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Are Consumer Expectations Theory-Consistent? The Role of Macroeconomic Determinants and Central Bank Communication

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Abstract

Using the microdata of the Michigan Survey of Consumers, we evaluate whether U.S. consumers form macroeconomic expectations consistent with different economic concepts. We observe that 50% of consumers have expectations consistent with the Income Fisher equation, 46% with the Taylor rule and 34% with the Phillips curve. For the Taylor rule and the Phillips curve we observe less consistency during recessions and with high inflation. Moreover, changes in the communication policy of the Fed affect consistency. The strongest positive effect comes from the introduction of the official inflation target. Finally, consumers with theory-consistent expectations have lower absolute inflation forecast errors.

Keywords: Macroeconomic expectations, microdata, macroeconomic literacy, central bank communication, consumer forecast accuracy.

JEL classification: D84, E31, C25.

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1 Introduction

Consumers' expectations regarding macroeconomic variables are important for economic decisions, such as the decision to purchase a house, the decision for a savings portfolio or wage negotiations, but also for policy makers attempting to guide consumers' expectations. Therefore, it is crucial to understand how consumers form expectations about key macroeconomic variables.

In this paper, we are not interested in individual series of expectations, but investigate whether expectations comove in a sensible way and hence are in line with established macroeconomic concepts. We then evaluate whether theory-consistency is beneficial for consumers' inflation forecasting accuracy and whether we can explain some of its variation.

Using survey microdata, we analyse individual consistency with an Income "Fisher" equation, the Phillips curve and the Taylor rule. We thus test if consumers' expectations correctly distinguish between real and nominal expected income, implying consistency with the Income Fisher equation. Regarding the Phillips curve, we analyse if consumers use the short-run trade-off between inflation and unemployment for forecasting.[1] Finally, we evaluate whether consumers are aware of the dual mandate of monetary policy regarding stable prices and high employment and, hence, whether they form expectations regarding interest rates, inflation and unemployment (or the output gap) in line with the Taylor rule. Note that throughout the paper the term "consistent expectations" denotes consistent with an economic concept.

This analysis is not only economically relevant, but also has important policy implications. Theory-consistency of consumers' expectations can vary over time, allowing us to identify patterns in consumers' behaviour that can be linked to macroeconomic factors. In addition, we can evaluate whether changes in the communication strategy of the Federal Open Market Committee over the last decades contributed to an enhanced understanding of macroeconomic relations in general and of monetary policy in particular. Notably, research efforts so far have focused on the reaction of professionals and experts. However, Blinder et al. (2008, p. 941) argue: "Virtually all the research to date has focused on central bank communication with the financial markets. It may be time to pay some attention to communication with the general public." In this paper, we shed some light on the response of consumers to central bank communication. Furthermore, by showing that consumers whose expectations are consistent with these basic concepts have a higher inflation forecast accuracy compared to those that are inconsistent, the results of this paper

[1] Although this is an empirical relationship which might not be realised in every period, it is, independent of this issue, very interesting to see to which extend consumers form their expectations in line with the Phillips curve. Hence, our main focus is not whether consumers should forecast in line with the Phillips curve, but in the implications and determinants of forecasting consistently. That said, we will check to which extend demand and supply shocks affect the propensity to form consistent expectations and control for different phases of the business cycle. Note that the Phillips curve trade-off is embedded in many forecasting models for inflation (see, e.g., Stock and Watson, 2008 and Faust and Wright, 2013).

may be used to develop better forecasts based on consumers that form theory-consistent expectations.

Our analysis is conducted utilising the microdata from the University of Michigan Survey of Consumers (henceforth Michigan Survey), which since January 1978 comprises monthly data of consumers' expectations regarding core macroeconomic variables, but also includes a wide range of socio-demographic characteristics.

We find that on average about 50% of consumers correctly distinguish between real and nominal income expectations, while 46% form expectations in line with the Taylor rule. The average share of consumers with expectations consistent with the Phillips curve is significantly lower at about 34%. However, on average only 6% of consumers form theory-consistent expectations with respect to all three concepts in a given period, implying that economic literacy does not necessarily cover all economic concepts simultaneously. Moreover, we find that the degree of consistency of consumers varies both across demographic groups and across time. Specifically, we show that women, as well as lower income and education groups are significantly worse at forming consistent macroeconomic expectations, particularly with respect to the Income Fisher equation. Moreover, the shares of consumers consistent with the Phillips curve and the Taylor rule show a cyclical pattern over time.

Evaluating the impact of macroeconomic determinants on the likelihood of eliciting theory-consistent expectations, we provide evidence that consistency with respect to the Phillips curve and the Taylor rule drops with rising inflation above the official inflation target of 2%, while the effect is positive for consistency with the Income Fisher equation. Moreover, consumers are significantly less likely to form expectations consistent with the Phillips curve and the Taylor rule during recession periods. We further investigate the effect of recession periods by studying the interaction effects with other macro variables. We find that several macroeconomic variables exhibit asymmetric effects on consistency over the business cycle.

Since the understanding of the macroeconomic relations evaluated may be affected by the communication strategy of monetary policy, we additionally analyse the effect of changes in the communication strategy of the Fed on the likelihood of consumers forming consistent expectations. We find that the continued steps towards a more transparent monetary policy had mostly positive effects on consistency. The greatest influence is observed on the understanding of the Taylor rule as well as the correct distinction between real and nominal values. The most important events, in terms of significance for consistency and the magnitude of the effect, turn out to be the announcement of changes in its target for the federal funds rate in February 1994 and the introduction of the official inflation target in January 2012.

Finally, we evaluate the forecast accuracy regarding future inflation of those consumers who form expectations consistent with those three macroeconomic relations, and compare their absolute forecast errors to those of the inconsistent sample of consumers in the

Michigan Survey, as well as to those from the Survey of Professional Forecasters (SPF). This part of our analysis relates to Ang et al. (2007) who compare the forecasting accuracy for inflation of forecasts from ARIMA models, models of the Phillips curve, term structure models and survey measures. We find that consumers with theory-consistent expectations on average have lower absolute forecast errors regarding inflation compared to consumers with non-consistent expectations.[2] Moreover, theory-consistent consumers are on average closer to the absolute forecast error of inflation forecasts from the SPF, except for the Fisher equation where there are no significant differences, and more often beat the SPF forecast. Again, we find some time-variation of these effects, suggesting that theory-consistency is particularly related to an improvement in inflation forecasting abilities in the later part of our sample.

There are several studies our paper is related to. The paper by Carvalho and Nechio (2014) is closely related to our analysis with respect to the Taylor rule. The authors study consistency of expectations with the Taylor rule by evaluating the fractions of answers within the cross-section of the Michigan survey that give consistent interest rate expectations, given their answers to the questions on unemployment and inflation. The results are then compared across demographic groups and to the Survey of Professional Forecasters. We design a complementary exercise to study the *individual* consistency with the Taylor rule relationship, but extend their approach in various ways. Besides considering further macroeconomic relations individually as well as jointly, we test for possible determinants of having consistent expectations and link consistency of expectations to monetary policy communication and forecast accuracy.[3]

There exist a few recent papers that investigate whether professional forecasters behave in line with macroeconomic concepts. While Mitchell and Pearce (2010) test whether wall street economists believe in Okun's law and the Taylor rule, Pierdzioch et al. (2011), Fendel et al. (2011a) and Fendel et al. (2011b) rely on the Consensus Economic Forecast poll for the G-7 countries to estimate whether professional forecasters report point estimates in line with a Phillips curve, the Taylor rule or Okun's law. Lastly, Rülke (2012) investigates the behavior of professional forecasters for six Asian-Pacific countries.

Overall, the gross majority of the existing literature has focused mainly on the formation of consumers' expectations with respect to individual macroeconomic aggregates, measured from survey data. Many studies focus on consumers' inflation expectations. Earlier studies such as Souleles (2004) and Mankiw et al. (2004) reject the rationality of U.S. consumers' inflation expectations and show that expectations are heterogeneous across demographic groups. Subsequently, Branch (2004, 2007), Andrade and Le Bihan (2013) as well as Coibion and Gorodnichenko (2010, 2012) test for expectation formation processes with limited information. In addition, Carroll and Dunn (1997) as well

[2]This result is broadly related to the findings in Bachmann et al. (2014). They show that a positive link between expected inflation and readiness to spend on durable goods only holds for those consumers that have a relatively high inflation forecasting accuracy.

[3]We also vary somewhat in the identification strategy of the Taylor rule as discussed in section 2.

as Curtin (2003) analyse the formation of U.S. consumers' unemployment expectations. They find a robust link between unemployment expectations and consumption and show that unemployment expectations contain private information measured by reported news heard on unemployment and by individual income expectations. More recently, Tortorice (2012) shows that consumers' unemployment expectations, like inflation expectations, are not formed rationally, but rather may be best explained by an extrapolative forecasting rule. Finally, Baghestani and Kherfi (2008) evaluate U.S. consumers' interest rate expectations and show that consumers are more likely to predict upwards than downwards movements if interest rates are relatively stable, interpreting this result as evidence in favour of asymmetric loss functions.

Analysing theory-consistency, our paper also relates to the literature on macroeconomic literacy, put forward by Blanchflower and Kelly (2008). The authors evaluate macroeconomic literacy regarding inflation and unemployment by estimating the likelihood for "don't know" answers in UK survey microdata asking for inflation expectations and satisfaction with the Bank of England. They find that illiteracy, i.e. the probability of non-response, is significantly higher for women, the young or the old as well as low education or low income groups. Moreover, respondents in the Eurobarometer Survey for the UK from these groups more often reported that they did not know the official rate of inflation. Generally, respondents frequently overestimated actual inflation. Armantier et al. (2011) show in a financially incentivised investment experiment that those consumers who did not act on their earlier reported inflation expectations regarding a choice between a nominal and an inflation-indexed investment tend to have lower numeracy skills, lower financial literacy and lower education. Moreover, they find only weak links between survey inflation expectations and the reported readiness to spend on durable goods, in line with Bachmann et al. (2014). In an experimental study, Burke and Manz (2011) moreover show that subjects with a higher economic literacy make a better choice of the information to use for forecasting and better use the given information in an inflation forecasting experiment.

Our paper also relates to the literature studying central bank communication practices. Over the last decades, central banks have attached a lot of attention to various communication strategies aimed at explaining monetary policy decisions and guiding expectations of professional forecasters as well as consumers. While, as pointed out by Blinder et al. (2008), communication and transparency improves the effectiveness of monetary policy, there is no consensus on what constitutes an optimal communication strategy.[4] Communication strategies of the Fed or more precisely of the Federal Open Market Committee are studied in, e.g., Middeldorp (2011) and Carlson et al. (2006). Furthermore, it has been shown for instance by Hayo and Neuenkirch (2010) for the Fed or Sturm and de Haan (2011) for the ECB that communication can help predict the future interest rate decision.

[4]See also Ehrmann and Fratzscher (2007).

The rest of the paper is structured as follows. We describe our identification method for expectations that are consistent with the Fisher Income equation, the Phillips curve and the Taylor rule in detail in section 2. Section 3 offers a description of the dataset. Our results are presented in section 4 and section 5 concludes.

2 Measuring the Consistency of Macroeconomic Expectations

We test the consistency of consumers' macroeconomic expectations in the University of Michigan Survey of Consumers by evaluating three core relations in macroeconomic theory: The distinction between real and nominal values captured by an Income Fisher equation, the Phillips curve and the Taylor rule. Specifically, we check whether the formation of macroeconomic expectations at the time of the interview is consistent with the prediction of the macroeconomic concept being tested. Note that while the Fisher equation is a theoretical concept which should always be satisfied by definition, both the Phillips curve trade-off and the Taylor rule were initially derived as empirical regularities and include unobservable variables.

First, we test if individual consumers correctly perceive the distinction between real and nominal values. This concept may be derived in the form of the Fisher equation, which describes the relation between nominal and real interest rates. Assuming that a bond earns a nominal return of i_t in the next period, its real return r_t must be depreciated with next period's expected inflation π_t^e:

$$r_t \approx i_t - \pi_t^e. \tag{1}$$

The Fisher equation thus gives the relation between real and nominal values and, hence, provides a concept to test also for money illusion. Since the Michigan Survey does not include any question about real interest rates, we apply the concept of the Fisher equation to consumers' real and nominal income expectations instead. We thus assume that since income expectations concern households' monetary income in the future, their real value should be depreciated with expected inflation similar to bonds' returns in the Fisher equation. We label this relation the "Income Fisher equation":

$$rinc_t^e \approx inc_t^e - \pi_t^e, \tag{2}$$

where $rinc_t^e$ and inc_t^e denote consumers' real and nominal income expectations, respectively. The Michigan Survey asks consumers to provide quantitative estimates for both expected inflation and expected nominal income in the next 12 months:

A15a "By about what percent do you expect your (family) income to (increase/decrease) during the next 12 months?"

A12b "By about what percent do you expect prices to go (up/down) on the average, during the next 12 months?"

From these two measures, we construct the implied quantitative real income expectations by subtracting individual inflation expectations from individual nominal income expectations. To evaluate the consistency of implied real income expectations, we compare the quantitative estimate that would be consistent with the Income Fisher equation to the qualitative answer to the survey question for real income expectations:

A14 "During the next year or two, do you expect that your (family) income will go up more than prices will go up, about the same, or less than prices will go up?"

