire internet survey. As explained in the next section, the respondents were also illegible to earn extra money if they

answered all the questions in the experiment. Although respondents were allowed to skip questions, those who tried to do so received a prompt encouraging them to provide an answer.

The survey consisted of 6 stages. In the 1st stage the respondent beliefs about future prices or future inflation was elicited. Stage 2 was aimed at understanding what the respondents thought about when answering the questions in stage 1 and where the respondents acquired information about inflation. The experiment, which is described in the next section, was conducted in stage 3. In stage 4, respondents were asked about any past actions they may have taken or future actions they intend to take that may be influenced by their beliefs about future inflation. In stage 5, information about past of future prices was first provided to the respondents, after which their beliefs about future inflation were once again elicited as in stage 1. Finally, stage 6 consisted of a series of questions aimed at measuring the respondents' numeracy, financial literacy, and willingness to take risk.

The questions asked in the survey are provided as supplementary materials. For the purpose of the paper we will ignore responses in stages 2, 4 and 5. Therefore we only describe here the questions asked in stages 1 and 6, and the variables we constructed from these responses.

Stage 1: Two informational treatments were conducted in stage 1. In the first treatment, respondents were asked about their expectations for the "prices of the things I

usually spend money on." In the second treatment, respondents were asked about their expectations for the "rate of inflation." In the remainder, the first survey treatment will be referred to as the "Price" treatment, and the second as the "Inflation" treatment. Point predictions were elicited for two time horizons: between now and 12 months from now, and between 24 and 36 months from now. In addition to point estimates, the respondents were asked to report their probabilistic beliefs. More specifically, respondents had to states the percent chance that, over the next 12 months, prices/inflation would fall within the following intervals:]-12% or less], [-12%,-8%], [-8%,-4%],[-4%,-2%], [-2%,0%], [0%,2%], [2%,4%], [4%,8%], [8%,12%], [12% or more[. Respondents could verify that their answers added to 100% and, if it was not the case, they were prompted to go back and make the appropriate changes.

From each respondent stated probabilistic beliefs we generate two variables that will be used in the econometric analysis reported in Section 4. The first is an "Estimated Expectation" for the respondent's prices/inflation belief. This variable is a simple weighted average where the center of each closed range (e.g. 6% for the range [4%,8%]) and the bounds of the two extreme ranges (i.e. 12% and -12%) are multiplied by weights equal to the respondent's stated prediction for that range. Following a similar approach, we calculate an "Estimated Standard Deviation of the Predictions" as an estimated measure of how diffuse the beliefs of the respondent are about future prices/inflation.

Stage 6: Six questions were asked in stage 6 to measure the respondent numeracy and financial literacy. The numeracy questions were drawn from Peters et al. (2006), while

the questions about financial literacy were slightly adapted from Lusardi (2007). We created a variable taking integer values between 0 and 6 depending on the number of correct answers the respondent gave to these questions. Respondents were also asked to assess their willingness to take risk regarding financial matters using a scale from 1 (Not willing at all) to 7 (very willing). In the remainder, an answer of 4 will be interpreted as reflecting risk neutrality, while lower (respectively higher) answers will be interpreted as reflecting risk aversion (respectively risk loving). Finally, we collected demographic measures including the respondent reported race, highest level of education completed, age, gender, and total combined income across all family members over the past 12 months.

3. The Experiment

The experiment consists of 10 questions. For each question the subject is asked to choose between two investments, investment A and investment B. Each investment generates a specific payoff 12 months later. The subject payoff under investment A depends on the annual rate of inflation. The possible earnings as a function of inflation were presented to the subjects as in Table 1, where the “rate of inflation” was defined to the subjects as the official U.S. Consumer Price Index over the following 12 months rounded to the nearest percentage point.

TABLE 1

Earnings under investment A												
Rate of inflation	-1% or less (deflation)	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10% or more
Earnings	$600	$550	$500	$450	$400	$350	$300	$250	$200	$150	$100	$50

In each of the 10 questions, investment A remains the same. In contrast, as may be seen in Appendix A where we report the experimental instructions given to subjects, the earnings produced by investment B were fixed in each question (i.e. they did not vary with inflation), but they changed from one question to the next.

We conducted two treatments by changing the order in which investment B was presented to subjects. In the "Ascending Scale" treatment, the earnings of investment B increase in increments of $50 from $100 in question 1 to $550 in question 10. In the "Descending Scale" treatment the earnings of investment B decrease in increments of $50 from $550 in question 1 to $100 in question 10. To simplify the description of the experiment, we consider the "Ascending Scale" treatment for the remainder of this section.

Observe that, although presented in an abstract way to facilitate the subjects' comprehension, investment A and B each has an economic interpretation. Indeed, investment A corresponds to the following scenario: "an agent borrows $5,000 for 12 months at a rate equal to the inflation rate, and invests the $5,000 for 12 months in an account that earns a fixed annual rate of 11%." Investment B corresponds to the following scenario: "an agent borrows $5,000 for 12 months at a rate equal to the

inflation rate, and invests the $5,000 for 12 months in an inflation protected account that earns an annual rate equal to the inflation rate plus *k* %, where *k* varies in increments of 1% from 2% in question 1 to 11% in question 10. ”

In nominal terms, investment B earns $5,000*$k$, while investment A earns $5,000*(0.11-$i$), where i denotes the inflation rate over the next 12 months. If expressed in real terms, investment A earns $5,000*(0.11-$i$)/(1+$i$)=$5,000*[1.11/(1+i)-1], while investment B earns $5,000*$k$/(1+$i$). It is then easy to see that the variance of the earnings with respect to inflation is always lower with investment B whether one expresses earnings in nominal or in real terms. In other words, investment B should be considered less risky as it does not vary as much with inflation. All else equal, and in particular if the expected return of the two investments are the same, then a risk averse subject should strictly prefer investment B to investment A. Conversely, all else equal, a risk lover should strictly prefer investment A to investment B. For instance, consider a subject who believes that the inflation rate is 4%. In question 6 the two investments produce the same expected return of $350. If this subject is risk averse (respectively risk loving) then he should select the safer (respectively riskier) option in question 6, that is, he should select investment B (respectively investment A).

Observe that the structure of the experiment is akin to the experiment designed by Holt and Laury (2002) to measure risk attitudes. In their experiment, subjects are presented with a series of 10 questions asking them to choose between two lotteries A and B with unequal terminal payoffs. From one question to the next, the payoffs of the lotteries

remain the same, while the probability gradually shifts from the lower to the higher payoff. The number of questions after which a subject switches from one lottery to the other therefore provides an estimate of the subject's degree of risk aversion. Similarly, in our ascending scale treatment, an expected payoff maximizer with an inflation expectation within]0%,9%[should first select investment A for the first few questions and then switch to investment B for the remaining questions. Therefore, as in the Holt and Laury's experiment, a rational subject should switch investments at most once.

