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HETEROGENEOUS INFLATION EXPECTATIONS, LEARNING AND MARKET OUTCOMES*

Carlos Madeira
Banco Central de Chile

Basit Zafar
Federal Reserve Bank of New York

Abstract

Using the panel component of the Michigan Survey of Consumers we estimate a learning model of inflation expectations, allowing for heterogeneous use of both private information and lifetime inflation experience. We find that women, ethnic minorities, and less educated agents have a higher degree of heterogeneity in their private information, and are slower to update their expectations. During the 2000s, consumers believe inflation to be more persistent in the short term, but temporary fluctuations in inflation have less effect on expectations of personal income and long-term inflation. Finally, we find evidence that heterogeneous expectations by consumers generate higher mark-ups and inflation.

Resumen

Utilizando el componente panel de la Encuesta de Sentimiento de Consumo de la Universidad de Michigan, estimamos un modelo de aprendizaje de expectativas de inflación, permitiendo el uso heterogéneo de información privada y experiencia de inflación a lo largo de la vida del agente. Encontramos que el sexo femenino, minorías étnicas, y personas de menor educación tienen una mayor heterogeneidad en su información privada y son más lentos en cambiar sus expectativas. Durante los años 2000 los consumidores creen que la inflación es más persistente a corto plazo, todavía cambios temporarios en la tasa de inflación tienen un menor impacto en las expectativas de inflación a largo plazo y del crecimiento de ingresos del individuo. Finalmente, encontramos evidencia que la heterogeneidad de expectativas de los consumidores genera *mark-ups* mayores y mayor inflación.

*Carlos Madeira: Central Bank of Chile, Agustinas 1180, Santiago, Chile. carlosmadeira2009@u.northwestern.edu. Basit Zafar: Federal Reserve Bank of New York, 33 Liberty Street, New York, NY 10045. Basit.Zafar@ny.frb.org. The views expressed in this paper do not necessarily re.ect those of the Federal Reserve Bank of New York or the Federal Reserve System as a whole.

1 Introduction

Inflation expectations of agents are the main focus of modern macroeconomic models as well as monetary policy (Sims, 2009). However, controlling inflation expectations requires one to understand how they are formed. Interpretation of the data and policy outcomes is greatly affected by whether models assume rational expectations or some sort of bounded rationality (Lucas, 1972), with monetary policy being less powerful when agents doubt the commitment of central banks to fight future inflation (Orphanides and Williams, 2003). More recently, macroeconomic studies that use time series of median expectations find that sticky prices are explained by non-rationalities in price expectations (Roberts, 1997, Adam and Padula, 2011, Eusepi and Del Negro, 2011). Survey work has shown that individuals are not fully informed about future outcomes, and that there is substantial divergence among individuals' beliefs (Mankiw, Reis, and Wolfers, 2003). There is little work, however, trying to explain the heterogeneity of individuals' expectations, how they learn from new information, and its impact on market outcomes. This paper fills some of that gap.

First, we show that over the last 35 years heterogeneity of predictions for future inflation is one of the main features of agents' beliefs. This dispersion in beliefs (as measured by the interquantile range of expectations) is significant and persists over time, therefore it is a phenomenon requiring more study. We propose a model where agents provide inflation forecasts based on observable information – such as the previous inflation rates experienced in their lifetime (as in Malmendier and Nagel, 2011a,b) – and unobservable information, and study how they update their beliefs. Our model improves upon previous work by including idiosyncratic heterogeneity and dynamic updating of each agent's inflation expectations. For this purpose, we use the panel component of the Reuters/University of Michigan Survey of Consumers (1978-2009). Previous studies have mostly forgotten about the panel dimension of survey expectations (Keane and Runkle, 1990; Souleles, 2004; and Anderson, 2008, are exceptions). This complicates the interpretation of previous work in terms of learning, since only the aggregate evolution of beliefs is analyzed, while the actual updating of individuals is not studied. It is important to note that estimates from aggregate time series are biased when individuals have different information sets (Keane and Runkle, 1990).