We define expectations as being consistent with the Income Fisher equation if the direction of consumers' qualitative real income expectations coincides with the sign of their implied quantitative real income expectations. Hence, if consumers report *"income goes up more than prices"*, they should report nominal price and income expectations which result in positive real income expectations and *vice versa*.[5] Note that a small caveat applies: The horizon of the qualitative real income question includes the next 12 months as in the quantitative questions, but also the year after that. Nevertheless, we argue that it is unlikely that consumers expect such large variations in real income over two years, that they might for instance have positive real income expectations over the next 12 months, but expect a drop in their real income over the next 1-2 years.[6]

Next, we evaluate if consumers have a Phillips curve trade-off in mind when forming expectations on inflation and unemployment. Even though the Phillips curve trade-off may not always be realised in empirical data, it is nevertheless interesting to see how many people form expectations in line with the trade-off, if they gain forecast accuracy when doing so and which factors explain the probability of forming consistent expectations. Consequently, we are neither focussing on proving the existence of the Phillips curve nor whether consumers should forecast in line with the Phillips curve. Some authors argue that, irrespective of its existence, incorporating a Phillips curve relationship may improve the accuracy forecasting models.[7] Furthermore, the empirical papers testing the Phillips curve trade-off for professional forecasters focus on a similar combination of questions.[8]

[5] Our test for consistency with the Income Fisher equation implicitly assumes that consumers' inflation and nominal income distributions are distributed in such a way that their joint distribution is in line with the implication of the individual distributions. Consequently, this assumption does not account for asymmetric loss functions regarding expected real income.

[6] Note that this argument is consistent with the law of iterated expectations.

[7] Comparing different methods of forecasting, Stock and Watson (2008), Dotsey et al. (2011) as well as Faust and Wright (2013) show that forecasting methods based on the Phillips curve were frequently outperformed by survey forecasts and univariate methods, especially during the Great Moderation years. Nevertheless, Phillips curve forecasts can perform relatively better especially during recessions and when inflation is relatively volatile, pointing towards potential non-linearities and a role of the trade-off especially for forecasting turning points in inflation.

[8] See Pierdzioch et al. (2011), Fendel et al. (2011a), and Fendel et al. (2011b).

That said, we are very aware that the Phillips curve trade-off and the believe in it might depend on the existence of specific shocks.[9] Hence, we will control for demand and supply shocks, where the latter can break down this relationship, to assess whether a higher empirical probability of observing an empirical Phillips curve trade-off increases the share of people that form expectations in line with such a relationship.[10]

The original Phillips curve proposed as an empirical relation by Phillips (1958) and Samuelson and Solow (1960) asserts a negative correlation between wage growth, or the general inflation rate π_t (assuming that prices grow in line with wages, adjusted for productivity growth), and the rate of unemployment u_t:

$$\pi_t = f(u_t), \quad \text{with } \frac{\partial f}{\partial u_t} < 0. \tag{3}$$

Although the Phillips curve may be non-linear, with a smaller slope at low inflation rates, the trade-off between inflation and unemployment is generally assumed to hold at least in the short run. Note that we define the trade-off to be satisfied also if both inflation and unemployment stay constant. For our analysis of consumers' expectations, we thus concentrate on the relation between expected changes in inflation and in the unemployment rate over the next 12 months.

For unemployment expectations, the Michigan survey includes a qualitative question, while for inflation expectations we use both a quantitative and a qualitative question:

A10 "How about people out of work during the coming 12 months – do you think that there will be more unemployment than now, about the same, or less?"

A12 "During the next 12 months, do you think that prices in general will go up, (go up at the same rate), go down, or stay where they are now?"

A12b "By about what percent do you expect prices to go up/down on the average during the next 12 months?"

The above two questions on expected inflation are posed regarding changes in prices. However, in order to evaluate the Phillips curve relationship we need to redefine them in terms of changes in inflation. Thus, following Carvalho and Nechio (2014), positive changes in expected inflation are defined as an expected increase of inflation stated in [A12b] above the average inflation in the last 12 months rounded to the nearest integer

[9] As Carlstrom and Fuerst (2008) point out, especially mark-up shocks might be problematic as they could lead to effects on output and inflation that are not consistent with the short-run Phillips curve correlations. However, under the assumption that shocks are not observed, the expectations of the public should still be aligned with the Phillips curve relationship.

[10] We evaluate the existence of a trade-off in actual data from correlations of inflation and unemployment over time in Figure A.3 in the appendix. The empirical data show that there was no trade-off especially during the stagflation period at the end of the 1970s and the subsequent Volcker disinflation as well as in some periods of the great moderation. As would be expected, these periods coincide with a lower share of consumers consistent with the Phillips curve trade-off, especially during the stagflation period.

and *vice versa* for negative changes. Consumers giving point estimates equal to average rounded past inflation are coded as expecting no change in inflation. This procedure is applied to consumers that answered to the qualitative question in [A12] that prices will either increase or decrease. Additionally, we extend the approach of Carvalho and Nechio (2014) and use information about perceived inflation, which we obtain for those respondents that answered in the qualitative question [A12] that prices will increase at the same rate or stay where they are now. We characterize them as expecting no change in inflation. Overall, we thus use information from both the quantitative and the qualitative questions on expected price changes to construct an individual measure of expected changes in inflation.

Consumers' expectations are then defined as being consistent with the Phillips curve if consumers expect inflation to increase and unemployment to decrease and *vice versa*. They are also consistent if they expect no changes in either inflation or unemployment.[11]

Finally, we analyse whether consumers form interest rate expectations in line with the Taylor rule, that is whether they are aware of the dual mandate of the Fed regarding price stability and high employment. The Taylor rule was formalised from past empirical observations of the Fed's monetary policy by Taylor (1993) and states that the central bank adjusts nominal short-run interest rates i_t in response to both deviations of inflation from the target level $(\pi_t - \pi^*)$ and the output gap $\hat{y}_t$. [12] The general Taylor rule, widely used in modern macroeconomics to describe monetary policy actions, then takes on the following form:[13]

[11] We check for robustness of our results with respect to alternative definitions of consumers' inflation expectations. In addition to our measure combining information from the quantitative and the qualitative question, we additionally define inflation expectations only from the quantitative question as in Carvalho and Nechio (2014) or only from the qualitative question. Moreover, we can identify expected changes of inflation by comparing the quantitative inflation estimates between the first and the second interview of those consumers within the rotating panel of the Michigan survey and use this information together with the answers from the qualitative question as in our baseline definition. Figure A.1 in the appendix shows the shares of consumers consistent with the Phillips curve and the Taylor rule under these alternative definitions, while Table A.1 contains the estimation results for our baseline heckprobit regression explaining the likelihood of consistency with macro determinants under these alternative definitions. Regarding the Phillips curve, the consistency shares from our baseline and from the definition with changes between interviews are relatively close, while the other shares are somewhat lower and more volatile. In the case of the Taylor rule, all calculated shares are very similar except for the share derived using only the qualitative inflation question, which is somewhat higher during the Great Moderation period. The estimation results are qualitatively similar across all different definitions.

[12] We argue that it makes sense to evaluate consistency of consumers' expectations with the Taylor rule also before the publication of his paper in 1993, since Taylor tested the relation on past data and the Fed has focussed on both inflation and output since the late 1970s. Since we do not test for the coefficients of the Taylor rule, exact knowledge of the concept is not necessary. As in the case of the Phillips curve, we are not *per se* interested in whether consumers should forecast in line with the Taylor rule. Nevertheless, we control for demand and supply shocks and link consistency over time to evidence of the Taylor rule in actual data. As in the case of the Phillips curve, Figure A.3 in the appendix shows that the Fed did not act according to a Taylor rule especially during the Volcker disinflation. As would be expected, we observe a lower consistency share during this period.

[13] Extended versions of the Taylor rule often include the lagged interest rate in order to account for interest rate smoothing by the central bank. Since this does not alter the general response of interest rates to changes in inflation or the output gap, we omit this term here.

$$i_t = f(\pi_t, \hat{y}_t) = \gamma + \alpha(\pi_t - \pi^*) + \beta\hat{y}_t \quad \text{with} \quad \alpha > 1, \beta > 0 \tag{4}$$

Since the output gap is negatively correlated with the unemployment rate, the Taylor rule can also be derived with the unemployment rate, where the coefficient β then becomes negative.

We measure consumers' inflation and unemployment expectations as explained above for the definition of consistency with the Phillips curve.[14] Finally, the Michigan Survey includes a qualitative question on nominal interest rates, which reads as follows:[15]

A11 "No one can say for sure, but what do you think will happen to interest rates for borrowing money during the next 12 months – will they go up, stay the same, or go down?"

We thus code consumers' expectations as being in line with the Taylor rule if respondents report that they expect rising interest rates, as well as increasing prices and falling unemployment. Furthermore, interest rate expectations are also consistent with the Taylor rule if consumers expect rising (or constant) interest rates with either rising price expectations or falling unemployment expectations, while the other variable is expected to remain constant. The same rules apply to expectations regarding falling interest rate expectations. Finally, if interest rates are expected to remain constant, both prices and unemployment must also be expected to stay the same.[16]

[14] Additionally, we check for robustness of our results with respect to an alternative definition of consistency with the Taylor rule which attempts to account for the role of the (possibly implicit) inflation target in equation (4). As a simple check, instead of deriving changes in consumers' quantitative inflation expectations with respect to past inflation, we condition on the current inflation target of 2%. The resulting share of consumers with consistent Taylor rule expectations is plotted together with our baseline specification in Figure A.2 in the appendix. The consistency shares are very close, with a correlation coefficient of 0.67.

[15] Unfortunately, the Michigan Survey does not specify the type of interest rates in question [A11]. In order to analyse consumers' consistency with the Taylor rule, we have to assume that the interest rate consumers have in mind when answering question [A11] is positively correlated with the policy rate. Over our whole sample period from 1978m1-2012m9, the effective Federal Funds Rate is strongly correlated with a coefficient of 0.99 with interest rates at short maturities (3 months and 1 year Treasury Rates) and with a coefficient of 0.92 with rates at long maturities (10-year Treasury Rate and 30-year Conventional Mortgage Rate). When considering only the recent zero lower bound period (ZLB) starting in 2008m12, correlations remain high at 0.86 and 0.62 for the short maturity rates, but drop to 0.30 and 0.36 for the longer maturities. Assuming that consumers have some average of interest rates in mind when answering question [A11], we argue that it is nevertheless sensible to take their answer as a proxy for their view on the policy rate throughout the whole sample period. Additionally, we account for a possible effect of the ZLB period on consistency as a robustness check.

[16] As Carvalho and Nechio (2014) point out, there is a potential endogeneity and causality problem when discussing the relationship among these forecasts. Households' expectations might not reveal the causal effect of inflation and unemployment on interest rates as there exists a potential endogeneity due to monetary policy shocks (i.e. departures from systematic interest rate policy). However, Carvalho and Nechio (2014) show that monetary policy shocks in the post-Greenspan period (from 1987-2007) account only for a very small fraction of the variability in inflation and the output gap in the US. We additionally account for effects of shocks by including time series for demand and supply shocks and by accounting for the ZLB from 2008m12 onwards. All results are presented in the Appendix.

3 Data

For our analysis, we use the microdata of the University of Michigan Survey of Consumers. The telephone survey collects monthly data since January 1978 on consumers' macroeconomic expectations, personal income expectations, purchasing attitudes, perceived economic news, wealth position as well as demographic characteristics. Each monthly cross-section is chosen as a representative sample of the U.S. population. Additionally, about 40% of each monthly sample are chosen to be re-interviewed after six months, so that the survey contains a rotating panel dimension. We employ the full available sample period from January 1978 to September 2012 and include the whole cross-section in our analysis.[17]

In addition to the survey questions on consumers' expectations reviewed in the previous section, we use a number of variables from the Michigan Survey as control variables. These contain personal demographic characteristics and their interaction terms, where we include the consumer's sex, age, race, marital status, number of children, region as well as education and income groups. While household income is grouped into quintiles, the education groups are defined as follows: *educ1* – "*Grade 0-8, no high school diploma*", *educ2* – "*Grade 9-12, no high school diploma*", *educ3* – "*Grade 0-12, with high school diploma*", *educ4* – "*4 yrs. of college, no degree*", *educ5* – "*3 yrs. of college, with degree*" and *educ6* – "*4 yrs. of college, with degree*". For the analysis of consistency across demographic groups, we further define the following age groups: *age young – 18-34*, *age medium – 35-54* and *age old – 55-97*.

In addition to the microdata from the Michigan survey, a number of macroeconomic variables are included as explanatory variables in the analysis. These include the CPI inflation rate (π) and its volatility (σ_π^2) measured as the sum of squared inflation changes over the previous six months. Moreover, we include data on the civilian unemployment rate (u), the growth rate of the money stock M2 ($m2growth$), the Federal Funds rate ($funds_rate$), year-on-year oil price growth (oil) as well as a dummy variable $nber_recession$ which indicates whether the current month is classified as a recession by the NBER. All macroeconomic data is obtained from the FRED database of the St. Louis Federal Reserve.