In the remainder, the variable of interest for a subject will be his or her "switching point." This switching point will only be defined for subjects whose behavior may be rationalized, that is for subjects who switch at most once from investment A to investment B in the ascending scale treatment and from investment B to investment A in the descending scale treatment. For these subjects, the switching point is set equal to 1 plus the number of questions for which the subject selected investment A. So, for both experimental treatments, the switching point is 1 if the subject always select investment B, and 11 if the subject always select investment A. Likewise, in the ascending scale treatment, the switching point is equal to 4 if the subject selects investment A for the first three questions, and then selects investment B for the remaining seven questions.

The subjects were informed that only two subjects would be paid according to their choices in the experiment. Once the survey was completed, we randomly picked one of the ten questions, and two survey participants who completed the experiment. Twelve months later, these two participants were paid according to the investment choice they

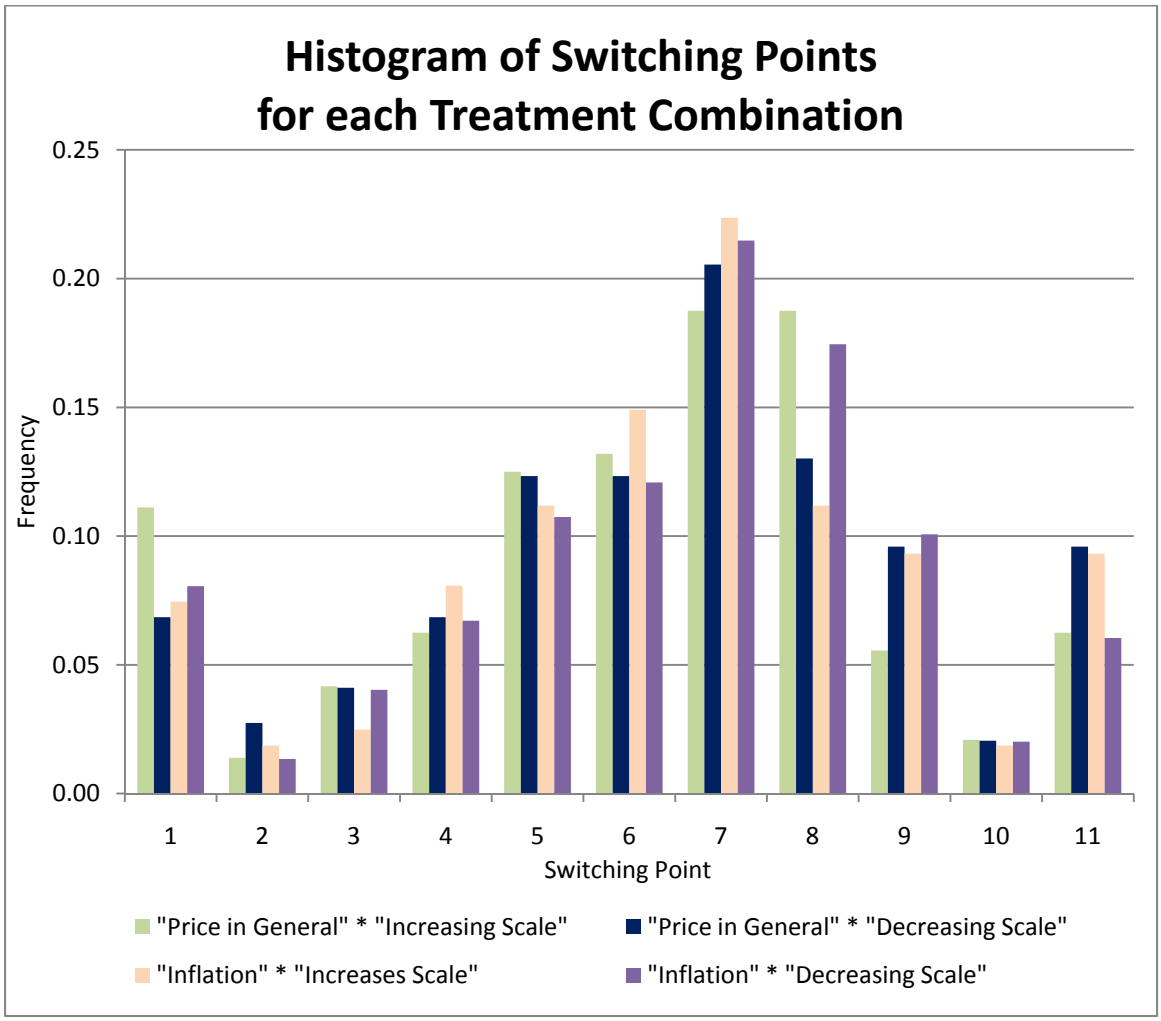
made for the selected question. Although the amounts a subject could earn were substantial compared to traditional lab experiments (i.e. up to $600), the random mechanism used to pay subjects created small expected incentives. In addition, since the exact number of participants was unknown at the time the experiment was conducted, the subjects were not able to calculate exactly their odds of being selected for payment. Paying randomly a subset of subjects has been adopted in several experimental studies (Armantier 2006, Wakker, Kobberling and Schwieren 2007, Bettinger and Slonim 2007), and in particular in large field experiments similar to the one conducted here (e.g. Harrison, Lau, and Williams 2002, Harrisson, Lau and Rustrom 2006).

4. Results

Out of the 745 respondents who completed the survey, we deleted 2 respondents with extreme point predictions (greater or equal to 75%), 28 respondents who did not provide a point prediction for the inflation/prices question, and 34 respondents who did not answer the 10 questions for the experiment. Out of the 681 remaining respondents, 601 (or 88.3%) provided answers to the questions in the experiment that may be rationalized. In other words, these subjects switched at most once from investment A to investment B during the course of the 10 questions. This ratio of rationalizable responses is consistent with those obtained in the literature on measuring risk attitude using the Holt and Laury's mechanism. In particular, Holt and Laury (2002) report that 25% of their subjects had non-rational answers, while this ratio was 15% in Eckel and Wilson (2004). Note also

that, perhaps not surprisingly, the respondents with multiple switching points score significantly lower on our scale of numeracy and financial literacy than the respondents with at most a single switching point (i.e. 3.67 versus 4.83).[10]

FIGURE 1



Our sample is segmented in four groups depending on which survey treatment (i.e. "Price" or "Inflation") and which experimental treatment (i.e. "Ascending Scale" or "Descending

[10] A more formal econometric analysis reveals that only the numeracy and financial literacy measure has significant power to explain why a respondent switches either multiple times or once from investment B to A.