We find empirical support for the importance of life experience. Our estimates also show that individuals differ substantially in how much importance they give to lifetime experience and how quickly they update their information. In particular, women, ethnic minorities, and less educated

agents are slower to update their expectations, giving a larger focus to previous life experience rather than to most recent events. These groups are also less likely to change their idiosyncratic private beliefs in the following semesters, and they also have a higher degree of heterogeneity in their private beliefs. The same demographic groups – women and less educated agents – have been found in the literature to report higher inflation expectations and to be less informed about objective measures of inflation (Armantier et al., 2011). Inflation series adjusted for the expenditure patterns of a large range of distinct demographic groups tends to be very similar to overall inflation (McGranahan and Paulson, 2006). This suggests that the differences in updating and learning that we find are driven by different information processing rules and not distinct inflation experiences. We also allow for the coefficients in our model to vary over time in order to control for changes in the macro-environment. We find that over the years the heterogeneity of expectations for both short-term and long-term inflation has decreased substantially, which is consistent with studies that find inflation has become easier to predict in recent times (Stock and Watson, 2007).

The Michigan survey also collects data on subjective income growth rates of respondents. Estimating an updating model of personal income growth, we find that young and more educated households have greater heterogeneity of personal income growth forecasts, which is consistent with the larger dispersion in their observable earnings (Attanasio et al., 1999; Katz and Autor, 1999). Also, we find a decrease in the heterogeneity of personal income growth forecasts over time, consistent with the evidence that the change in the earnings' structure was largely predictable by individual agents (Primiceri and van Rens, 2009). Policy-makers are always concerned about the vicious cycle of inflation expectations feeding into wage demands. We do find that, over the period 1978-1985, households incorporated a great degree of their inflation forecasts in their income growth expectations. However, this tendency decreased after 1985 and in the 2000's there is no longer an effect of inflation expectations on income growth forecasts.

We also relate heterogeneity in inflation expectations to realization of future inflation. Models where consumers search for "best-bargains" show that heterogeneity of price expectations leads firms to charge higher prices (Benabou and Gertner, 1993). Heterogeneous information observed by consumers and slow updating of new information increases the monopoly power of firms, since there will be a higher mass of consumers accepting to buy at high prices. We test this hypothesis by analyzing the statistical relation between inflation and the inter-decile range of

inflation expectations in the Michigan survey data. We also test whether the estimated measure of sticky expectations obtained from our model of price updating could cause inflation, since firms may be slower to change prices when consumers are slow to update their information set. Both heterogeneity of idiosyncratic information and "sticky expectations" by consumers are statistically significant in explaining the next quarter's inflation, which lends empirical support to the negative effects of uncertainty and heterogeneous information on firm competition and price mark-ups.

Previous literature on inflation expectations has studied possible explanations for the heterogeneity of agents' beliefs. Souleles (2004) and Anderson (2008) find that females, racial minorities, and lower income persons have larger forecast errors than average, showing inflation beliefs are systematically heterogeneous and correlated with demographic characteristics. Furthermore, this systematic heterogeneity in forecast errors is important in explaining the excess sensitivity of household expenditure to sentiment data (Souleles, 2004). We use heterogeneous lifetime experiences (of inflation) in individuals' updating process and estimate a structural model of belief-updating, and link the heterogeneity in updating to market outcomes. Other studies look at the (cross-sectional) heterogeneity of inflation forecasts and explain it as a result of different lifetime inflation experiences (Malmendier and Nagel, 2011a), switching between different prediction rules (Branch, 2004, 2007), or rational inattention (Carroll, 2003, Mankiw, Reis, and Wolfers, 2003). We show that while the fit of our model is similar to previous models when explaining the conditional mean of inflation expectations, our model vastly outperforms these models when trying to explain the other conditional moments of the expectations distribution, i.e., the heterogeneity in expectations and the individual updating between different time periods.

This paper is divided as follows. Section 2 discusses our model of expectations formation and outlines how we deal with both observable information and unobservable idiosyncratic beliefs. Section 3 summarizes the Michigan survey data and the historical inflation series we use in our work. Section 4 discusses the results of our learning model, analyzing differences across demographic groups and over time. In Section 5 we use a search framework to relate the effects of heterogeneous expectations and slow learning to the pricing evolution of consumer goods. Finally, Section 6 concludes the paper with a summary of our findings.