Additionally, we aim at evaluating the effects of changes in the monetary policy communication strategy on consumers' ability to form consistent macroeconomic expectations. Therefore, we construct dummy variables representing important milestones on the path to more communication and greater transparency. In particular, we control for the introduction of the Beige Book first published in June 1983 ($BeigeBook83_t$), the announcement of changes in its target for the federal funds rate in February 1994 ($FFTargetAnnouncement94_t$), the practice of issuing a "balance of risks" statement along with the policy decision in January 2000 ($BalanceofRisk00_t$), the inclusion of votes with

[17]Note that we truncate quantitative inflation estimates to lie in the range from -5 to 30 in order to exclude any extreme forecasts. For further details on the University of Michigan Survey of Consumers, see http://www.sca.isr.umich.edu.

name(s) of dissenters in the statement in March 2002 ($Votes02_t$), providing forward guidance by explicitly indicating the likely direction of rates over an extended period in August 2003 ($ForwardGuidance03_t$), adding the Chairman's press conference to the release of projections in April 2011 ($PressConference11_t$) and finally including an explicit inflation target of 2% in January 2012 ($ExplicitTarget12_t$). Note that all communication dummies take on the value of 1 at the month of the introduction of the measure and all subsequent months, so that the coefficients measure the additional effect of this particular communication measures to the ones introduced previously.

Finally, we use data on professionals' inflation expectations from the Survey of Professional Forecasters (SPF) in order to compare the forecasting accuracy of consistent consumers with that of professional forecasters. The SPF contains, *inter alia*, quarterly forecasts on inflation over the next 12 months ($\pi_{prof}^{e,1yr}$), where one-year-ahead forecasts are available since 1981q3.

4 Results

4.1 Consistency of Expectations over Time and Across Demographic Groups

In this section, we present and discuss how many consumers form expectations in line with the Income Fisher equation, the Phillips curve and the Taylor rule. First, we show how the share of consumers with consistent expectations varies across the three economic concepts as well as across sociodemographic groups, where we compare shares between males and females, across age and education groups as well as income quintiles. Note that the unconditional probability of forming theory-consistent expectations in the Michigan Survey is one third for the Income Fisher equation and the Phillips curve, while it is 41.23% for the Taylor rule. Additionally, the unconditional probability of being consistent with all three principles is 4.58%. We use these unconditional probabilities as a natural benchmark. For all three relations individually as well as taken together, we find that the overall share of consistent consumers is significantly different from the unconditional probability, see Tables 1-4. Second, we check if the share of consumers with consistent expectations changes over time. If we find support for the latter, it would make sense to check for possible determinants that may affect the degree of consistency over time.

The following tables show how many individuals, relative to the overall sample, behave in line with accredited economic concepts. Regarding the Income Fisher equation, see Table 1, we conclude that roughly 51% of the surveyed population have theory-consistent expectations. When looking at the sociodemographic characteristics, it seems that men are more consistent than women. Moreover, the propensity to behave in line with the Income Fisher equation rises with education, income, and age. According to t-tests for equality of means and Kruskal-Wallis rank tests for equality of population, in all so-

ciodemographic groups both the mean and the median are significantly different from the remaining sample.[18] These results are very similar to the observed heterogeneity of inflation expectations across demographic groups in the literature.[19]

Table 1: Shares of Consumers with Consistent Expectations Regarding the Income Fisher Equation

	Mean	Median	SD	Min	Max	N	T-test Mean	K-W Test Median
All	0.51	0.51	0.04	0.41	0.64	223,143	97.23***	–
Male	0.54	0.54	0.04	0.40	0.67	99,539	-20.23***	306.08***
Female	0.49	0.49	0.04	0.37	0.64	123,237	20.22***	305.70***
Age young	0.48	0.49	0.05	0.26	0.61	65,133	15.71***	184.81***
Age medium	0.52	0.52	0.04	0.41	0.66	83,472	-3.61***	9.73***
Age old	0.53	0.53	0.06	0.37	0.69	73,283	-11.84***	104.94***
Educ1	0.47	0.47	0.13	0.00	1.00	9,896	7.11***	37.88***
Educ2	0.47	0.47	0.10	0.13	0.85	15,703	10.06***	75.83***
Educ3	0.47	0.47	0.05	0.34	0.73	68,603	22.16***	367.03***
Educ4	0.51	0.51	0.06	0.33	0.68	53,007	1.43	1.52
Educ5	0.54	0.54	0.06	0.36	0.72	44,962	-13.62***	138.98***
Educ6	0.59	0.58	0.06	0.41	0.81	28,672	-25.43***	483.07***
Inc quint1	0.50	0.50	0.07	0.24	0.75	32,181	5.34***	21.37***
Inc quint2	0.50	0.50	0.07	0.28	0.72	37,637	4.09***	12.51***
Inc quint3	0.50	0.50	0.06	0.31	0.72	39,113	3.71***	10.31***
Inc quint4	0.50	0.50	0.06	0.36	0.73	47,219	4.35***	14.18**
Inc quint5	0.54	0.54	0.05	0.37	0.71	49,124	-15.34***	176.07***

Notes: The last two columns represent (except the first row- All) tests for equality of means (medians) between a particular subsample indicated in the first column and the rest of the sample. For the mean we employ a two-sample mean-comparison t-test with equal variances and for the median a Kruskal-Wallis equality-of-populations rank test. In the first row we test whether the mean is different from the unconditional probability of having theory-consistent expectations in the Michigan Survey (0.33) with a one-sample t-test. ***/**/* indicates significance at the 1/5/10% level.

With regard to the Phillips curve (Table 2), we find a lower average a share of consistent consumers (34%) than in the case of the Income Fisher equation. While for the Income Fisher equation we could report substantial variation across educational groups, the shares forming expectations in line with the Phillips curve seem to be relatively homogeneously distributed across all educational groups. Nevertheless, we find a similar pattern for the distribution across income groups. In most cases the sub-groups are significantly

[18] We also apply Kruskal-Wallis equality-of-populations rank tests to test for significant differences in medians within the demographic groups, i.e. within age, education and income groups, for the shares shown in Tables 1-4. In all cases, except for the age groups of consistency with the Taylor rule, we find that the medians differ significantly also within groups. Test results are available from the authors upon request.

[19] See, for example, Jonung (1981), Bryan and Venkatu (2001), Pfajfar and Santoro (2009), and Anderson et al. (2010).

Table 2: Shares of Consumers with Consistent Expectations Regarding the Phillips Curve

	Mean	Median	SD	Min	Max	N	T-test Mean	K-W Test Median
All	0.34	0.34	0.05	0.16	0.47	238,396	4.89***	–
Male	0.34	0.35	0.05	0.17	0.50	106,349	-1.25	1.08
Female	0.34	0.34	0.05	0.15	0.48	131,542	1.12	0.82
Age young	0.35	0.36	0.06	0.16	0.53	71,453	-7.32***	36.13***
Age middle	0.34	0.34	0.06	0.16	0.51	88,146	3.94***	10.50***
Age old	0.34	0.33	0.06	0.14	0.54	77,329	2.90***	5.64**
Educ1	0.36	0.37	0.13	0.00	1.00	11,042	-4.48***	13.49***
Educ2	0.34	0.34	0.09	0.00	0.60	17,527	0.76	0.36
Educ3	0.34	0.34	0.06	0.16	0.51	73,949	-0.07	0.01
Educ4	0.33	0.34	0.06	0.13	0.50	56,170	3.18***	6.87***
Educ5	0.35	0.35	0.07	0.14	0.58	46,924	-3.06***	6.26**
Educ6	0.34	0.33	0.08	0.13	0.56	30,038	1.62	1.80
Inc quint1	0.33	0.33	0.07	0.00	0.57	32,552	5.17***	18.20***
Inc quint2	0.34	0.34	0.07	0.00	0.59	38,675	3.03***	6.20**
Inc quint3	0.34	0.33	0.07	0.09	1.00	39,847	4.17***	11.80***
Inc quint4	0.35	0.35	0.06	0.11	0.50	48,349	-3.70***	9.28***
Inc quint5	0.36	0.36	0.06	0.14	0.55	50,470	-6.90***	32.31***

Notes: The last two columns represent (except the first row- All) tests for equality of means (medians) between a particular subsample indicated in the first column and the rest of the sample. For the mean we employ a two-sample mean-comparison t-test with equal variances and for the median a Kruskal-Wallis equality-of-populations rank test. In the first row we test whether the mean is different from the unconditional probability of having theory-consistent expectations in the Michigan Survey (0.33) with a one-sample t-test. ***/**/* indicates significance at the 1/5/10% level.

different from the rest of the sample. The rather low variation across sociodemographic groups together with the substantial gap between minimum and maximum values already suggest a remarkable time variation.

With respect to the Taylor rule (Table 3), we find the share of consistent consumers to be around 46% on average. Similar to the results for the Phillips curve, we find only little, but nevertheless often significant, variation across socioeconomic characteristics, where the patterns across demographic groups are mostly in line with those found for the Income Fisher equation. Again, summary statistics show substantial variation over time.

Finally, we present the summary statistics for the share of people that form consistent estimates for all three economic concepts simultaneously at a time. Results are presented in Table 4. Only 6% of the surveyed population have expectations that are in line with all three concepts. This is significantly below the average of the individual tables and indicates that if people have reacted for instance appropriately with regard to the Taylor rule, this does not necessarily imply that they will form expectations in line with the other economic concepts. Nevertheless, this still seems to increase the likelihood of

Table 3: Shares of Consumers with Consistent Expectations Regarding the Taylor Rule

	Mean	Median	SD	Min	Max	N	T-test Mean	K-W Test Median
All	0.46	0.46	0.08	0.23	0.63	238,396	13.47***	–
Male	0.46	0.45	0.08	0.23	0.69	106,349	0.42	0.14
Female	0.46	0.46	0.08	0.24	0.65	131,542	-0.50	0.26
Age young	0.44	0.44	0.08	0.19	0.71	71,453	10.15***	76.60***
Age middle	0.46	0.46	0.08	0.24	0.70	88,146	-0.39	0.14
Age old	0.47	0.47	0.09	0.20	0.68	77,329	-9.79***	71.29***
Educ1	0.42	0.42	0.14	0.00	1.00	11,042	5.69***	24.05***
Educ2	0.42	0.42	0.11	0.14	0.80	17,527	9.11***	61.80***
Educ3	0.45	0.45	0.08	0.19	0.64	73,949	4.60***	15.78***
Educ4	0.46	0.46	0.08	0.22	0.67	56,170	0.76	0.39
Educ5	0.47	0.47	0.09	0.21	0.74	46,924	-7.32***	39.95***
Educ6	0.48	0.48	0.11	0.17	0.72	30,038	-8.17***	49.62***
Inc quint1	0.44	0.44	0.08	0.11	1.00	32,552	6.96***	36.06***
Inc quint2	0.45	0.46	0.09	0.22	0.68	38,675	3.69***	10.13***
Inc quint3	0.47	0.47	0.09	0.18	0.76	39,847	-0.75	0.45
Inc quint4	0.46	0.46	0.09	0.18	0.77	48,349	0.68	0.36
Inc quint5	0.48	0.48	0.10	0.20	0.76	50,470	-8.67***	56.05***

Notes: The last two columns represent (except the first row- All) tests for equality of means (medians) between a particular subsample indicated in the first column and the rest of the sample. For the mean we employ a two-sample mean-comparison t-test with equal variances and for the median a Kruskal-Wallis equality-of-populations rank test. In the first row we test whether the mean is different from the unconditional probability of having theory-consistent expectations in the Michigan Survey (0.41) with a one-sample t-test. ***/**/* indicates significance at the 1/5/10% level.

being consistent with all three relations as we find that 6% is significantly higher than the unconditional probability of 4.58%. Again, we find rather little variation across sociodemographic characteristics, but increased variation over time. This result thus also supports the presumption that the degree of consistency is time-varying and may be linked and tested with regard to a set of possible macroeconomic determinants.