Scale") they were assigned to. We can see in Figure 1 that the distribution of switching points does not seem to exhibit any specific pattern in each of the four treatment combination. This observation is confirmed by a series of non-parametric Mann-Whitney tests reported in Table 2 showing that the distributions of switching points do not differ significantly across treatment combination.

TABLE 2

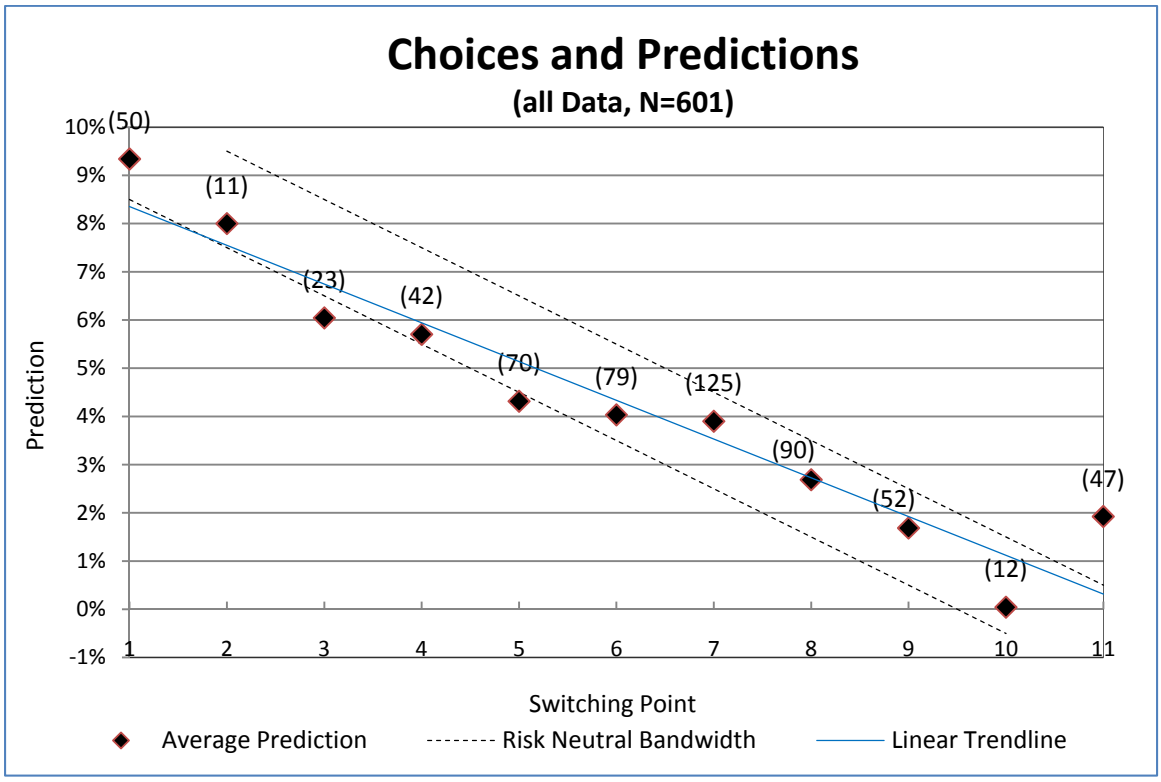
Comparison of Switching Points Distribution Across Treatment Combinations with Mann–Whitney Test			
	"Prices in General" * "Decreasing Scale"	"Prices in General" * "Decreasing Scale"	"Inflation" * "Increasing Scale"
"Prices in General" * "Decreasing Scale"	Z=0.907 *P-value* =0.364	—	—
"Inflation" * "Increasing Scale"	Z=0.821 *P-value* =0.412	—	—
"Inflation" * "Decreasing Scale"	Z=0.968 *P-value* =0.333	Z=0.023 *P-value* =0.982	Z=0.152 *P-value* =0.879

4.1. The Link Between Beliefs and Behavior

We now turn our attention to the correspondence between a respondent prices/inflation point prediction and his/her switching point. In Figure 2, we consider the entire sample of respondents (i.e. regardless of the treatment combination to which they were assigned) and we plot for each switching point between 1 and 11 the average prices/inflation prediction for the respondents who selected that switching point. For instance, we can see that the 50 respondents who always selected investment B, and who therefore have a switching point equal to 1, reported an average prices/inflation point prediction of 9.3%. Observe first in Figure 2 that, consistent with theory, there is a generally monotonic

decreasing relationship between the reported price/inflation beliefs and the switching point.

FIGURE 2



The numbers in parenthesis are equal to the number of respondents who selected the corresponding switching point.

We also plot in Figure 2 a risk neutral bandwidth indicating the range of beliefs that would rationalize each switching point under risk neutrality. For instance, if a rational and risk neutral respondent selects a switching point equal to 6, then that implies that his point prediction should belong to the interval [3.5%,5.5%]. Switching points below (respectively, above) the risk neutral bandwidth may be rationalized under risk aversion (respectively, risk loving). Indeed, as explained earlier, all else equal, and in particular for a given point prediction, a more risk averse (respectively, risk loving) agent has a lower (respectively, higher) switching point. We can see in Figure 2 that, on average, subjects

exhibited behavior consistent with risk neutrality, although a number of pairs of switching point and prediction are close to the risk averse frontier. This does not imply, however, that most of the respondents behaved as if risk neutral. Instead, we find that respectively 41%, 21% and 28% of the respondents behaved as if risk averse, risk neutral, and risk loving. Below, we will explore whether it is truly risk attitude that drives the choice of a switching point, or if instead respondents may be considered risk neutral but they make errors when selecting the switching point that best corresponds to their stated belief.

The general trend observed in Figure 2 seems to be robust. In particular, we report in Appendix 2 two figures in which, instead of the average point prediction, we plot the median point prediction in one case, and the estimated expected prediction in the other case. Although slightly flatter, these two additional figures display a similar relationship between point prediction and switching point. In Appendix 3, we also reproduce Figure 2 with the data collected in each of the four treatment combinations. Although the average point predictions are more volatile across switching points than in Figure 2, the general trend does not seem to vary substantially across treatment combinations.