2 The model of expectation updating

2.1 Basic model

We denote $\pi^{p}_{t',i}(t)$ as the prediction for the annualized inflation observed at quarter $t' \geq t$ that agent i makes in quarter t. Assume agent i of cohort s learns about future inflation by using previous inflation experiences lived in his lifetime, $\pi^{life}_{t,s}(\theta)$, and other public information available to everyone, $z_{t'}(t)$. Lifetime inflation experience is measured as a weighted average of observed inflation rates in the previous life of the agent, with more recent experiences slowly adding to older ones (as in Malmendier and Nagel, 2011a). Public information includes all contemporary information generally known to the public, such as the last reported inflation rate. We assume for simplicity a linear updating model for future inflation expectations based on $\pi^{life}_{t,s}(\theta)$ and $z_{t'}(t)$:

2.1) $\pi^{p}_{t',i}(t) = \beta\pi^{life}_{t,s}(\theta) + z_{t'}(t) + \eta^{p}_{t',i}(t)$, with $t' \geq t$,

where β denotes the importance attached to lifetime inflation experiences, and $\eta^{p}_{t',i}(t)$ is idiosyncractic private information. That is, agents' expectations are assumed to depend on both public and private information. While inflation is an aggregate event, there could be several sources of private information affecting individual agents' predictions. For instance, agents may differ in how frequently they read financial news, if at all, or in the price information observed at their local supermarket. Also, poorer households are more likely to be aware of rent and food price inflation, while richer households should arguably be more aware of prices of durable and luxury goods. Older households are more sensitive to health costs. Since the sources of private information differ markedly across households of different background, it is reasonable to assume that $\eta^{p}_{t',i}(t)$ is heteroscedastic both across demographic groups and time.

We assume the idiosyncratic private information term, $\eta^{p}_{t',i}(t)$, follows an AR(1) process:

2.2) $\eta^{p}_{t',i}(t) = \lambda\eta^{p}_{t',i}(t-1) + u_{t',i}(t)$, with $\lambda \leq 1$.

The term λ informs us how slow individuals are to update their idiosyncratic opinions on inflation rates, which could be a mix of both the innovation process in the information sources of the agent and of the actual behavioral speed with which the agent updates his predictions.

It is assumed $u_{t',i}(t)$ is normally distributed $(u_{t',i}(t)) \sim N(0; \sigma^2_{u_i}(t'-t))$. $\sigma^2_{u_i}(t'-t)$ can be interpreted as a measure of the unexplained heterogeneity or dispersion in agents' beliefs about

future inflation. It can also be denoted as "disagreement" in opinions, as in Mankiw, Reis, and Wolfers (2003) and Rich and Tracy (2006). The indicator $(t'-t)$ in the variance term $\sigma^2_{u_i}(t'-t)$ is written to imply that the variance in the dispersion of opinions depends on the duration between the time at which the forecast is made and the event. The Michigan survey data collects information for two time horizons, 1 year and 5-10 years after the forecast. Therefore our model allows us to learn about the dispersion in expectations at different time horizons.

Lifetime inflation is updated as a weighted-average of observed inflation in previous quarters:

2.3) $\pi^{life}_{t,s}(\theta) = \pi^{life}_{t-1,s} + \gamma_{t-s}(\pi_t - \pi^{life}_{t-1,s})$, $t > s$, with $\gamma_{t-s} = \dfrac{\theta}{t-s}$ and $\pi^{life}_{t=s,s}(\theta) = \pi_{t-1}$.

This parsimonious learning model is therefore summarized in a vector of four parameters: $\varpi \equiv \{\beta, \theta, \lambda, \sigma^2_{u_i}(t'-t)\}$. θ denotes how rapidly agents include new information in their estimates of lifetime inflation, while β denotes how important lifetime inflation is in agents' expectations. A positive fixed θ indicates that the gain sequence of learning is decreasing in age. This is consistent with empirical results showing younger agents to be more overconfident in the reliability of recent information (Barber and Odean, 2001, Vissing-Jorgensen, 2003, Greenwood and Nagel, 2009).