The substantial time variation indicated by the previous tables calls for a deeper investigation of this issue. Consequently, we plot the calculated shares over time. Figure 1 shows the shares of consistent expectations for all three economic concepts individually as well as the share of consistent expectations satisfying all three economic concepts simultaneously. Regarding the Income Fisher equation, we observe, as already indicated by the summary statistics, rather little time variation. This is in line with our presumption that the distinction between real and nominal income should be less dependent on changes in macroeconomic conditions than the Phillips curve and the Taylor rule which may not

Table 4: Shares of Consumers with Consistent Expectations for All Three Economic Concepts

	Mean	Median	SD	Min	Max	N	T-test Mean	K-W Test Median
All	0.06	0.06	0.02	0.02	0.15	223,143	19.16***	–
Male	0.07	0.07	0.03	0.02	0.17	99,539	-8.93***	14.53***
Female	0.06	0.06	0.02	0.01	0.15	123,237	8.89***	14.39***
Age young	0.06	0.06	0.03	0.00	0.20	65,133	5.06***	4.64**
Age middle	0.06	0.06	0.02	0.01	0.16	83,472	1.69*	0.53
Age old	0.07	0.07	0.03	0.01	0.21	73,283	-6.95***	8.81***
Educ1	0.06	0.05	0.07	0.00	0.67	9,896	0.51	0.03
Educ2	0.05	0.05	0.04	0.00	0.30	15,703	5.01***	4.60**
Educ3	0.06	0.06	0.02	0.00	0.17	68,603	8.84***	14.24***
Educ4	0.06	0.06	0.03	0.00	0.22	53,007	3.52***	2.27
Educ5	0.07	0.07	0.03	0.01	0.23	44,962	-7.60***	10.51***
Educ6	0.08	0.08	0.04	0.00	0.26	28,672	-10.74***	21.04***
Inc quint1	0.06	0.06	0.03	0.00	0.20	32,181	3.29***	1.99
Inc quint2	0.06	0.05	0.03	0.00	0.19	37,637	6.13***	6.87***
Inc quint3	0.06	0.06	0.03	0.00	0.16	39,113	1.99**	0.71
Inc quint4	0.06	0.06	0.03	0.00	0.18	47,219	2.03**	0.76
Inc quint5	0.08	0.07	0.03	0.01	0.19	49,124	-11.65***	24.75***

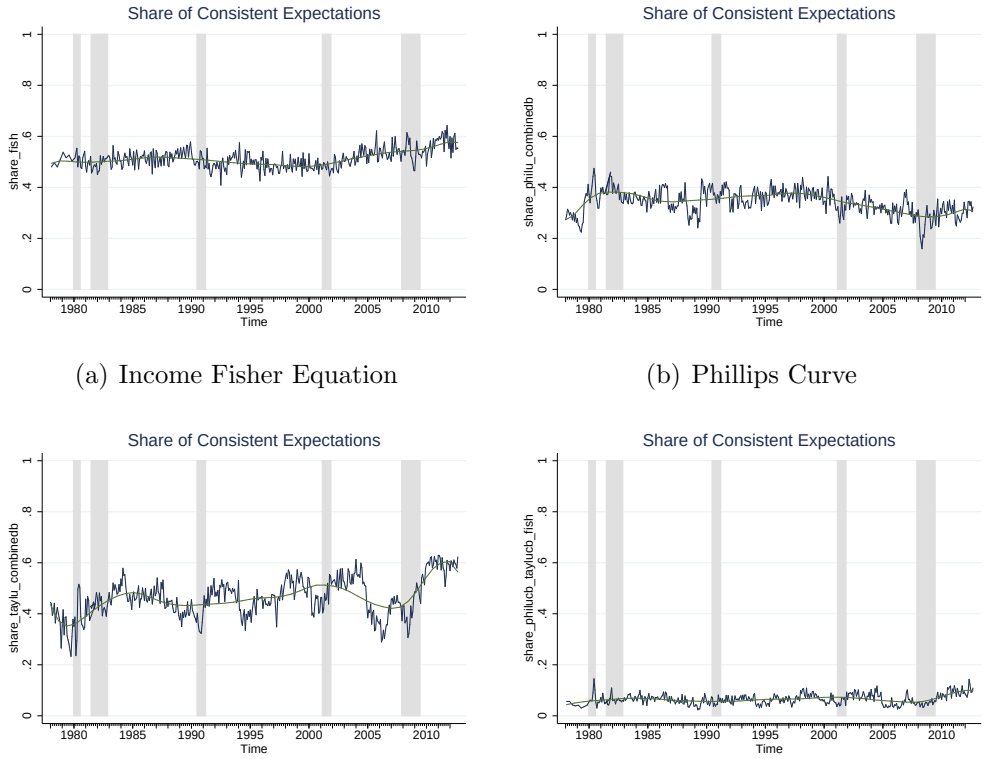
Notes: The last two columns represent (except the first row- All) tests for equality of means (medians) between a particular subsample indicated in the first column and the rest of the sample. For the mean we employ a two-sample mean-comparison t-test with equal variances and for the median a Kruskal-Wallis equality-of-populations rank test. In the first row we test whether the mean is different from the unconditional probability of having theory-consistent expectations in the Michigan Survey (0.046) with a one-sample t-test. ***/**/* indicates significance at the 1/5/10% level.

always be satisfied in reality.[20] Over the last ten years the consistency of the public with respect to the Income Fisher equation seems to follow an upwards trend.

With respect to the Phillips curve and the Taylor rule, the consistency shares show more time variation with a pronounced cyclical pattern especially for the share of consumers consistent with the Taylor rule. Recession periods dated by the NBER, indicated by the shaded areas, seem to impair the ability to form consistent expectations as they correspond with downward dips in the consistency shares. Regarding the share of consumers consistent with the Phillips curve, we observe that the share has fallen somewhat since the beginning of the 2000s. This may be due to the relatively low and stable infla-

[20]Figure A.3 in the appendix depicts the shares of consumers consistent with the Phillips curve and the Taylor rule together with the periods when the Phillips curve trade-off and the Taylor rule concept where realised in the changes in actual data 12 months ahead, rounded to the nearest integer. It seems that both were realised in the majority of periods in our sample. However, there are pronounced gaps at the beginning of the sample period, when the U.S. economy was experiencing the stagflation of the 1970s and the subsequent Volcker disinflation. This could provide an explanation for the relatively low consistency shares observed during this period.

Figure 1: Shares of Consistent Expectations



(a) Income Fisher Equation

(b) Phillips Curve

(c) Taylor Rule

(d) All

Note: Graphs present the shares of consumers with consistent expectations, together with a polynomial trend. Shaded areas denote recession periods as defined by the NBER.

tion rate in recent years, which might make it more difficult for consumers to grasp the Phillips curve trade-off.

Looking at the Taylor rule share specifically, we observe that it exhibits more variability compared to the other two concepts. We can report that the share of consistent consumers is lower during recessions, especially for the Volcker disinflation period and the recent recession. Generally, in all cross-sections there are higher shares of households who expect interest rate increases than decreases. Therefore, within a tightening cycle, when actual interest rates increase, the expectations become more in line with the Taylor rule concept. Moreover, we observe that after the economy hit the zero lower bound, the consistency share increased. One could conjecture that the ZLB together with the improvement in forward guidance helped people in forming consistent expectations. Regarding effects of the chairman of the Federal Reserve Board, it is difficult to visually confirm any difference in consistency with the Taylor rule across the mandates. Finally, one could also argue that after the publication of the Taylor (1993) paper more people became aware of the way the monetary policy is conducted. However, eyeballing the graph it is difficult to confirm these results.

Finally, we further find some variation over time of the share of consumers consistent with all three macroeconomic relations, albeit at a very low level. Again, we observe small dips during recession periods.

While we have shown that the shares of consistent consumers vary over time and across demographic groups, it is also interesting to check if consumers stay consistent between the first and the second interview of the rotating panel. Overall, between 45-60% of consumers are either consistent or inconsistent in both interviews. This result holds for all three concepts evaluated. Moreover, being consistent in the first interview increases the likelihood of being consistent in the second interview by about 10-16% for a representative consumer as defined below.[21]

Furthermore, we are interested in elaborating the reasons why expectations are not consistent with the economic concepts. Looking at the Income Fisher relationship, we observe that there are more inconsistent households that have negative real income expectations, but at the same time expect higher growth in nominal income than in prices, than *vice versa*. Regarding the Phillips curve, those households that report prices to go up, do not expect unemployment to go down. In fact, more than 85% of households who expect inflation to go up, predict the unemployment rate to stay about the same or to be higher in the next year. Dissecting the Taylor rule relationship implies that households generally have problems with cases when nominal interest rates should be expected to fall, either due to lower inflation or higher unemployment expectations. Especially, there exist only weak links between expecting higher rates of unemployment and falling interest rates. This is quite an interesting result. The Fed is known to put significant weight on unemployment rates and economic growth relative to inflation as compared for instance to the ECB. Therefore, one would expect that consumers in the U.S. would have less difficulties in understanding this relationship for a central bank that is as active in regarding stabilizing unemployment as the Fed is.

4.2 Determinants of Consistency

In this section, we analyse possible macroeconomic determinants for the formation of consistent expectations and check for effects of monetary policy communication. Specifically, we evaluate the relevance of macroeconomic conditions like inflation, unemployment, money growth, short-run interest rates or the effect of being in a recession. We furthermore investigate the inflation effect on consistency in more detail by distinguishing between inflation above and below the official target of 2%. Next, we check whether macroeconomic effects differ between boom and recession periods. Finally, we analyse how changes in the communication strategy of the Federal Reserve have affected consumers' consistency with

[21] Estimation results from heckprobit models controlling for demographic factors are available from the authors upon request.

macroeconomic concepts. All macroeconomic variables are included with one lag in order to account for a publication lag.

We estimate probit models on the probability of forming theory-consistent expectations regarding the Income Fisher equation, the Phillips curve, the Taylor rule as well as for all three macroeconomic relations simultaneously. Tables 5-8 report marginal effects for our set of determinants. In order to enable comparability across models, all marginal effects are evaluated at a hypothetical "representative" consumer which we take to be male, white, 40 years old, married, with a medium level of education and income and living in the Northcentral region of the U.S. All models additionally include a wide range of demographic controls including interaction terms thereof. Robust standard errors are calculated with the δ method (Oehlert 1992).[22]

We thus specify a binary response model. The following variable is defined:

$$z_{i,t} = \begin{cases} 1 \text{ if } z^*_{i,t} > 0 \\ 0 \text{ if } z^*_{i,t} \leq 0 \end{cases}, \; i = 1, 2, ..., N, \tag{5}$$

where $z^*_{i,t}$ is the latent variable that accounts for consumers' theory-consistent expectations. Its discrete counterpart, $z_{i,t}$, takes value one if the ith respondent formed theory-consistent expectations in period t, and zero otherwise. The following latent process is assumed:

$$z^*_{i,t} = \alpha_1 + \mathbf{y}_t\alpha_2 + \mathbf{x}_{i,t}\alpha_3 + u_{i,t}, \tag{6}$$

where α_1 is a constant, $\mathbf{y}_t$ is the vector of macroeconomic variables, $\mathbf{x}_{i,t}$ is a vector of socio-demographic characteristics (namely gender, age, income, education, race, marital status, location in the US and interaction terms between gender and education, race and region, as well as income and marital status) and $u_{i,t}$ is normally distributed. We derive the marginal partial effects from the estimation of $\Pr(\, z_{i,t}= 1|\, \mathbf{h}_{i,t}) = \Phi\left(\mathbf{h}_{i,t}\xi\right)$, where $\Phi(\cdot)$ is the CDF of the standard normal distribution, $\mathbf{h}_{i,t}$ is the vector of covariates and ξ is a vector of coefficients.

Since our dataset contains single survey interviews as well as interviews within the rotating panel, estimations on the full dataset may lead to biased estimates due to a sample selection problem. Moreover, additional sample selection might arise from non-response bias, which might be higher for specific demographic groups.[23] We therefore account for possible attrition both with respect to non-response and with respect to being selected into the rotating panel and estimate all models with a Heckman correction. Our selection variable thus takes on the value of one for second interviews within the rotating

[22] Using standard errors clustered at the monthly level yield qualitatively similar results, and are shown in the Appendix in Table A.2. Robust standard errors are used here as there is no obvious dimension for clustering.

[23] Specifically, we evaluate non-response to the question on quantitative inflation expectations. We argue that this question might be perceived as being more demanding than the qualitative questions and, thus, more prone to non-response.

panel, conditional on response to the question on quantitative inflation expectations.[24] Sample selection will only bias the estimates if the error terms of the outcome and of the selection equation are significantly correlated as measured by the parameter ρ. Overall, sample selection seems to have relatively small effects in our models since a Wald test frequently cannot reject $\rho = 0$.

The marginal effects from the Heckman probit models in Table 5 imply that U.S. consumers are less likely to form theory-consistent macroeconomic expectations with respect to the Taylor rule in periods with high inflation levels and volatility, whereas the inflation level is positively related to consistency with the Income Fisher equation. This could imply that while high and volatile inflation makes it harder for consumer to predict the appropriate monetary policy response, higher inflation increases the difference between real and nominal values and, thus, makes money illusion less likely. Interestingly, a higher Federal Funds rate has a negative impact on consistency with both the Income Fisher equation and the Taylor rule. Similarly, higher oil prices impair consumers' ability to form expectations consistent with the Phillips curve and jointly for all three relations. Results regarding the effect of unemployment and money growth are less clear-cut and difficult to interpret. Finally, consumers show significantly lower degrees of consistency with the Phillips curve and the Taylor rule in recession periods, while we find no significant business-cycle-effect on consistency with the Income Fisher equation. This result is as expected, considering the low time-variation in the share of consistent consumers regarding the Income Fisher equation compared to consistency shares for the Phillips curve and the Taylor rule.

Next, we evaluate the nature of the inflation effect on consistency in more detail. In Table 6 we check whether inflation effects on consistency differ between periods with inflation above or below the official target of 2%. We find that consistency with the Phillips curve and the Taylor rule, and to some extent also consistency with all relations, is negatively affected by inflation at rates above 2%: At high inflation rates, consumers are increasingly unsure about the inflation-unemployment trade-off and the appropriate monetary policy reaction. Additionally, we find a positive inflation effect at rates below 2%, suggesting that consumers also have problems with correctly identifying the macroeconomic relations under consideration when inflation is below the target. Interestingly, our results suggest a positive effect of inflation above 2% on consistency with the Income Fisher equation. Additionally, the marginal effects of inflation volatility become insignificant when we account for asymmetric inflation effects below and above 2%.

In a next step, we interact the recession dummy with the other macroeconomic determinants in Table 7 in order to evaluate whether these macro effects differ over the business cycle. Throughout all three macroeconomic concepts analysed, macroeconomic determinants have significantly different effects between boom and recession periods. In

[24]Note that our Heckman probit estimates thus effectively account for only second interviews within the rotating panel.