To confirm these observations, and to better identify the determinants of behavior in the experiment, we report in Table 3 estimates of a series of ordered probit models in which the dependent variable is defined as the switching point of a respondent. The estimation outcome of Model 1 in Table 3 indicates that the parameter associated with the variable “Point prediction” is highly significant and negative. This result therefore confirms the

strong relationship between a respondent's price/inflation point prediction and his/her switching point. We also find that the parameter associated with the self reported measure of risk attitude is positive and significant. According with theory, we find that, all else equal, more risk averse subjects have lower switching point, while more risk loving subjects have higher switching point. The parameter associated with the variable measuring the estimated standard deviation of the prediction is significant and negative. In other words, respondents with more diffuse beliefs tend to switch investment earlier. This result may be rationalized under a standard expected utility framework if respondent exhibit risk aversion. Indeed, if a risk averse agent is indifferent between the two investments for a given belief distribution, then the agent should strictly prefer the safer investment (here investment B) for any mean preserving changes of his belief distribution that increases the variance. In other words, all else equal, a risk averse agent should switch from investment A to investment B earlier when the standard deviation of his beliefs is larger.

Finally, the estimation outcome of Model 1 in Table 3 reveals that neither the measure of numeracy and financial literacy, nor the time taken by respondents to complete the survey seems to have explanatory power. Likewise, none of the treatment dummies is significantly difference from 0, thereby supporting the absence of treatment effect.

TABLE 3

Identifying the Determinants of the Switching Point:
Outcome of ordered Probit estimations where the dependent variable is the switching point (an integer between 1 and 11) for each respondent (N=590)

	Model 1	Model 2	Model 3	Model 4
"Prices" * "Increasing Scale"	-0.163 (0.119)	-0.155 (0.120)	-0.200 (0.119)	-0.097 (0.153)
"Prices" * "Decreasing Scale"	0.055 (0.118)	0.049 (0.119)	-0.015 (0.118)	0.109 (0.152)
"Inflation" * "Decreasing Scale"	0.026 (0.117)	0.025 (0.118)	0.036 (0.118)	0.066 (0.148)
Point prediction	-0.094*** (0.009)	-0.094*** (0.009)	—	-0.083*** (0.017)
Point prediction * "Prices" * "Increasing Scale"	—	—	—	-0.015 (0.025)
Point prediction * "Prices" * "Decreasing Scale"	—	—	—	-0.015 (0.023)
Point prediction * "Inflation" * "Decreasing Scale"	—	—	—	-0.011 (0.025)
Estimated Expected Prediction [c]	—	—	-0.101*** (0.013)	—
Reported Risk Attitude [a]	0.228*** (0.030)	0.225*** (0.030)	0.182*** (0.030)	0.226*** (0.031)
Numeracy and Financial Literacy Score [b]	-0.020 (0.034)	-0.024 (0.035)	-0.011 (0.035)	-0.026 (0.035)
Estimated Standard Deviation of Prediction [c]	-0.067*** (0.025)	-0.064*** (0.025)	-0.114*** (0.025)	-0.067*** (0.025)
Log of Time Taken to Complete the Survey	0.005 (0.024)	0.003 (0.024)	0.005 (0.024)	0.003 (0.024)
Gender (female)	—	-0.067 (0.089)	-0.107 (0.089)	-0.069 (0.090)
Age	—	0.004 (0.003)	0.004 (0.003)	0.004 (0.003)
Income	—	-0.010 (0.015)	-0.009 (0.014)	-0.010 (0.015)
Highest Education	—	0.033 (0.023)	0.043 (0.023)	0.033 (0.023)
Race	—	0.061 (0.067)	-0.009 (0.067)	0.060 (0.067)
Log Likelihood	-1,223.6	-1,220.9	-1,238.9	-1,220.6

The standard deviations are robust and clustered at the treatment combinations level. Significance: * = 10%, ** =5%, *** = 1%.

[a] Self reported willingness to take risk regarding financial matters on a scale from 1 (Not willing at all) to 7 (very willing). An answer of 4 is interpreted as reflecting risk neutrality, while lower (respectively higher) answers are interpreted as reflecting risk aversion (respectively risk loving).

[b] The variable takes integer values between 0 and 6 depending on the number of correct answers the respondent gave to the six questions asked to measure the respondent's numeracy and financial literacy.

[c] As explained in Section 2, these variables are calculated using the probabilistic beliefs reported by the respondent.

In Model 2 of Table 3, we augment the specification by including demographic variables. Observe that the parameters estimated in Model 1 remain essentially unchanged. In addition, none of the demographic variable seems to play a role in explaining when a respondent switch from investment A to investment B. In Model 3, we replace the reported price/inflation point prediction by the estimated expected predictions calculated from the respondents reported distribution (see Section 2). Once again the parameters previously estimated remain essentially unchanged. The parameter associated with the estimated expectation variable in Model 3 is very similar, both in sign and magnitude, to the parameter associated with the point prediction variable in Model 1. In fact, a log likelihood ratio test reveals that the two parameters are statistically indistinguishable at the usual significance levels (*P-value*=0.362). Finally, the point prediction variable was multiplied by the treatment combination dummy in Model 4. None of the resulting parameters are found to be significantly different from zero at the usual significance levels. In other words, we do not find statistical evidence that the slope of the relationship between the point prediction and the switching point varies significantly across treatments.

4.2. Risk Attitude and Optimization Error

Although the estimates in Table 3 confirm the relationship between beliefs and actions, they do not allow us to fully identify the determinants of behavior. In particular, we are not able to establish the extent to which choices in the experiment may be explained by risk attitude and/or optimization errors. If the respondent's point prediction truly reflects her beliefs, then two hypotheses may be formulated to explain why her switching point

cannot be rationalized under risk neutrality. First, the respondent is an expected utility maximizer, but she is not risk neutral. Second, the respondent is risk neutral but she makes a suboptimal choice when deciding when to switch from investment A to investment B.

In an effort to disentangle between these two hypotheses, we estimate an order probit model in which the dependent variable is defined as the distance between a respondent's switching point and the switching point of a rational risk neutral agent with the same point prediction as the respondent. More specifically, we first calculate for each respondent the pair of theoretic switching points he could have selected if rational and risk neutral given his stated point prediction. For instance, consider a respondent in the ascending scale treatment who made a point prediction of 3%. If risk neutral, this respondent should have switched from investment A to investment B either in question 7 (because the respondent is then indifferent between the two investments which both earn $400), or in question 8 (because the respondent strictly prefers investment B in question 8 as it earns $450). In other words, if risk neutral, the respondent should have selected a switching point equal to 7 or 8. Next, we calculate a "distance from the risk neutral choice" as the minimum absolute value of the difference between the respondent actual switching point and his pairs of theoretic risk neutral switching points. For instance, if in the example above the respondent selected a switching point of 6, then her distance from the risk neutral choice is equal to 1=Min{|6-7|,|8-6|)}.