2.2 Estimation

To study the learning process of inflation expectations we use the panel component of the Michigan Survey of Consumer Expectations. In this survey respondents give, for two consecutive semesters, their subjective expectations of inflation in the next 12 months and inflation for the next 5-10 years.

The Michigan data allows us to measure observable heterogeneity in expectations updating across different demographic characteristics. Therefore we consider heterogeneity in learning by allowing the empirical model to differ across x_i, i.e.: $\varpi = \varpi(x_i)$, with x_i including income, education, race, and gender. To estimate the model we assume a parametric form for the public information observed by rational agents, $z_{t'}(t)$:

3.1) $z_{t'}(t) = \gamma[\pi_{t'}, \pi_{t-1}, d_t]$,

where d_t is a dummy variable for the half-decade period of the survey, π_{t-1} is the inflation rate of the previous quarter and $\pi_{t'}$ is the actual inflation rate realized in the future (which can be partially known by a signal observed by forward-looking agents). Therefore, $z_{t'}(t)$ allows us to

measure how much agents approach the ideal rational agent. If agents are perfectly rational, then realized inflation should be equivalent to their inflation prediction plus a random term of mean zero, $\pi^p_{t',i}(t) = \pi_{t'} + \eta^p_{t',i}(t)$. For rational agents this implies the coefficient of $\pi_{t'}$ should be close to one, while the others should be zero and insignificant. Note that rational expectations is different from perfect foresight, since with perfect foresight the forecast error $\eta^p_{t',i}(t)$ is 0.

A significant problem is that our panel only includes observations for two periods, which requires specifying a different likelihood for the initial observation. We solve this by specifying the first period error term to be a purely idiosyncratic term $\eta^p_{t',i}(t) = u^1_{t',i}(t)$ and using the AR(1) process, $\eta^p_{t',i}(t) = \lambda\eta^p_{t',i}(t-1) + u^2_{t',i}(t)$, in the second period. This gives us two variance terms to estimate, $\sigma^2_{u^1_i}(t'-t)$ and $\sigma^2_{u^2_i}(t'-t)$[1]. We also consider parametric forms for $\varpi = \varpi(x_{i,t})$:

3.2) θ is a constant scalar,

3.3) $\beta = \exp(\alpha_\beta x_{i,t})$,

3.4) $\lambda = \dfrac{\exp(\alpha_\lambda x_{i,t})}{1+\exp(\alpha_\lambda x_i)}$,

3.5) $\sigma^2_{u^a_i}(t'-t) = \exp(\alpha_{u_i,t} x_{i,t})$ for $a = 1, 2$,

where $x_{i,t} \equiv \{$*Female, Asian, Black, Hispanic, Young, Middle-aged, low-income, middle-income, years of education, half-decade,* π_{t-1}, $|\pi_{t-1} - \pi_{t-2}|\}$. We also allow $\sigma^2_{u_i}(t'-t)$ to depend on the inflation change observed in the previous period, since previous studies find that individuals are more uncertain in periods of high and volatile inflation rates (Rich and Tracy, 2006).

3 Data

The Michigan Survey of Consumer Expectations has been conducted monthly by the University of Michigan between 1978 to the present day, based on telephone interviews of a sample of approximately 500 respondents representative of the US population. The survey incorporates a rotating sample design, where 40% of the monthly sample are re-contacts from six-months before, and the remaining

[1] Another option is to impose $\sigma^2_{u^1_i}(t'-t) = \dfrac{\sigma^2_{u^2_i}(t'-t)\times(1-\lambda^{2\times a(i)})}{1-\lambda^2}$, which is the steady-state variance for someone with $a(i)$ quarters of age. Assuming this form has no qualitative differences in our results. We prefer to report the two variance terms for each panel period due to its simplicity.

60% are new respondents. Although this survey has been implemented since 1953, the panel data are only available after 1978. Rather surprisingly, few studies have exploited this feature of the Survey of Consumer Expectations; exceptions include Souleles (2004) and Anderson (2008).