Table 5: Macro Determinants of Consistency

	Income Fisher eq.	Phillips curve	Taylor rule	All Three
π_{t-1}	0.0125***	-0.0047	-0.0067**	0.0031
	(0.0023)	(0.0031)	(0.0029)	(0.0032)
$\sigma^2_{\pi,t-1}$	-0.0007	-0.0002	-0.0046***	-0.0012
	(0.0014)	(0.0017)	(0.0016)	(0.0014)
oil_{t-1}	0.0001*	-0.0002***	0.0001	-0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
u_{t-1}	0.0072***	-0.0028*	0.0142***	0.0044**
	(0.0012)	(0.0015)	(0.0015)	(0.0021)
$m2growth_{t-1}$	0.0030***	-0.0028*	0.0067***	0.0037*
	(0.0007)	(0.0015)	(0.0008)	(0.0021)
$funds_rate_{t-1}$	-0.0095***	0.0045	-0.0111***	-0.0074
	(0.0011)	(0.0038)	(0.0015)	(0.0050)
$nber_recession_t$	0.0032	-0.0287**	-0.0319***	-0.013
	(0.0077)	(0.0117)	(0.0110)	(0.0100)
N	93,763	95,893	95,389	93,109
χ^2	656.052	241.017	731.434	842.513
Demographic Controls	Yes	Yes	Yes	Yes
ρ	-0.815	-0.068	-0.494	-0.606
Wald test ($\rho = 0$, χ^2)	12.60***	0.02	4.46**	1.44

Notes: Table 5 reports the marginal partial effects from the heckprobit models evaluated at the representative consumer. The Wald test for $\rho = 0$ gives the χ^2 statistics of the Wald test for independence from the sample selection equation. Robust standard errors are calculated with the δ method (Oehlert 1992) and are reported in parentheses. ***/**/* indicates significance at the 1/5/10% level.

line with our results in Table 6, we find that inflation increases the likelihood for consumers to form expectations consistent with the Phillips curve during recessions (when inflation rates typically fall). Interestingly, our results suggest that the effect of oil price increases moves in the opposite direction to the inflation effect: Higher oil prices significantly increase the likelihood of consistency with the Income Fisher equation during recessions, while they have a detrimental effect on consistency with the Phillips curve or the Taylor rule. This can be explained with rather strong oil price hikes during some of the recessions in our sample period, especially during the oil price shocks of 1980 and 1990-91 and at the beginning of the financial crisis in 2008. Finally, both the marginal effects of the Fed Funds rate and money supply growth seem relatively constant over the business cycle.

Finally, we test for an impact of changes in the communication strategy of the Fed on consumers' likelihood of forming consistent expectations. This is highly relevant, since having a sound understanding of monetary policy increases the effectiveness of monetary policy making. In an effort to improve the understanding of monetary policy and to guide expectations of the public, central banks have, over the last two decades, established new

Table 6: Inflation Effects Above and Below 2% on Consistency

	Income Fisher eq.	Phillips curve	Taylor rule	All Three
$dummy_\pi_below2_{t-1}$	0.0247**	-0.0347**	-0.0418***	-0.0225**
	(0.0116)	(0.0141)	(0.0139)	(0.0114)
π_{t-1}	0.0127***	-0.0092***	-0.0134***	-0.0017
	(0.0029)	(0.0034)	(0.0033)	(0.0026)
$\pi_{t-1} * dummy_\pi_below2_{t-1}$	-0.008	0.0278***	0.0383***	0.0220***
	(0.0056)	(0.0068)	(0.0070)	(0.0067)
$\sigma^2_{\pi,t-1}$	-0.0009	0.002	-0.0042*	0.0012
	(0.0020)	(0.0025)	(0.0024)	(0.0019)
$\sigma^2_{\pi,t-1} * dummy_\pi_below2_{t-1}$	-0.0009	-0.0034	-0.0008	-0.0045*
	(0.0025)	(0.0033)	(0.0031)	(0.0027)
oil_{t-1}	0.0002***	-0.0002**	0.0001	-0.0002**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
u_{t-1}	0.0072***	-0.0011	0.0172***	0.0058**
	(0.0012)	(0.0017)	(0.0015)	(0.0026)
$m2growth_{t-1}$	0.0026***	-0.0034***	0.0056***	0.0028
	(0.0007)	(0.0013)	(0.0008)	(0.0018)
$funds_rate_{t-1}$	-0.0086***	0.0054*	-0.0091***	-0.0058
	(0.0010)	(0.0031)	(0.0014)	(0.0042)
$nber_recession_t$	0.0032	-0.0154	-0.0155	0.0006
	(0.0085)	(0.0140)	(0.0111)	(0.0132)
N	93,763	95,893	95,389	93,109
χ^2	649.422	265.052	770.548	1235.004
Demographic Controls	Yes	Yes	Yes	Yes
ρ	-0.814	-0.053	-0.435	-0.569
Wald test ($\rho = 0$, χ^2)	12.95***	0.01	3.77**	1.26

Notes: Table 6 reports the marginal partial effects from the heckprobit models evaluated at the representative consumer. The Wald test for $\rho = 0$ gives the χ^2 statistics of the Wald test for independence from the sample selection equation. Robust standard errors are calculated with the δ method (Oehlert 1992) and are reported in parentheses. ***/**/* indicates significance at the 1/5/10% level.

means of communication and transparency. To evaluate the success of these efforts, we test to which extend the introduction of specific elements improved the understanding of the public regarding monetary policy and helped them to form consistent expectations.[25] In order to analyse potential effects, we use the same set of macroeconomic determinants used beforehand and amend this regression by the set of dummy variables representing

[25]We also tested for an effect of the Chairmen of the Federal Reserve Board by including dummy variables for the terms of Volcker and Greenspan (with Bernanke's term as reference period). When the Chairmen dummies are included as regressors together with the communication dummies, we find only one significant effect on consistency with the Income Fisher equation. Thus, it seems that the communication dummies capture the effects of changes in the conduct of monetary policy on consistency reasonably well. If we exclude the communication dummies, we find that consumers were less consistent with the Income Fisher equation during both the Volcker and the Greenspan presidencies, while the Greenspan presidency coincided with an improvement in consistency regarding the Phillips curve and the Taylor rule. Additionally, we find no significant effect of the publication of the Taylor (1993) paper on consistency with the Taylor rule. All results are available upon request.

Table 7: Recession Interaction Effects on Consistency

	Income Fisher eq.	Phillips curve	Taylor rule	All Three
π_{t-1}	0.0127***	-0.0068**	-0.0111***	-0.0001
	(0.0029)	(0.0028)	(0.0029)	(0.0014)
$\pi_{t-1} * nber_recession_t$	-0.0065	0.0342***	0.0135	0.0053
	(0.0116)	(0.0115)	(0.0115)	(0.0060)
$\sigma^2_{\pi,t-1}$	0.0022	0.003	-0.0090***	0.0003
	(0.0023)	(0.0022)	(0.0023)	(0.0012)
$\sigma^2_{\pi,t-1} * nber_recession_t$	-0.0047	-0.0053	0.0097**	-0.0007
	(0.0040)	(0.0039)	(0.0039)	(0.0020)
oil_{t-1}	-0.0001	-0.0002**	0.0002**	-0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0000)
$oil_{t-1} * nber_recession_t$	0.0009***	-0.0010***	-0.0014***	-0.0002
	(0.0003)	(0.0003)	(0.0003)	(0.0002)
u_{t-1}	0.0069***	-0.0039***	0.0164***	0.0023***
	(0.0015)	(0.0014)	(0.0014)	(0.0008)
$u_{t-1} * nber_recession_t$	0.0095	0.0208***	-0.0238***	-0.0015
	(0.0080)	(0.0079)	(0.0080)	(0.0040)
$m2growth_{t-1}$	0.0007	-0.0019**	0.0054***	0.0016***
	(0.0009)	(0.0009)	(0.0009)	(0.0005)
$m2growth_{t-1} * nber_recession_t$	0.0113	0.008	0.0005	0.0001
	(0.0097)	(0.0094)	(0.0096)	(0.0048)
$funds_rate_{t-1}$	-0.0041***	0.0034***	-0.0069***	-0.0025***
	(0.0014)	(0.0013)	(0.0015)	(0.0008)
$funds_rate_{t-1} * nber_recession_t$	0.0036	0.0073	0.0055	0.0029
	(0.0051)	(0.0050)	(0.0051)	(0.0026)
$nber_recession_t$	-0.1517	-0.3397***	0.0267	-0.0335
	(0.1317)	(0.1293)	(0.1319)	(0.0654)
N	93,763	95,893	95,389	93,109
chi2	609.24	272.297	668.813	261.544
Demographic Controls	Yes	Yes	Yes	Yes
rho	-0.019	-0.118	0.051	0.024
Wald test (rho=0, chi2)	0.06	2.05	0.22	0.04

Notes: Table 7 reports the marginal partial effects from the heckprobit models evaluated at the representative consumer. The Wald test for $\rho = 0$ gives the χ^2 statistics of the Wald test for independence from the sample selection equation. Robust standard errors are calculated with the δ method (Oehlert 1992) and are reported in parentheses. ***/**/* indicates significance at the 1/5/10% level.

important milestones in the communication strategy of the Fed, as defined in section 3.[26] Estimation results are presented in Table 8.

As those milestones should influence the likelihood of being consistent with the Taylor rule the most, we interpret these results first. We can report that the introduction of the Beige Book, the assessment of risk, as well as the announcement of an explicit inflation target helped to increase the propensity of consumers to form consistent expectations.

[26] Middeldorp (2011) also incorporates dummy variables to control for important milestones of communication.

Table 8: Consistency and Central Bank Communication

	Income Fisher eq.	Phillips curve	Taylor rule	All Three
π_{t-1}	-0.0008	0.0080**	-0.0082**	0.0026
	(0.0031)	(0.0037)	(0.0037)	(0.0032)
$\sigma^2_{\pi,t-1}$	-0.0030**	0.0059***	0.0006	0.0011
	(0.0015)	(0.0018)	(0.0018)	(0.0014)
oil_{t-1}	0.0001**	-0.0003***	0.0002*	-0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
u_{t-1}	0.0044***	0.0002	0.0170***	0.0064***
	(0.0017)	(0.0020)	(0.0020)	(0.0024)
$m2growth_{t-1}$	-0.0030***	0.0001	0.0056***	0.0014
	(0.0010)	(0.0016)	(0.0015)	(0.0015)
$funds_rate_{t-1}$	0.0022	-0.0023	-0.0108***	-0.0041***
	(0.0015)	(0.0017)	(0.0020)	(0.0014)
$nber_recession_t$	0.0288***	-0.0453***	-0.0380***	-0.0063
	(0.0082)	(0.0133)	(0.0142)	(0.0175)
$BeigeBook83_t$	-0.0398***	0.0106	0.0529**	0.0058
	(0.0136)	(0.0226)	(0.0207)	(0.0254)
$FFTargetAnnouncement94_t$	-0.0061	0.0345***	-0.0035	0.0127*
	(0.0072)	(0.0087)	(0.0083)	(0.0072)
$BalanceofRisk00_t$	0.0125	-0.0263*	0.0283**	0.0068
	(0.0097)	(0.0157)	(0.0127)	(0.0207)
$Votes02_t$	0.0214*	-0.0158	-0.0262*	0.0132
	(0.0117)	(0.0136)	(0.0141)	(0.0128)
$ForwardGuidance03_t$	0.0234**	-0.0366***	-0.0393***	-0.0312*
	(0.0103)	(0.0141)	(0.0114)	(0.0160)
$PressConference11_t$	0.0396***	-0.0349**	0.0113	-0.0072
	(0.0150)	(0.0174)	(0.0175)	(0.0144)
$ExplicitTarget12_t$	0.1056***	0.0407	0.0948***	0.1023
	(0.0196)	(0.0582)	(0.0326)	(0.0806)
N	93,763	95,893	95,389	93,109
χ^2	826.565	356.641	774.066	451.758
Demographic Controls	Yes	Yes	Yes	Yes
ρ	-0.832	0.091	-0.350	-0.586
Wald test (ρ=0, χ^2)	17.91***	0.06	2.41	1.28

Notes: Table 8 reports the marginal partial effects from the heckprobit models evaluated at the representative consumer. The Wald test for $\rho = 0$ gives the χ^2 statistics of the Wald test for independence from the sample selection equation. Robus standard errors are calculated with the δ method (Oehlert 1992) and are reported in parentheses. ***/**/* indicates significance at the 1/5/10% level.

Regarding the relative size of the effects, the announcement of the explicit inflation target stands out followed by the introduction of the Beige Book. Both events may certainly be characterized as major steps in the communication policy of the Federal Reserve. Moreover, given that the introduction of the explicit target has to be seen relative to the introduction of the means beforehand, this result is remarkable in terms of size and significance. Furthermore, we can also observe that the publication of the voting record did not

help to improve the ability to form consistent expectations with respect to the Taylor rule. This might not be surprising as this basically reflects a dimension of disagreement that may not help to steer expectations in a specific direction. Interestingly, the introduction of forward guidance in 2003 does not lead to significantly more people having consistent Taylor rule expectations relative to the other means introduced beforehand.

Moreover, we also find effects of monetary policy communication on consistency with the Income Fisher equation and the Phillips curve. The announcement of changes in the Federal Funds target rate in February 1994 stands out as it had a positive effect on consistency with the Phillips curve as well as consistency with all three concepts simultaneously. Moreover, the announcement of the explicit inflation target in January 2012, in addition to improving consistency with the Taylor rule, also significantly raised the likelihood of consistency with the Income Fisher equation. Notably, the effect has a similar size for both relations. Additionally, we find positive effects of the publication of votes, the introduction of forward guidance and the press conference on consumers' likelihood of correctly distinguishing between real and nominal expected income.[27]

Finally, we conduct some robustness checks. First, we re-estimate Table 8 with clustered standard errors at the monthly frequency, second we control for a potential effect of the zero lower bound (ZLB) period when interest rates set by the Federal Reserve were close to zero, and third we control for effects of demand and supply shocks as identified by Kilian (2009).