As an explanatory variable, we also define a respondent "self reported distance from risk neutrality" as being equal to the absolute value of the difference between i) the respondent self reported willingness to take risk regarding financial matters which, as explained earlier, is expressed on a scale going from 1 (Not willing at all) to 7 (very willing), and ii) the middle of that scale, 4, which is interpreted as reflecting risk neutrality. The self reported distance from risk neutrality is therefore an integer between 0 (reflecting risk neutrality) and 4 (reflecting either high risk aversion of risk loving). The theoretical hypothesis is that if choices are driven exclusively by risk attitudes, then the self reported distance from risk neutrality should be the only explanatory variable with statistical power to explain the distance from the risk neutral choice.

The results reported in Table 4 reveal a strong positive relationship between the self reported distance from risk neutrality and the distance from the risk neutral choice. According with our hypothesis, reported risk attitude therefore plays a role in explaining why respondents did not behave in the experiment as if risk neutral. In contrast with theory, however, additional parameters are significantly different from zero in Table 4. Furthermore, these additional effects tend to suggest that optimization errors also play a role in explaining a respondent's choice of switching point. Indeed, observe that the parameter associated with the numeracy and financial literacy score is highly significant and negative. In other words, is seems that all else equal, and in particular controlling for self reported risk attitude, the experimental choices of respondents with lower numeracy and financial literacy scores tend to deviate more from a risk neutral optimizer.

We also find that subjects who took longer to complete the survey have a behavior in the experiment that contrasts more with a risk neutral optimizer. This result could either reflect the fact that these respondents do not remember the beliefs they initially stated in stage 1 of the survey when they finally reach the experiment in stage 3 (some subjects took more than 10 days between the time they started and completed the survey), or that these subjects did not complete the survey and the experiment with the same attention as the other respondents.

In model 2 reported in Table 4, we augment the specification by controlling for demographic variables. Observe that the parameters estimated in Model 1 do not change substantially. Note also that a single demographic variable, the education level, seems to have a significant effect. More specifically, we find that, all else equal, the switching point of less educated respondents deviates more from the switching point of a risk neutral optimizer. This result thereby provides further support to the hypothesis that the choices between the two investments in the experiment were driven not only by risk attitude but also by optimization errors.

TABLE 4

Are Switching Points Driven by Risk Attitudes and/or Optimization Errors?
Ordered Probit estimations where the dependent variable is the "distance from the risk neutral choice." [a] (N=590)

	Model 1	Model 2
"Prices" * "Increasing Scale"	0.160 (0.121)	0.168 (0.122)
"Prices" * "Decreasing Scale"	0.014 (0.122)	0.036 (0.123)
"Inflation" * "Decreasing Scale"	-0.065 (0.122)	-0.051 (0.122)
Distance from Risk Neutrality [b]	0.153*** (0.047)	0.134*** (0.048)
Numeracy and Financial Literacy Score [c]	-0.188*** (0.035)	-0.170*** (0.036)
Estimated Standard Deviation of Point prediction [d]	-0.041 (0.025)	-0.034 (0.025)
Log of time taken to complete the survey	0.061** (0.024)	0.063** (0.024)
Gender (female)	—	-0.107 (0.091)
Age	—	-0.003 (0.003)
Income	—	0.008 (0.015)
Highest Education	—	-0.074*** (0.024)
Race	—	-0.003 (0.069)
Log Likelihood	-1,055.1	-1,049.3

The standard deviations are robust and clustered at the treatment combinations level. Significance: * = 10%, ** =5%, *** = 1%.

[a] The dependent variable is equal to the absolute value of the difference between i) the switching point selected by the respondent and ii) the switching the respondent should have selected if risk neutral given his/her reported point prediction.

[b] The variable is equal to the absolute value of 4 minus the respondent self reported willingness to take risk regarding financial matters.

[b] The variable takes integer values between 0 and 6 depending on the number of correct answers the respondent gave to the six questions asked to measure the respondent's numeracy and financial literacy.

[c] As explained in Section 2, these variables are calculated using the probabilistic beliefs reported by the respondent.

5. Discussion

The objective of this paper was i) to investigate whether the survey responses of individual consumers are informative about their true inflation expectations, and ii) to shed some light on the possible impact of inflation expectations on the decisions of individual consumers. To address these two issues we compared the inflation expectations reported by individual consumers in a survey with their behavior in a financially incentivized investment experiment. Our results reveal that, on average, there is a relatively tight correspondence between stated beliefs and behavior in the experiment. Nevertheless, we find a substantial amount of heterogeneity in behavior across respondents which appears to be explained by a combination of risk attitudes and optimization errors. We now conclude with a brief discussion about the extent to which our results can be generalized.

To be clear, our results do not prove that the respondents in inflation expectations surveys accurately report their true beliefs. Since subjective beliefs are not observable, this proposition is by definition not directly testable. Our results simply suggest that inflation expectations surveys of individual consumers appear to be informative in the sense that the beliefs elicited are generally consistent with the decisions of the respondents in a financially incentivized experiment. This criterion is consistent with Manski (2004) who argues that to judge the information content of expectations surveys, one needs to investigate the extent to which responses are internally consistent or correlated with relevant behavior.

Likewise, we have not shown that the decisions made by individual consumers in their daily life are influenced by the beliefs they hold about future inflation. Indeed, the behaviors observed in our experiment do not necessarily imply that consumers take into consideration future inflation when making investment, saving, wage, or large purchase decisions. What we have shown is that, when presented with an opportunity to act on their inflation beliefs, consumers responding to a survey make decisions consistent with the expectations they report. Our results may therefore be considered a first step in establishing whether future inflation prospects affect the actual behavior of individual consumers.

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Appendix 1: Experimental Instruction (Ascending Scale Treatment)

You can earn extra money by answering the following 10 questions. In each question, you are asked to choose between 2 investments, investment **A** and investment **B**.

- If you choose investment **A**, then how much you earn depends on what the rate of inflation will be over the next 12 months. Your earnings under investment **A** depending on the rate of inflation are summarized in the table below:

Earnings under investment **A**												
Rate of inflation	-1% or less (deflation)	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10% or more
Earnings	$600	$550	$500	$450	$400	$350	$300	$250	$200	$150	$100	$50

For example, we can see in the table that your earnings under investment **A** will be $50 if the rate of inflation over the next 12-months is 10% or more. Alternatively, your earnings under investment **A** will be $600 if the rate of inflation over the next 12-months is -1% or less (deflation).