In this survey respondents provide their subjective expectations of inflation in the next 12 months and inflation for the next 5-10 years by answering the following questions:

> *During the next 12 months, do you think that prices in general will go up, or go down, or stay where they are now?*
>
> *By about what percent do you expect prices to go (up/down) on the average, during the next 12 months?*

In addition, households are asked to forecast their personal income growth over the next year:

> *During the next 12 months, do you expect your income to be higher or lower than during the past year?*
>
> *By about what percent do you expect your income to (increase/decrease) during the next 12 months?*

Therefore the Michigan survey measures the expectations of more than 85,000 individuals at two different points in time in the period 1978 to 2009.

We also use long-term historical data on the Consumer Price Index (CPI) collected by Robert Shiller to calculate the US quarterly inflation rates. Then we estimate the average lifetime inflation experienced by each birth cohort using a quarterly update interval for several values of θ. The updating rule considered in 2.3.2) is highly non-linear in the inflation rates of previous periods and the age of the respondents, requiring the algorithm to go over all the life inflation rates of each agent and compute a different weight for each period. To reduce the computation burden of this exercise we computed the life inflation series at 40 different values of θ and then used a linear interpolation rule to compute the life inflation at intermediate values.[2]

According to Judd (1998), approximating a function through linear interpolation between points gives consistent and shape-preserving estimates of the true function as the number of evaluation

[2] We chose {0, 0.5, 1, 1.25, 1.5, 1.65, 1.8, 1.9, 2, 2.05, (2.1: 0.025: 2.2), (2.2: 0.01: 2.3), (2.3: 0.025: 2.4), 2.45, 2.5, 2.6, 2.7, 2.85, 3, 3.25, 3.5, 4, 4,5, 5}, as the exact values of θ., where : a : denotes an arithmetic progression in steps of a.

points increases to infinity. Since we use 40 points to approximate a function of one unknown parameter, it is reasonable to expect that the approximation error is small. There is a correlation of 99.99% between adjacent series of θ around 2.2 and 2.3, which represent the most likely values for this parameter. The correlation between life inflation at adjacent points is high, therefore there is little measurement error involved in this approximation.

3.1 Descriptive analysis

Before estimation of the updating model described in Section 2, we show some descriptive patterns in the data. We retain the full sample for this purpose and do not restrict to the respondents who are re-surveyed. Figure 1 shows the median one-year ahead inflation expectations in the Michigan survey. Compared to realized one-year ahead inflation the median underestimates the realized inflation up to the early 1990s. After that the median expectation slightly overestimates the realized inflation. The visual depiction of the two series suggests that inflation expectations lag behind realized inflation, i.e., they seem to be anchored to realized inflation in the survey year. The figure also reports the 25th and 75th percentiles of the expectations distributions. The inter-quantile range – a measure of respondents' disagreement – is quite large. Though the range is larger in periods of high inflation, the inter-quantile range is about 5% even in periods of low inflation. This indicates substantial heterogeneity in point forecasts of survey respondents.

To shed light on differences in expectations, we regress the respondents' point forecast of one-year ahead inflation onto a set of demographic variables plus the annual rate of inflation prevalent at the time of the survey as well as the actual realized one-year ahead inflation. Table 1 shows that female, Black, Hispanic, young, the less wealthy, and less educated respondents report higher expectations, similar to results found in previous studies (Bryan and Venkatu, 2001, Bruine de Bruin et al., 2010). Also, the coefficient on current inflation is about 0.4, while the magnitude of the coefficient on one-year ahead inflation is close to 0. This suggests that respondents are closer to adaptive expectations than to rational expectations.

Table 2 shows the heterogeneity in revisions of one-year ahead inflation expectations by regressing the absolute change in point forecasts between the two surveys onto a set of demographic variables plus the absolute error in the respondent's forecast (defined as the absolute gap between the respondent's point forecast of one-year ahead inflation and actual realized one-year ahead inflation)

and the realized change in inflation between the two surveys. We show that females, minorities, young, lower-income, and less-educated agents make larger absolute revisions. These are the same demographic groups that report larger inflation forecasts and therefore have more to learn in order to approach less biased expectations. Furthermore, the absolute error in the respondent's forecast and the realized change in inflation between the two surveys have positive and statistically significant coefficients. Therefore respondents with worse forecasts in the first survey tend to make larger revisions, and respondents revise their beliefs more during periods of more variable inflation.