Table A.2 in the appendix contains the results using robust clustered standard errors. While this method slightly reduces the significance of the reported coefficients, it does not change our main implications. Hence, we can still report the relevance of communication milestones and the recession effect.

Next, Table A.3 comprises the results with a dummy for the ZLB period, which takes on the value of one from 2008m12 onwards. We include both a level effect and interaction terms with all macroeconomic determinants, except for the Fed Funds rate, which is constant at the ZLB. Overall, our results remain valid with respect to both macroeconomic determinants and communication effects. Interestingly, the level effect of the ZLB period on consistency is not statistically significant. Nevertheless, we find some significant interaction terms. If the interaction effect is significant, it reduces the explanatory power of those macro factors on consistency during the ZLB. For instance, while money growth

[27] We also check for the potentially heterogeneous impact of communication effects across demographic groups by varying different characteristics of our representative agent when calculating marginal effects. While we find the differences across demographic groups to be small, and generally not significant, we still observe some patterns: For example, regarding the Taylor rule the effect of the introduction of the inflation target is higher for men, poorer consumers, and those with less education. On the contrary, regarding the effect of announcing the Federal Funds target on consistency with the Phillips curve, we find that it is higher for wealthier and more educated households. The results are available from the authors upon request. We furthermore investigate if our results hold also if we add a time trend and if we estimate the same equation with only a subset of dummy variables, i.e. using only the events Beige Book, Federal Funds Target and the explicit announcement of the inflation target. The results remain virtually the same.

increases the probability of forming consistent expectations with the Taylor rule, being at the ZLB mutes this effect, as the coefficient of the dummy variable works in the opposite direction. The same can be reported for inflation volatility and oil prices with respect to the Phillips-Curve. This result is quite interesting and might reflect the fact that the recent economic crisis is quite different and that some structural relationships are not present or have to be recalibrated.

Finally, we check whether demand or supply shocks hitting the economy have an effect on consistency. In principle, especially predominant supply shocks could affect consumers' consistency with the Phillips curve. This is because supply shocks shift the Phillips curve, so that the economy moves along an aggregate demand curve and we might observe a positive relation between inflation and unemployment in actual data. A prominent example for this type of situation is the stagflation period in the 1970s and early 1980s. Figure A.4 in the Appendix shows the share of consumers consistent with the Phillips curve together with periods where demand shocks dominated in absolute size over supply shocks.[28] During these periods, the trade-off is thus relatively more likely to hold in actual data. In the earlier part of the sample, we observe that the consistency share drops when supply shocks dominate the economy for several periods. This relation becomes less obvious in the second half of our sample period, when the economy was hit by fewer predominant supply shocks. Next, we include both supply and demand shocks in the regressions in Table A.4.[29] Overall, demand and supply shocks seem to have only minor influence on consumers' consistency, and especially no significant effect on consistency with the Phillips curve. Nevertheless, we do find a negative effect of demand shocks on consistency with the Taylor rule and a marginally significant positive effect of supply shocks on consistency with the Income Fisher equation. Hence, it seems that supply shocks, which typically coincide with upward jumps in inflation, help consumers to distinguish between real and nominal values, while demand shocks, which typically lead to a fall in inflation, make it harder for consumers to predict the appropriate monetary policy reaction. Notably, while a number of macroeconomic determinants become insignificant for consistency with the Income Fisher equation, most effects of macroeconomic determinants remain robust in the regressions for the Phillips curve and the Taylor rule, but the negative recession effect becomes insignificant. The effects of central bank communication also remain largely robust, but we loose a few effects on consistency with the Taylor rule. This is an interesting finding, as it suggests that some communication effects for the understanding of the conduct of monetary policy interact with the occurrence of shocks, especially demand shocks.

[28]The time series for demand and supply shocks are obtained from Kilian (2009) who estimates the shocks in a VAR framework. Note that the time series in Kilian (2009) run only until 2007m12.

[29]Since the time series in Kilian (2009) run only until 2007m12, we cannot check for robustness of the effects from introducing a press conference in April 2011 and the explicit inflation target in January 2012.

4.3 Consistency and Forecast Accuracy

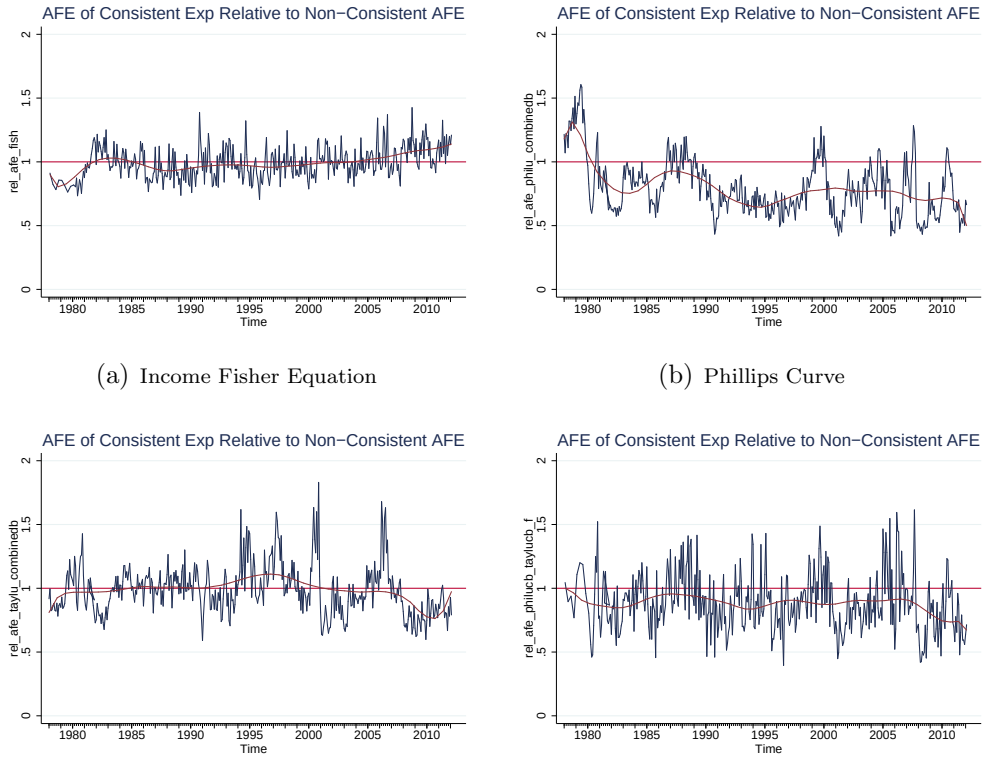
Do respondents that form theory-consistent expectations also form more accurate forecasts? Ang et al. (2007) show that professional forecasters in the SPF predict inflation better than any other forecasting model or than expectations extracted from the bond market. Several studies have further pointed out that household expectations are important from the perspective of monetary policy. We study the accuracy of quantitative inflation expectations of consistent and non-consistent consumers and compare them to the median forecast of the SPF. Thus, we evaluate if we can systematically extract individuals – not only based on demographic characteristics – that produce more accurate inflation forecasts.

We start the analysis by plotting the average absolute forecast errors (AFEs) of theory-consistent consumers relative to the AFEs of consumers with non-consistent expectations in Figure 2, where summary statistics of the relative shares are given in Table 9. A relative share below one means that theory-consistent consumers in a given period have lower absolute forecast errors than non-consistent consumers, and *vice versa*. In most periods, consistent consumers produce lower AFEs with respect to inflation, where the effect is particularly pronounced regarding consistency with the Phillips curve.[30] An exception is the period at the beginning of our sample where consumers that have theory-consistent expectations perform worse than non-consistent consumers, especially in the case of consistency with the Phillips curve and the Taylor rule. We have to bear in mind that those respondents surveyed in the late 1970's and early 1980's experienced stagflation and that in most of these early periods neither the Phillips curve relationship nor the Taylor rule held in reality as shown in Figure A.3 in the appendix. As shown in Figure 1 in section 4.1, we also find a relatively lower share of consumers forming consistent expectations during this period, which one would expect when consumers expect stagflation. After the appointment of Volcker as the Fed chairman at the end of 1979, more consumers started to forecast in a theory-consistent way and their forecasts became more accurate compared to consumers giving non-consistent forecasts. Especially with respect to the Phillips curve and the Taylor rule, we observe that consumers with theory-consistent expectations in recent years markedly improved their inflation forecasts in relation to the non-consistent consumers.

Overall, respondents who correctly distinguish between nominal and real variables and those that have expectations consistent with the Taylor rule produce forecasts that have on average 1% lower AFEs than non-consistent consumers. While this difference is relatively small, respondents who form consistent expectations with respect to the Phillips curve

[30]Note that the average differences in forecast accuracy between the consistent and non-consistent groups are more pronounced when the two groups differ in size. Regarding consistency with the Income Fisher equation and the Taylor Rule, the consistency shares are close to 50%, while only 34% are consistent with the Phillips curve. It seems that this criterion does better in filtering the part of the population with higher economic literacy and, thus, better inflation forecasting abilities.

Figure 2: Relative AFEs with Consistent and Non-Consistent Exp



(a) Income Fisher Equation

(b) Phillips Curve

(c) Taylor Rule

(d) All

Note: Graphs show average absolute forecast errors of consistent consumers, relative to the forecast errors of non-consistent consumers.

differ much more in their forecast accuracy compared to the respective non-consistent samples and have 20% lower AFEs. Consumers whose expectations are consistent with all three principles have on average 12% lower AFEs than the non-consistent consumers. Note that the improvement in forecast accuracy of consistent consumers is even larger when we compare the median values. In Figure 2 we can also observe that the variance is relatively high with the highest variance for consistency with all three principles. Summary statistics are provided in Table 9.

Next, we evaluate the distance of the AFEs of consistent and non-consistent forecasts to the AFEs of the SPF, shown in Figure 3 with summary statistics in Table 10. As the

Table 9: AFEs of Consumers with Consistent Expectations Relative to AFEs with Non-Consistent Expectations

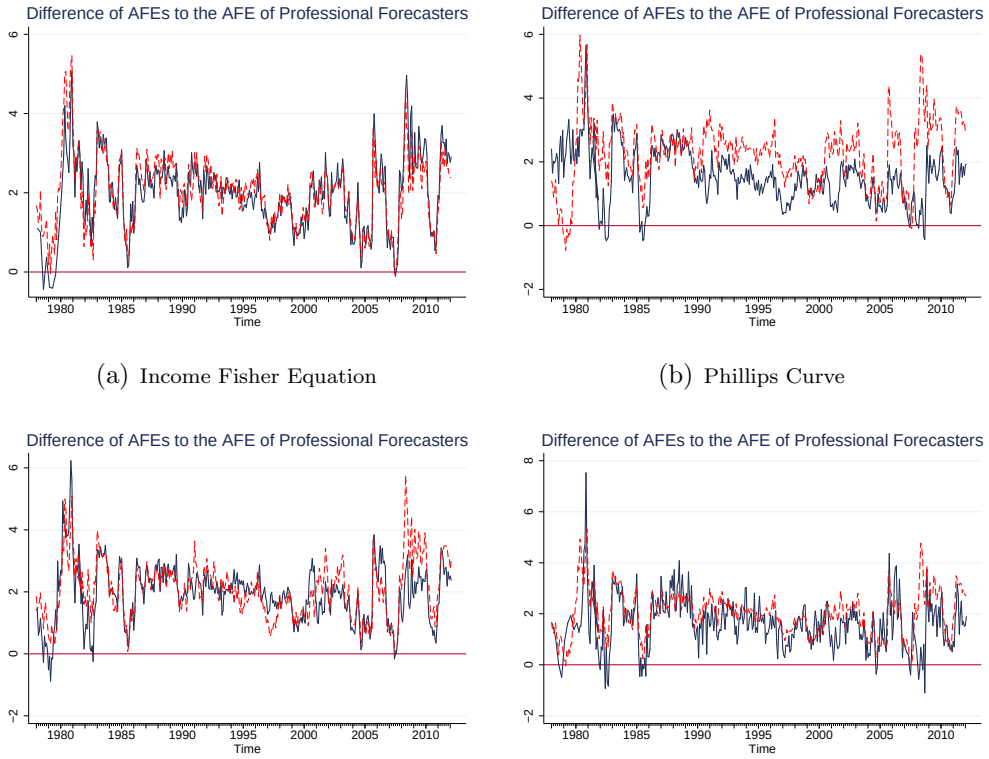
	Mean	Median	SD	Min	Max	N
Fisher equation	0.99	0.98	0.12	0.71	1.43	219,606
Phillips curve	0.80	0.76	0.22	0.42	1.61	234,859
Taylor rule	0.99	0.98	0.19	0.59	1.83	234,859
All three	0.88	0.87	0.23	0.40	1.61	219,606

Table 10: Distance of Consumers' AFEs to the AFE of Professional Forecasters

	Mean	Median	SD	Min	Max	N	T-test Mean	K-W Test Median
Consistent Fisher	2.01	2.06	0.88	-0.44	5.06	219,606	0.28	31.74***
Non-Consistent Fisher	2.01	2.06	0.87	-0.05	5.46	234,859	–	–
Consistent Phillips	1.53	1.50	0.85	-0.47	5.65	234,859	38.71***	906.74***
Non-Consistent Phillips	2.24	2.37	1.03	-0.79	5.98	234,859	–	–
Consistent Taylor rule	1.93	1.99	0.93	-0.88	6.23	234,859	9.07***	19.51***
Non-Consistent Taylor rule	2.08	2.08	0.92	0.01	5.76	234,859	–	–
Consistent all three	1.63	1.62	1.00	-1.10	7.53	219,606	13.25***	102.80***
Non-Consistent all three	2.03	2.05	0.87	-0.05	5.33	234,859	–	–

Notes: The last two columns represent tests for equality of means (medians) between the subsamples of consistent vs. non-consistent consumers for a particular relation. For the mean we employ a two-sample mean-comparison t-test with equal variances and for the median a Kruskal-Wallis equality-of-populations rank test. ***/**/* indicates significance at the 1/5/10% level.