- If you choose investment **B**, then how much you earn will not depend on the rate of inflation. Exactly how much you earn under investment **B** will be specified in each of the 10 questions below.

Once the survey is completed, we will randomly pick 1 of the 10 questions, and 2 survey participants. Twelve months from now, these 2 participants will be paid extra money according to the investment choice they made for the selected question. So answer every question carefully, as you may earn up to several hundred dollars. For investment **A**, the inflation rate over the next 12 months will be based on the official U.S. CPI index (Consumer Price Index) and it will be rounded to the nearest percentage point.

Earnings under investment **A**												
Rate of inflation	-1% or less (deflation)	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10% or more
Earnings	$600	$550	$500	$450	$400	$350	$300	$250	$200	$150	$100	$50

For every question, please choose between investment **A** and investment **B**.

Question 1: Which one of these two investments do you choose?
( ) Investment **A**: your earnings are determined by the table above.
( ) Investment **B,** your earnings are exactly **$100**?

Question 2: Which one of these two investments do you choose?
( ) Investment **A**: your earnings are determined by the table above.
( ) Investment **B,** your earnings are exactly **$150**?

Question 3: Which one of these two investments do you choose?
( ) Investment **A**: your earnings are determined by the table above.
( ) Investment **B,** your earnings are exactly **$200**?

Question 4: Which one of these two investments do you choose?
( ) Investment **A**: your earnings are determined by the table above.
( ) Investment **B,** your earnings are exactly **$250**?

Question 5: Which one of these two investments do you choose?
( ) Investment **A**: your earnings are determined by the table above.
( ) Investment **B,** your earnings are exactly **$300**?

Question 6: Which one of these two investments do you choose?
( ) Investment **A**: your earnings are determined by the table above.
( ) Investment **B,** your earnings are exactly **$350**?

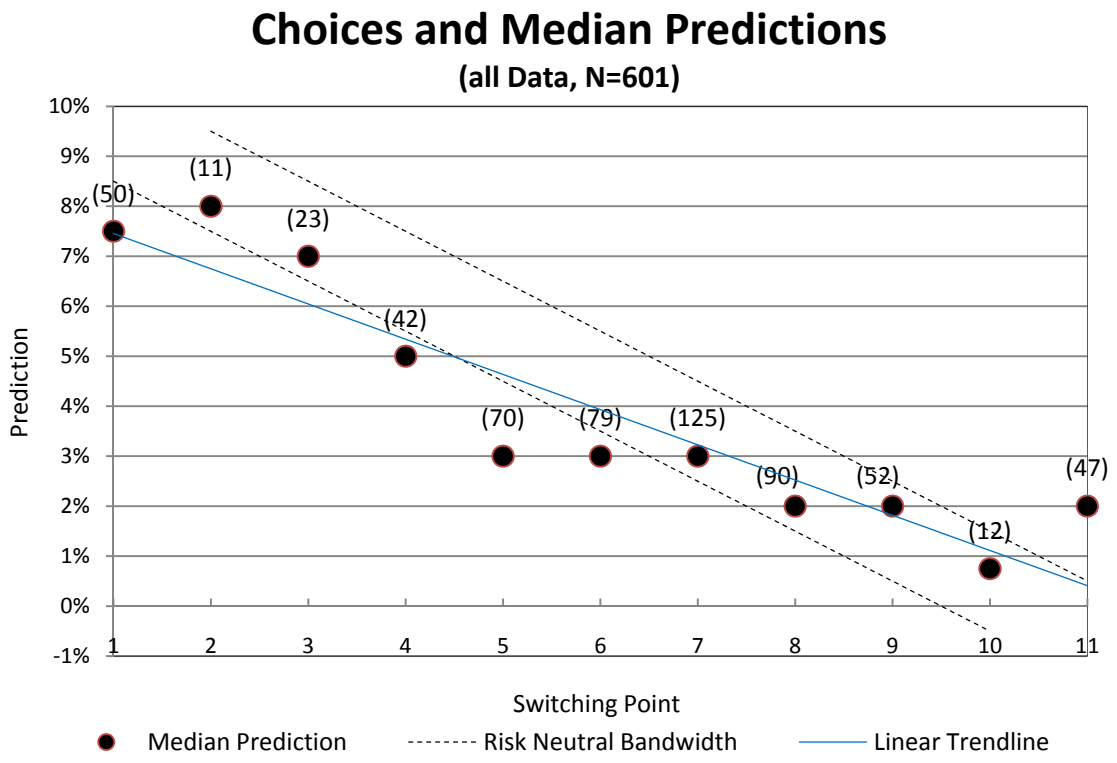
Question 7: Which one of these two investments do you choose?
( ) Investment **A**: your earnings are determined by the table above.
( ) Investment **B,** your earnings are exactly **$400**?

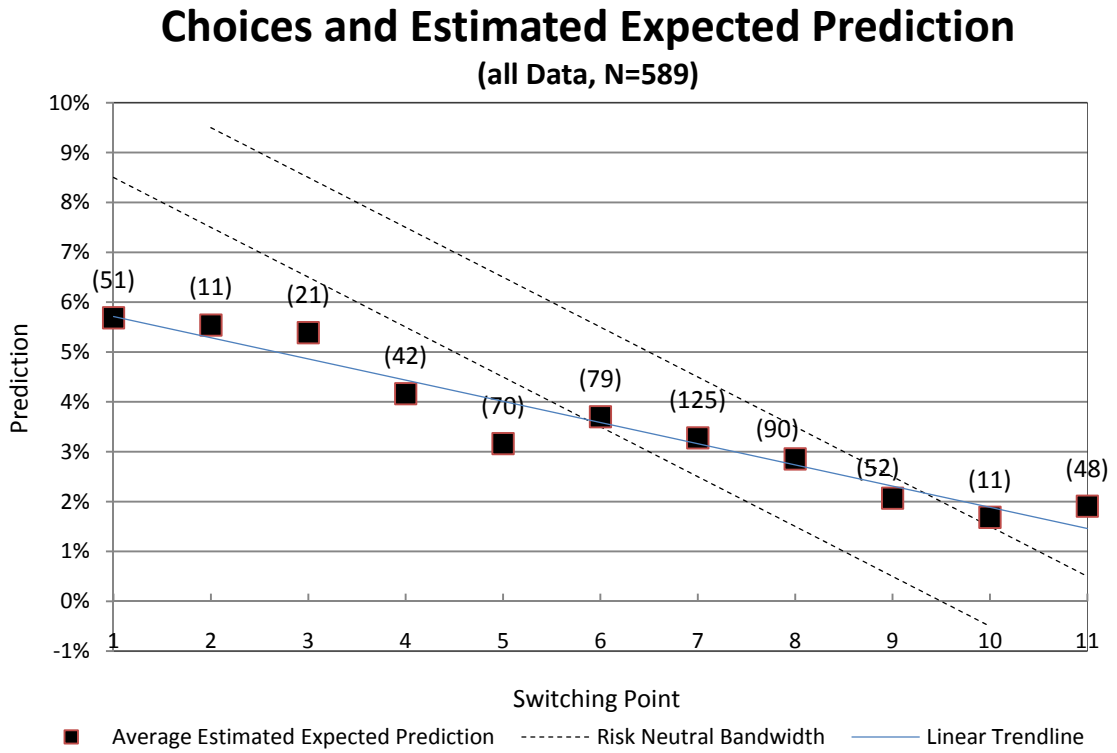
Question 8: Which one of these two investments do you choose?
( ) Investment **A**: your earnings are determined by the table above.
( ) Investment **B,** your earnings are exactly **$450**?