The last two columns report the OLS estimates of a regression of the absolute error in the respondent's point forecast for one-year ahead inflation in each of the two surveys that respondents answer. We conclude that demographic groups who report larger point forecasts and revise more between the two surveys - females, minorities, young, the less wealthy and the less educated – also make larger forecast errors. Also, even when interviewed the second time, error patterns by demographics look similar. These results are consistent with Souleles (2004) and Anderson (2008) who also find that females, racial minorities, and low income respondents make larger forecast errors than average. We also find a positive relationship between the absolute error in the first survey and the error in the second survey, i.e., there is persistence in forecast errors of respondents.

Why do certain demographic groups report larger point forecasts, make larger forecast errors, and revise more? It could be that females, lower income individuals, less educated, young, and minorities have different actual inflation experiences and hence report larger point forecasts. Also, groups facing more volatile inflation rates could show less persistence in their inflation expectations. However, we find that this explanation is unlikely and should play a minor role. The Chicago Fed IBEX 12 month inflation series (1983-2005)[3] takes into account the different inflation experiences of various socioeconomic and demographic groups. The series uses Consumer Expenditure Survey (CEX) data and price data produced by the Bureau of Labor Statistics to construct a group-specific inflation rate, and includes the inflation rates for 42 distinct demographic groups with a monthly frequency between January of 1983 and December of 2005, which corresponds to a time series of 324 observations for each group. McGranahan and Paulson (2006) find that lower income and lower education groups have somewhat more variable inflation than higher income and higher education groups. We estimated the correlation of the inflation rates of each one of these demographic groups

[3] Description of the series is available at http://www.chicagofed.org/webpages/research/data/ibex/ibex_inflation.cfm.

with the aggregate monthly inflation series of the Bureau of Labor Statistics (BLS). We find that the correlation of each demographic group's inflation rate with the BLS inflation is above 90% for all groups during the period 1983 to 2005.[4] Therefore it is unlikely that the small differences in the inflation rate experienced by each group can explain the large heterogeneity of inflation expectations observed in the data, which is consistent with evidence in previous empirical studies (McGranahan and Paulson, 2006; Hobijn et al., 2009). Malmendier and Nagel (2011a) also show that group specific inflation rates have little significance in explaining cohort inflation expectations, once the lifetime weighted average inflation experience of the cohorts is accounted for.

Other possible explanations for demographic differences in inflation expectations include different expectations formation and information-processing rules. More specifically, there could either be demographic differences in heterogeneity of private information, or the speed at which different groups update their inflation expectations. Heterogenous updating of expectations has implications for steady-state inflation, fiscal deficits, and asset savings, and understanding the underlying channels is important for effective monetary policy. We next explore sources of demographic differences in updating explicitly in our model.

4 Interpreting the heterogeneity of prediction rules

4.1 Short-term inflation forecasts

We estimate the model of equations 2.1) and 2.2) by Maximum Likelihood[5], using agents' forecasts at 1 year and 5-10 year horizons. Tables 3 and 4 summarize the empirical results for inflation expectations at the 1 year horizon.

The first two columns of Table 3 show the estimated coefficients and standard errors for the mean expectations process, $z_{t'}(t)$, for β, and θ for the 1-year horizon. The model clearly rejects the hypothesis of rational expectations. This can be concluded by the estimated coefficient for future one-year ahead inflation being close to zero, while the coefficient for the inflation lag being close to

[4] In fact the correlation of each demographic group's specific inflation rate is above 95% with the BLS inflation and with the inflation specific rates of all the other 41 demographic groups, with the single exception of the group defined as "Food-stamp recipients". "Food-stamp recipients" are the single group exhibiting a specific inflation rate with a correlation of only 92% in relation to the BLS aggregate inflation and the inflation of the other groups.

[5] It is also possible to estimate our model by using just the conditional moments of the mean, variance, and auto-correlation of the expectations. These GMM estimates do not require the normality assumption.