Figure 3: Consistent and Non-Consistent AFEs of Consumers vs. AFEs in the SPF



(a) Income Fisher Equation

(b) Phillips Curve

(c) Taylor Rule

(d) All

Note: Black lines denote differences in AFEs of consistent consumers, red dotted lines denote differences in AFEs of non-consistent consumers.

difference approaches zero, consumers' forecast accuracy regarding inflation approaches that of the SPF. A positive difference means that consumers have higher AFEs than professional forecasters, while a negative difference means that consumers beat the SPF forecast on average. As one would expect, in most periods consumers' AFEs are higher than the SPF errors for both consistent and non-consistent consumers, where the overall median AFE from the Michigan survey is 135% higher than the median AFE of the SPF. As shown in Table 10, consumers with expectations consistent with the Income Fisher equation produce AFEs that are 2.01 inflation points higher than those in the SPF, while AFEs from forecasts consistent with the Phillips curve and the Taylor rule are 1.53 and 1.93 points higher, respectively. For comparison the average absolute forecasts error in the SPF is 1.27 inflation points.

Nevertheless, there exist periods where consumers that form consistent forecasts outperform the SPF. These are most evident in the first half of the 1980s and in 2008; the latter especially for consistency with the Phillips curve as well as with all three principles. Moreover, consumers with consistent expectations are consistently better able to match the SPF forecast accuracy than their non-consistent counterparts. This is especially true in the later part of the sample period, after the Volcker disinflation. As shown in Table

10, these differences are statistically significant in almost all cases, meaning that consistency with economic concepts on average moves consumers' inflation forecasts closer to professionals' estimates.

5 Conclusion

Expectations are of key relevance for macroeconomic outcomes. While many papers have investigated the properties of expectations of individual series in depth, there is almost no evidence on whether expectations on several macroeconomic aggregates are formed consistent with important economic concepts.

This paper addresses this research gap by calculating the share of people that form consistent expectations regarding the Taylor rule, the Phillips curve and the Income Fisher equation. In addition, we explore how this share of (theory-)consistent consumers changes over time, how it is affected both by macroeconomic variables and by the communication policy of the Federal Reserve, and finally, check if people benefit from having consistent expectations in terms of reduced inflation forecast errors.

We find that 50% of the surveyed U.S. population form expectations in line with the Income Fisher equation, while 46% incorporate the Taylor rule relationship into their expectations. Furthermore, 34% correctly infer the Phillips curve trade-off. While this share is relatively time-invariant for the Income Fisher equation, it seems to be more business-cycle-dependent for the Phillips curve and the Taylor rule. When looking at the heterogeneity across socioeconomic characteristics, we find some variation for all concepts considered, especially for the consistency with the Income Fisher equation.

In addition, we show that having consistent expectations is affected by a certain set of macro determinants. In particular, higher inflation above 2% decreases the probability of forming consistent expectations with respect to the Phillips curve and the Taylor rule, while the effect is positive for consistency with the Income Fisher equation. Also, during recessions people have problems forming consistent expectations regarding the Phillips curve trade-off and the Taylor rule relationship. Moreover, consistency with respect to all macroeconomic concepts analysed was affected significantly by changes in the communication strategy of the Federal Reserve. We find that consistency with the Taylor rule and with the Income Fisher equation are most strongly positively affected by improvements in communication and transparency, where the strongest effect is found for the introduction of the official inflation target in January 2012.

Finally, we can show that having consistent expectations benefits consumers. Investigating their inflation forecast accuracy, we report that consumers make better inflation forecasts and are closer to the SPF forecast accuracy if they have consistent expectations.

This paper offers interesting insights regarding the formation process of expectations by consumers. We contribute to the literature by testing for the consistency of economic concepts instead of only analysing the rationality of individual time series. Furthermore,

the result that people benefit from having consistent expectations and at the same time have problems with recession periods may call for policy actions. Related to that, we can show that the already introduced measures of monetary policy communication have had significantly positive effects on the likelihood of forming consistent expectations. Hence, our results could give further reasons for a clear communication by monetary and fiscal authorities especially during recession periods and, thus, could give further motivation for the recently popular measures of forward guidance. Additional benefit might be gained by targeting specific demographic groups such as older, less educated and lower income groups as this could increase overall economic literacy in the population. Finally, our result that consistent consumers have lower inflation forecast errors could be used to improve forecasting methods which incorporate consumer expectations.

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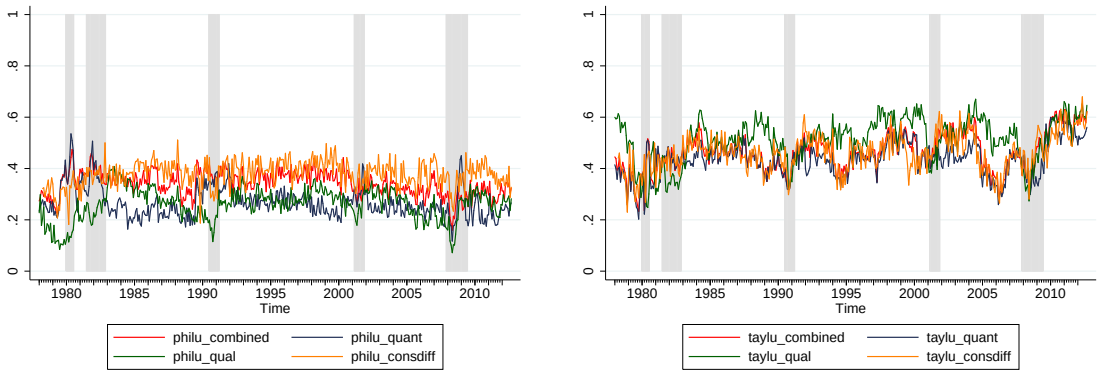
7 Appendix

Figure A.1: Consistency Shares with Alternative Definitions of Inflation Expectations

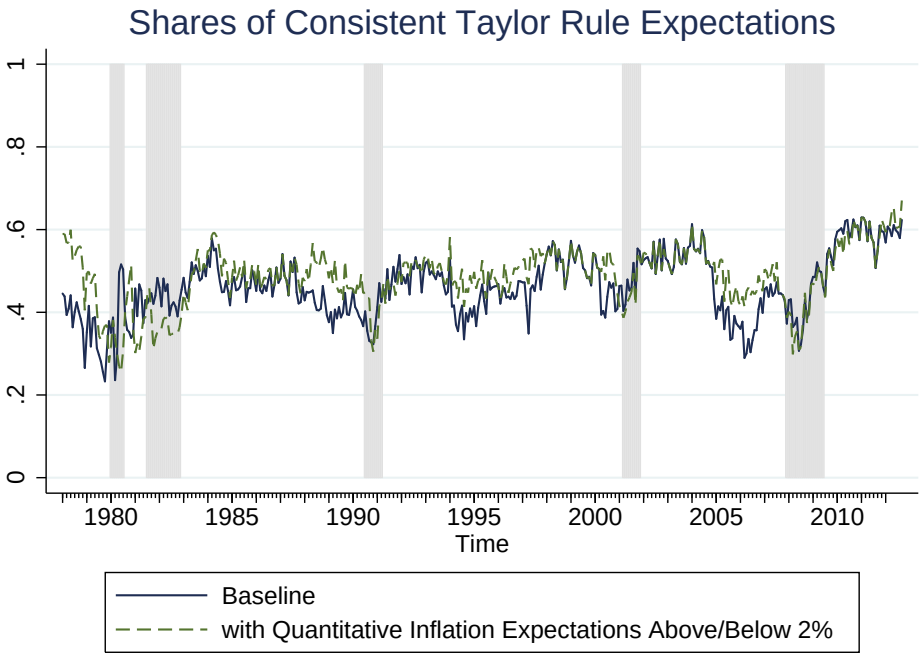


(a) Phillips Curve

(b) Taylor Rule

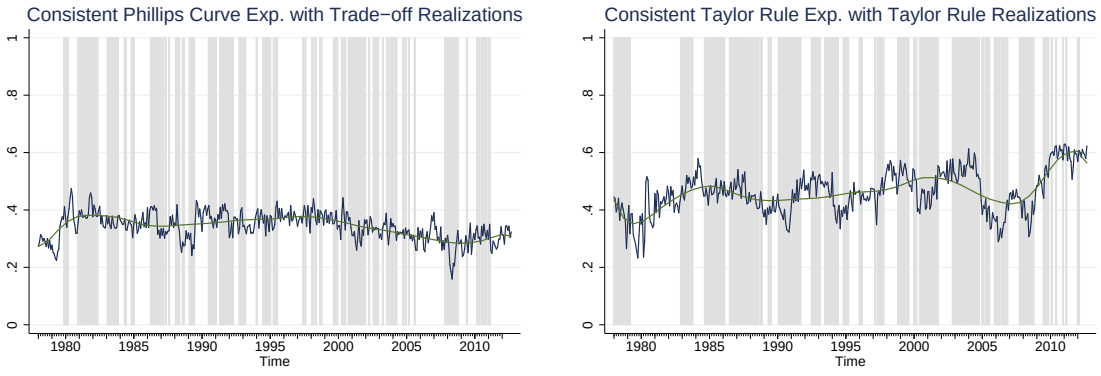
Note: *philu_combined* (*taylu_combined*) gives the baseline share of consumers consistent with the Phillips curve (Taylor rule), where inflation expectations are defined from both the quantitative question [A12b], compared to a rounded average of actual inflation over the previous 12 months, and the qualitative question [A12] as discussed in the paper. *Philu_quant* (*taylu_quant*) uses the identification of inflation expectations from only the quantitative question [A12b] as in Carvalho and Nechio (2014), where quantitative point estimates are compared to a rounded average of actual inflation over the previous 12 months. *Philu_qual* (*taylu_qual*) is derived using only qualitative inflation expectations from question [A12]. *Philu_consdiff* (*taylu_consdiff*) identifies expected inflation changes by comparing the quantitative inflation forecasts between the second and the first interview in the rotating panel. Shaded areas denote recession periods as defined by the NBER.

Figure A.2: Consistency with the Taylor Rule when Inflation Expectations are Evaluated Relative to the Inflation Target



Note: Shaded areas denote recession periods as defined by the NBER.

Figure A.3: Consistency and Realised Data

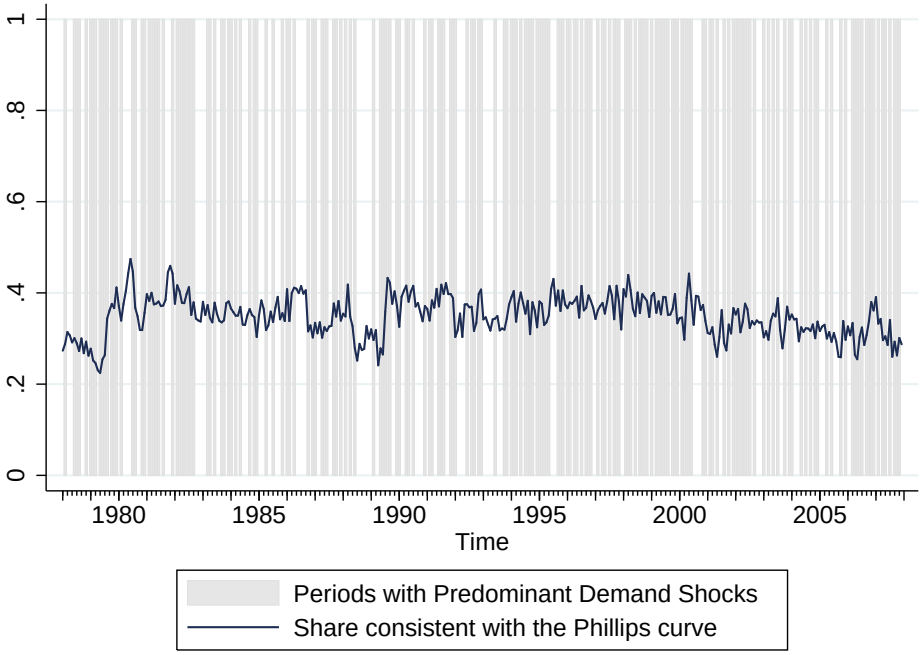


(a) Phillips Curve

(b) Taylor Rule

Note: Shaded areas denote periods where the Phillips curve trade-off, using actual data rounded to the nearest integer, was realised 12 months ahead, i.e. where future changes 12 months ahead of the Federal Funds rate, the inflation rate, and the unemployment rate, rounded to the nearest integer, were in line with a Taylor rule.