Question 9: Which one of these two investments do you choose?
( ) Investment **A**: your earnings are determined by the table above.
( ) Investment **B,** your earnings are exactly **$500**?

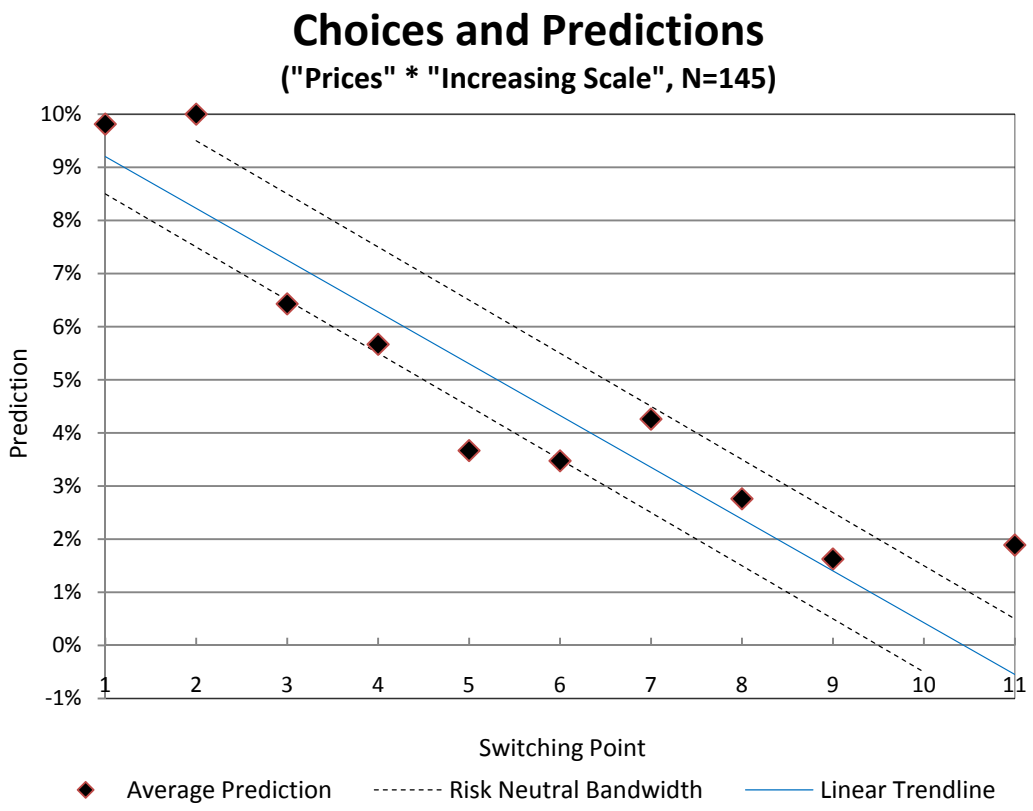
Question 10: Which one of these two investments do you choose?
( ) Investment **A**: your earnings are determined by the table above.
( ) Investment **B,** your earnings are exactly **$550**?

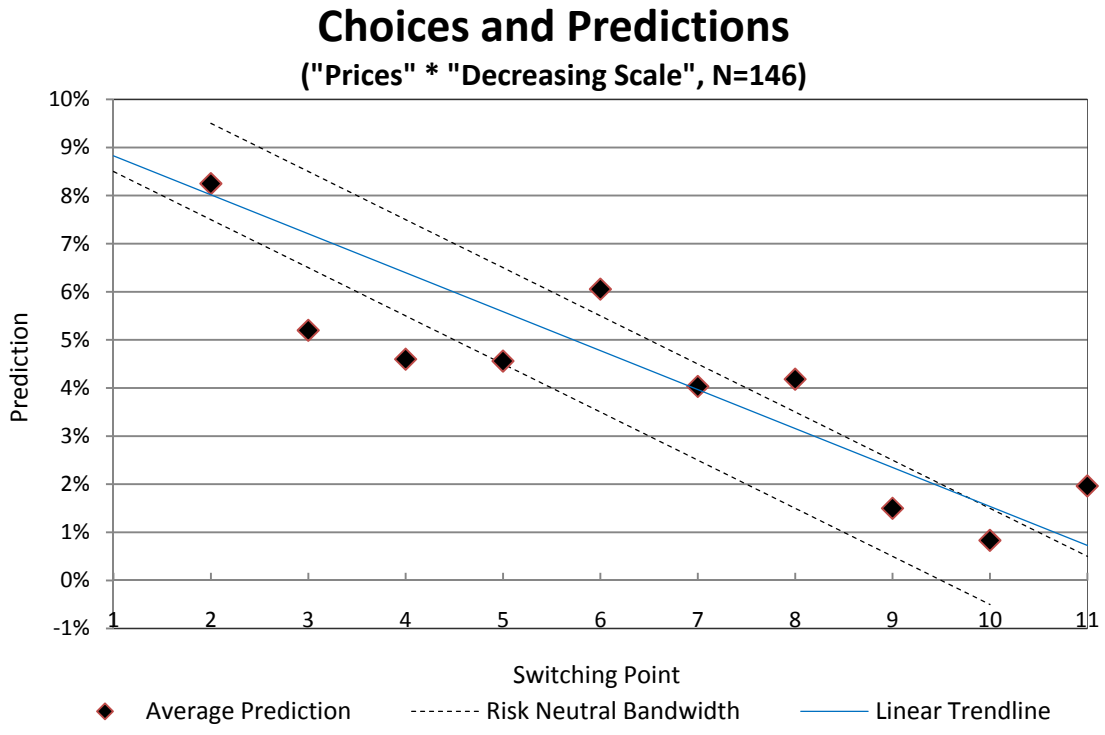
Appendix 2: Median and Average Estimated Choices and Point Predictions