0.5. Therefore households are closer to adaptive expectations than to rational expectations. From estimates of β, it is also clear that women, ethnic minorities, lower income, and less educated agents are slower to update their expectations, since they give more importance to lifetime inflation. Our estimate of the life inflation update velocity θ is 2.41, while the estimate of the importance given to lifetime inflation, β, averages 0.24 for all individuals. Malmendier and Nagel (2011a) estimate a similar model, using cohort-average inflation expectations instead of the individual forecasts, finding an estimate of 2.485 for θ and 0.479 for β. However, their estimate of β is 0.332 for the period 1984-2009. Our estimate of β shows that lifetime inflation plays a smaller role in explaining expectations than the one described by Malmendier and Nagel (2011a) for the period 1953-2009.

The estimated coefficients in Table 4 show that women, ethnic minorities, lower income, and less educated agents have a higher degree of heterogeneity in their expectations (i.e., larger estimates of $\log(\sigma^2_{u_i})$). The data also shows that there is a higher dispersion (or disagreement) in the inflation predictions of households in periods of higher inflation and more volatile inflation (as measured by the absolute change of inflation in the previous two quarters). We also find that Asians, Hispanics, and higher educated persons are slower to update their idiosyncratic opinions on inflation.

In Panel A of Table 5 we show how the heterogeneity has evolved over the years through the dummies for each half-decade. It is evident that the heterogeneity of inflation forecasts has decreased significantly over the years, particularly since the early 80s. This result is consistent with the evidence shown by Stock and Watson (2007), who find that inflation has been easier to forecast in the last two decades. However, the heterogeneity of inflation expectations has increased since 2005, perhaps as a consequence of the greater uncertainty due to the economic crisis.

The persistence of inflation shocks in macro models may depend on how much expectations incorporate changes in the previous inflation rates (Orphanides and Williams, 2003). Our model estimates suggest that the lagged inflation term, π_{t-1}, is the most important determinant of inflation expectations. Therefore it is interesting to see how much agents' reliance on the information of past inflation has changed over different periods and policy regimes. Allowing for coefficients to change with each half-decade, the evidence in Panel B of Table 5 suggests that households in the 2000's condition more strongly their expectations on the previously observed inflation. Again, this result is consistent with the findings of Stock and Watson (2007), who show that the use of the last observed inflation in the economic models' forecasts has increased substantially in the last decade.

4.2 Long-term inflation forecasts

In general the estimates of the learning model for inflation at a 5 year horizon is qualitatively similar to those at the 1 year horizon. The last quarterly inflation is a positive determinant of the 5-10 year inflation expectations (last two columns of Table 3). We also find that women, ethnic minorities, and less educated agents are slower to update their expectations and attach more importance to lifetime inflation. Again, our estimate of the life inflation update velocity θ is 2.68, which differs from the estimate of 1.889 by Malmendier and Nagel (2011a). This estimate implies that individuals update their lifetime inflation experience more quickly in order to forecast future long-term inflation. Our value of β averages 0.29 for all individuals, which is very similar to the value of 0.269 estimated by Malmendier and Nagel for the period 1984-2009.

The coefficient of 0.14 for previous inflation in the long-term expectations is smaller than the 0.48 estimate for the one year horizon, indicating that agents do expect recent inflation shocks to die out as time passes. In general, due to the high persistence in price formation, one should expect that shocks to inflation affect expectations of short-term expectations. However, the fact that the last observed inflation matters for long-term expectations implies that agents believe that central banks do not have a completely credible target for long-term inflation.

We also used the mean inflation of 5-10 years in the future ($\bar{\pi}_{t+4\times10,t+4\times5}$) and 5-10 years in the past ($\bar{\pi}_{t-4\times10,t-4\times5}$) as regressors. However, neither previous long-term inflation or future long-term inflation is significant. The fact that future long term inflation rates do not affect current long-term inflation expectations implies that agents are again rejected to be rational.