Figure A.4: Identification of the Phillips Curve



Note: Shaded areas denote periods with predominant demand shocks, which are identified as those periods where demand shocks are larger than supply shocks in absolute terms. Data for demand and supply shocks is obtained from Kilian (2009).

Table A.1: Robustness Check: Heckprobit Models with Different Identifications of Inflation Expectations

	Phillips curve				Taylor rule			
	philu_combined (baseline)	*philu_quant*	*philu_qual*	*philu_consdiff*	*taylu_combined* (baseline)	*taylu_quant*	*taylu_qual.*	*taylu_consdiff*
π_{t-1}	-0.0047	0.0078***	-0.0039	-0.0129***	-0.0067**	-0.0091***	-0.0140***	0.0027
	(0.0031)	(0.0029)	(0.0043)	(0.0026)	(0.0029)	(0.0033)	(0.0042)	(0.0026)
$\sigma^2_{\pi,t-1}$	-0.0002	0.0097***	0.0064***	0.002	-0.0046***	-0.0060***	0.0027	-0.0042***
	(0.0017)	(0.0017)	(0.0019)	(0.0016)	(0.0016)	(0.0017)	(0.0019)	(0.0016)
oil_{t-1}	-0.0002***	-0.0006***	-0.0003**	-0.0002**	0.0001	0.0003***	-0.0001	-0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
u_{t-1}	-0.0028*	-0.0041***	0.0165*	-0.0034**	0.0142***	0.0100***	-0.0242***	0.0114***
	(0.0015)	(0.0012)	(0.0098)	(0.0014)	(0.0015)	(0.0014)	(0.0085)	(0.0014)
$m2growth_{t-1}$	-0.0028*	-0.0050***	-0.0048**	-0.0024**	0.0067***	0.0045***	-0.0013	0.0066***
	(0.0015)	(0.0007)	(0.0022)	(0.0011)	(0.0008)	(0.0010)	(0.0022)	(0.0008)
$funds_rate_{t-1}$	0.0045	-0.0011	-0.006	0.0036	-0.0111***	-0.0053**	-0.0155***	-0.0126***
	(0.0038)	(0.0022)	(0.0058)	(0.0025)	(0.0015)	(0.0025)	(0.0052)	(0.0014)
$nber_recession_t$	-0.0287**	0.0388***	-0.0338***	-0.0414***	-0.0319***	-0.0308**	-0.0472***	-0.0088
	(0.0117)	(0.0111)	(0.0130)	(0.0087)	(0.0110)	(0.0129)	(0.0131)	(0.0102)
N	95,893	95,893	95,893	95,893	95,389	95,389	95,389	95,389
χ^2	241.017	409.629	1127.469	259.314	731.434	365.214	1108.565	629.738
Demographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.068	0.119	-0.290	0.104	-0.494	-0.471	-0.321	-0.590
Wald test ($\rho = 0$, χ^2)	0.02	0.18	1.32	0.12	4.46**	2.27	2.57	5.01**

Notes: For explanation of the definitions, see notes to Figure A.1. Table A.1 reports the marginal partial effects from the heckprobit models evaluated at the representative consumer. The Wald test for $\rho = 0$ gives the χ^2 statistics of the Wald test for independence from the sample selection equation. Robust standard errors are calculated with the δ method (Oehlert 1992) and are reported in parentheses. ***/**/* indicates significance at the 1/5/10% level.

Table A.2: Robustness Check: Central Bank Communication Models with Standard Errors Clustered at the Monthly Level

	Income Fisher eq.	Phillips curve	Taylor rule	All Three
π_{t-1}	-0.0008	0.0080*	-0.0082	0.0026
	(0.0046)	(0.0048)	(0.0056)	(0.0039)
$\sigma^2_{\pi,t-1}$	-0.003	0.0059**	0.0006	0.0011
	(0.0020)	(0.0025)	(0.0023)	(0.0015)
oil_{t-1}	0.0001	-0.0003***	0.0002	-0.0002**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
u_{t-1}	0.0044*	0.0002	0.0170***	0.0064**
	(0.0026)	(0.0022)	(0.0035)	(0.0028)
$m2growth_{t-1}$	-0.0030**	0.0001	0.0056***	0.0014
	(0.0015)	(0.0019)	(0.0019)	(0.0017)
$funds_rate_{t-1}$	0.0022	-0.0023	-0.0108***	-0.0041**
	(0.0026)	(0.0023)	(0.0027)	(0.0019)
$nber_recession_t$	0.0288**	-0.0453***	-0.0380**	-0.0063
	(0.0118)	(0.0167)	(0.0177)	(0.0186)
$BeigeBook83_t$	-0.0398	0.0106	0.0529*	0.0058
	(0.0302)	(0.0211)	(0.0279)	(0.0280)
$FFTargetAnnouncement94_t$	-0.0061	0.0345***	-0.0035	0.0127
	(0.0108)	(0.0101)	(0.0139)	(0.0089)
$BalanceofRisk00_t$	0.0125	-0.0263	0.0283*	0.0068
	(0.0116)	(0.0181)	(0.0158)	(0.0210)
$Votes02_t$	0.0214	-0.0158	-0.0262	0.0132
	(0.0150)	(0.0161)	(0.0172)	(0.0137)
$ForwardGuidance03_t$	0.0234*	-0.0366***	-0.0393**	-0.0312*
	(0.0121)	(0.0137)	(0.0153)	(0.0166)
$PressConference11_t$	0.0396*	-0.0349*	0.0113	-0.0072
	(0.0206)	(0.0202)	(0.0206)	(0.0178)
$ExplicitTarget12_t$	0.1056***	0.0407	0.0948***	0.1023
	(0.0263)	(0.0603)	(0.0323)	(0.0853)
N	93,763	95,893	95,389	93,109
χ^2	681.605	353.748	598.582	352.314
Demographic Controls	Yes	Yes	Yes	Yes
ρ	-0.832	0.091	-0.35	-0.586
p-value Wald test ($\rho = 0$, χ^2)	0.000	0.815	0.123	0.266

Notes: Table A.2 reports the marginal partial effects from the heckprobit models evaluated at the representative consumer. The Wald test for $\rho = 0$ gives the χ^2 statistics of the Wald test for independence from the sample selection equation. Standard errors are clustered at the monthly level and are reported in parentheses. ***/**/* indicates significance at the 1/5/10% level.

Table A.3: Robustness Check: Accounting for the Effect of the Zero Lower Bound Period

	Income Fisher eq.	Phillips curve	Taylor rule	All Three
d_zlb_t	-0.0567	0.2223	0.1757	0.2195
	(0.1668)	(0.2284)	(0.2030)	(0.2176)
π_{t-1}	0.0048	0.0101**	-0.0105**	0.0038
	(0.0033)	(0.0042)	(0.0043)	(0.0034)
$\pi_{t-1} * d_zlb_t$	-0.0096	-0.0086	0.0208	-0.008
	(0.0117)	(0.0170)	(0.0153)	(0.0166)
$\sigma^2_{\pi,t-1}$	-0.0016	0.0185***	-0.0044	0.0033
	(0.0026)	(0.0038)	(0.0034)	(0.0028)
$\sigma^2_{\pi,t-1} * d_zlb_t$	0.0076*	-0.0242***	0.005	-0.0016
	(0.0041)	(0.0050)	(0.0051)	(0.0041)
oil_{t-1}	0.0000	-0.0004***	0.0000	-0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$oil_{t-1} * d_zlb_t$	-0.0010*	0.0010*	-0.0002	0.0002
	(0.0005)	(0.0006)	(0.0006)	(0.0005)
u_{t-1}	-0.0001	-0.0032	0.0054*	0.0022
	(0.0022)	(0.0027)	(0.0028)	(0.0022)
$u_{t-1} * d_zlb_t$	0.0152	-0.0171	-0.0055	-0.0141
	(0.0173)	(0.0225)	(0.0210)	(0.0198)
$m2growth_{t-1}$	0.0006	0.0012	0.0087***	0.0042***
	(0.0009)	(0.0012)	(0.0013)	(0.0014)
$m2growth_{t-1} * d_zlb_t$	-0.0112***	-0.0021	-0.0173***	-0.0137**
	(0.0039)	(0.0051)	(0.0047)	(0.0065)
$nber_recession_t$	-0.0021	-0.0421***	-0.0391***	-0.0149*
	(0.0078)	(0.0107)	(0.0102)	(0.0090)
$nber_recession_t * d_zlb_t$	-0.0496	0.06	0.0175	0.0112
	(0.0311)	(0.0371)	(0.0379)	(0.0299)
$funds_rate_{t-1}$	-0.0013	-0.0042**	-0.0112***	-0.0061**
	(0.0016)	(0.0021)	(0.0019)	(0.0027)
$BeigeBook83_t$	-0.0403***	0.0125	0.0247	0.0062
	(0.0135)	(0.0200)	(0.0189)	(0.0207)
$FFTargetAnnouncement94_t$	-0.0081	0.0342***	-0.0230***	0.008
	(0.0072)	(0.0094)	(0.0089)	(0.0073)
$BalanceofRisk00_t$	0.0069	-0.0404***	0.0155	-0.0036
	(0.0095)	(0.0144)	(0.0133)	(0.0177)
$Votes02_t$	0.0119	-0.0145	-0.0119	0.0114
	(0.0119)	(0.0142)	(0.0143)	(0.0109)
$ForwardGuidance03_t$	0.0284***	-0.0444***	-0.0427***	-0.0261**
	(0.0101)	(0.0127)	(0.0120)	(0.0118)
$PressConference11_t$	0.0925***	-0.0533	-0.0084	0.0357
	(0.0286)	(0.0375)	(0.0372)	(0.0427)
$ExplicitTarget12_t$	0.0951***	0.0284	0.1079***	0.086
	(0.0233)	(0.0452)	(0.0313)	(0.0602)
N	93,763	95,893	95,389	93,109
χ^2	823.983	406.635	865.085	684.401
Demographic Controls	Yes	Yes	Yes	Yes
ρ	-0.849	0.156	-0.294	-0.549
Wald test ($\rho = 0$, χ^2)	23.69***	0.17	1.98	1.11

Notes: The dummy *d_zlb* takes on the value of 1 from 2008m12 onwards, when the Fed Funds Target Rate was set to 0.25. Table A.3 reports the marginal partial effects from the heckprobit models evaluated at the representative consumer. Robust standard errors are reported in parentheses. ***/**/* indicates significance at the 1/5/10% level.

Table A.4: Robustness Check: Accounting for the Effect of Demand and Supply Shocks

	Income Fisher eq.	Phillips curve	Taylor rule	All Three
π_{t-1}	0.0044	0.0094**	-0.0094**	0.0044
	(0.0039)	(0.0045)	(0.0046)	(0.0035)
$\sigma^2_{\pi,t-1}$	-0.0047	0.0173***	-0.0084**	0.0022
	(0.0031)	(0.0036)	(0.0037)	(0.0026)
oil_{t-1}	0.0001	-0.0003***	0.0001	-0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
u_{t-1}	0.0018	-0.0026	0.0077**	0.0033
	(0.0026)	(0.0030)	(0.0030)	(0.0028)
$m2growth_{t-1}$	-0.0025**	0.0019	0.0088***	0.0034***
	(0.0011)	(0.0016)	(0.0019)	(0.0009)
$funds_rate_{t-1}$	0.0014	-0.0052***	-0.0120***	-0.0052**
	(0.0017)	(0.0020)	(0.0022)	(0.0021)
$nber_recession_t$	0.0250**	-0.0243	-0.0184	0.0006
	(0.0104)	(0.0154)	(0.0157)	(0.0122)
$demand_shock_t$	0.002	0.0026	-0.0082***	0.0008
	(0.0023)	(0.0026)	(0.0027)	(0.0018)
$supply_shock_t$	0.0041*	0.0017	0.0004	0.0001
	(0.0024)	(0.0027)	(0.0027)	(0.0019)
$BeigeBook83_t$	-0.0513***	0.0087	0.0296	0.013
	(0.0150)	(0.0234)	(0.0227)	(0.0153)
$FFTargetAnnouncement94_t$	-0.0054	0.0356***	-0.0198**	0.0102
	(0.0081)	(0.0102)	(0.0097)	(0.0081)
$BalanceofRisk00_t$	0.0089	-0.0451***	0.0078	-0.0117
	(0.0108)	(0.0168)	(0.0166)	(0.0115)
$Votes02_t$	0.0261**	-0.0136	-0.0066	0.0142
	(0.0123)	(0.0143)	(0.0147)	(0.0117)
$ForwardGuidance03_t$	0.0173	-0.0370***	-0.0366***	-0.0213
	(0.0110)	(0.0142)	(0.0125)	(0.0140)
N	78,683	80,638	80,198	78,121
χ^2	549.287	234.516	384.039	1858.757
ρ	-0.837	0.022	-0.263	-0.398
Wald test ($\rho = 0$, χ^2)	15.93***	0.00	0.77	0.59

Notes: The time series for demand and supply shocks are taken from Kilian (2009) and cover the time period 1978m1-2007m12. Table A.4 reports the marginal partial effects from the heckprobit models evaluated at the representative consumer. Robust standard errors are reported in parentheses. ***/**/* indicates significance at the 1/5/10% level.