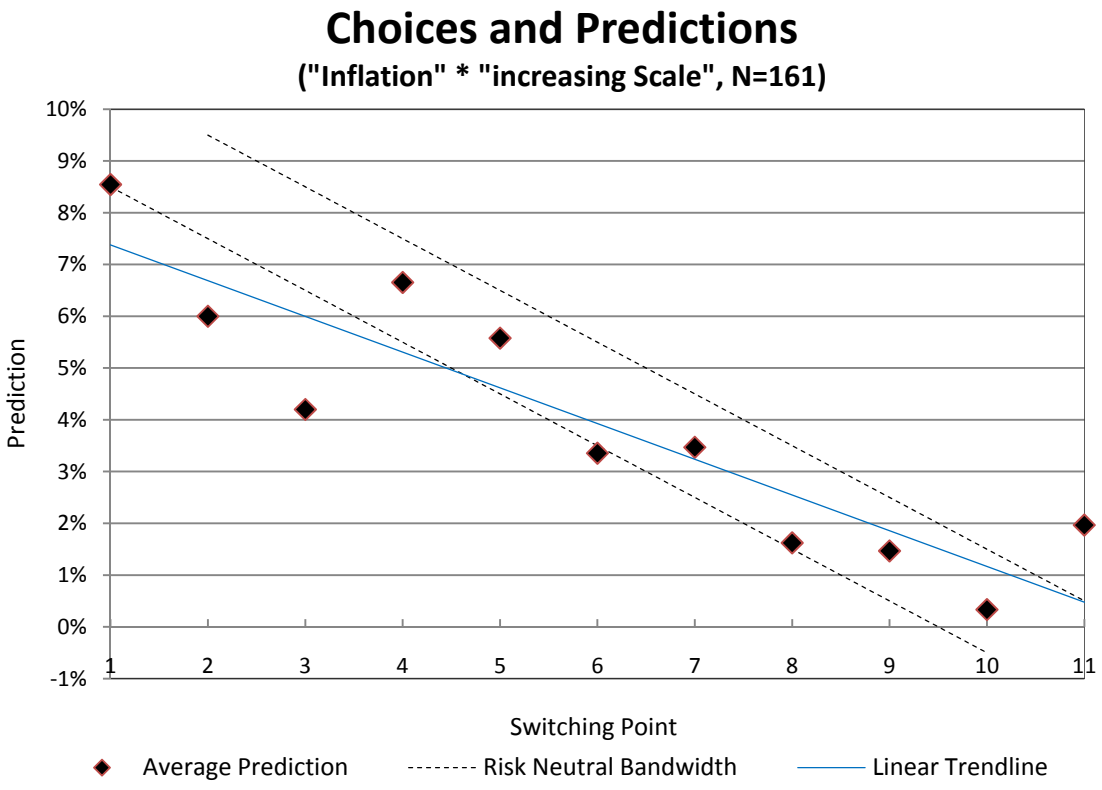


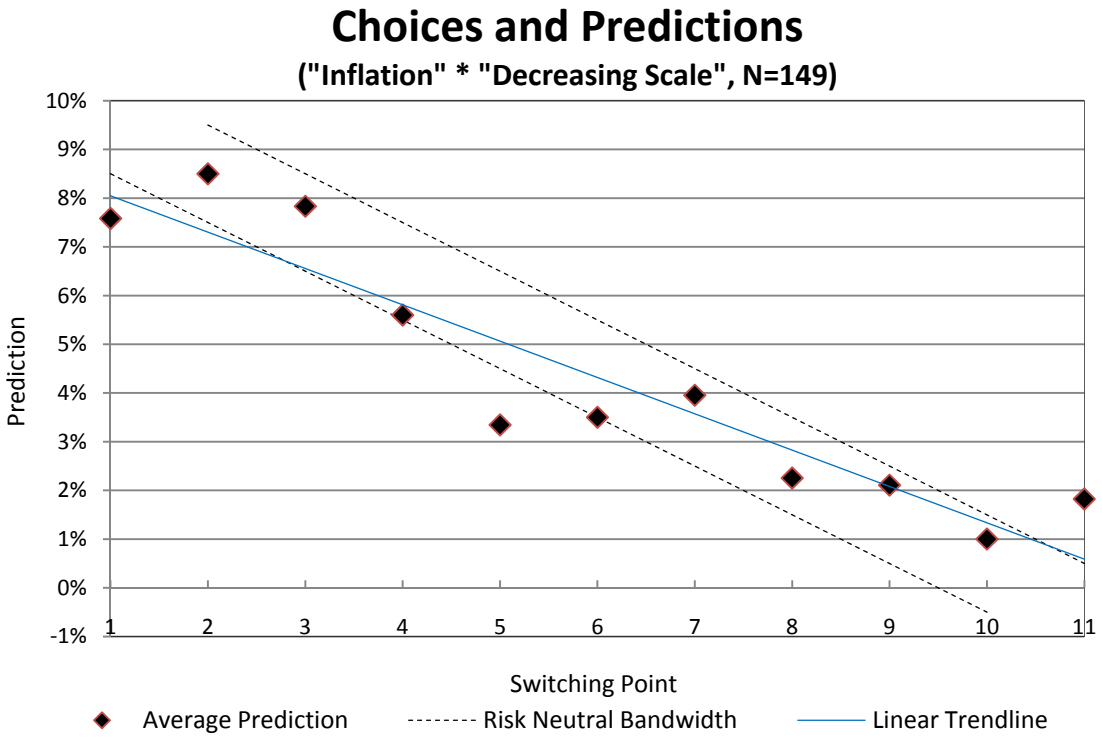


Appendix 3: Choices and Point Prediction for each Treatment Combinations






Choices and Predictions
("Inflation" * "increasing Scale", N=161)
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
-1%
Prediction
1
2
3
4
5
6
7
8
9
10
11
Switching Point
Average Prediction
Risk Neutral Bandwidth
Linear Trendline


Choices and Predictions
("Inflation" * "Decreasing Scale", N=149)
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
-1%
Prediction
1
2
3
4
5
6
7
8
9
10
11
Switching Point
Average Prediction
Risk Neutral Bandwidth
Linear Trendline