Also, heterogeneity within each demographic group is qualitatively similar to the expectations of inflation at 1 year horizon (lower panel of Table 4). Again we find that women, ethnic minorities, younger persons, lower income, and less educated agents have a higher degree of heterogeneity in their expectations. The data also show that there is a higher dispersion (or disagreement) in the inflation predictions of households in periods of higher inflation. However, the persistence of long-term inflation expectations behaves differently than in the short-term. Here, we find that females, Asians and Blacks are quicker to update their idiosyncratic opinions on inflation. We also show how the heterogeneity has evolved over the years through the dummies for each half-decade (Table 5). Again, it is clear that the heterogeneity of inflation forecasts decreased significantly over the years, and that the heterogeneity of inflation expectations has increased since 2005.

Lower income agents have a higher heterogeneity of expectations both at short-term (top panel of Table 4) and long-term horizons (bottom panel of Table 4). A potential explanation could be that lower income households consume different consumption baskets and may have a higher consumption share in items, such as food, that have more volatile prices at both the local level and at different time periods (Mankiw, Reis, and Wolfers, 2003). However, using the quarterly average of the Chicago Fed IBEX inflation rate as a regressor instead of the CPI does not change the results significantly, suggestion that different inflation volatility across demographic segments does not play a significant role (results not reported here; available from the authors upon request).

Again, it is also interesting to see how the effect of past inflation on long-term inflation expectations has changed over different periods and policy regimes. Next, we re-estimate the updating model allowing for the coefficient for the lagged inflation term to change at each decade and half-decade. The coefficients for each half-decade in Panel B of Table 5 show that American households, during the late 1980s and the 2000s, did not incorporate short-term fluctuations in the previous inflation rate in their long-term inflation expectations. This is interesting, because it suggests that people were slow to react to the credibility of the new regime imposed by Volcker in the early 1980s. It is also a sign that consumers during the 2000's trust the ability of the Federal Reserve to revert short-term inflation fluctuations over the long term.

4.3 Personal income growth forecasts

Economists are often worried that inflation expectations could affect wage demands. We explore this issue by studying how the households' personal income growth forecasts of the households in the next year relate to their inflation expectations. The first two columns of Table 6 regress the subjective income growth expectation reported in the first and second surveys on various demographic variables and controls, respectively. Male, young and middle-age respondents report economically and statistically significant higher income growth expectations, which is consistent with actual life-cycle patterns (Attanasio, Banks, Meghir, and Weber, 1999).

The elasticity of income growth expectations with respect to inflation expectations is 0.030, suggesting that respondents perceive a positive but weak link between wage fluctuations and inflation. The last column reports the coefficient estimates of regressing the absolute change in income expectations on the various covariates. Low income and young respondents revise their

income expectations more, which could be the result of their labor market experiences being more volatile. Absolute revisions in income expectations are positively correlated with absolute revisions of inflation expectations, but not with realized changes in inflation. This result makes sense, since it is reasonable to expect households to rely more on their subjective inflation forecast when forming their expectations for their own personal income growth.

We next estimate the same learning model described in section 2 using the forecasts of personal income growth as the dependent variable. We also use the subjective inflation expectation of the household for the next year, $\pi^{p}_{t+4,i}(t)$, as a regressor to explain personal income growth forecasts. The results are shown in Tables 7 and 8. In both survey periods agents' personal income growth forecasts rely more on their subjective inflation expectations than on the past inflation (Table 7), especially in the first period forecast. This makes a strong case for central banks to contain inflation expectations, since the estimates imply that rises in inflation expectations are tied to an expected increase in wages. Our model estimates also show that males, low and middle income, and more educated households rely more on their lifetime inflation experience than others (i.e., higher estimates of β). The data also shows that there is a higher dispersion in the personal income growth forecasts during periods of higher inflation volatility, although there is lower dispersion in forecasts during periods of higher inflation (Table 8).

Young, middle-aged, low and middle income, and highly educated households have a higher heterogeneity of personal income growth forecasts than the average (Table 8). This is consistent with the life-cycle evidence. Most of the heterogeneity in the trend growth of personal income happens early in life (Attanasio, Banks, Meghir, and Weber, 1999). Moreover, evidence on the inequality of work earnings shows that highly educated workers are the ones with more intra-group heterogeneity (Katz and Autor, 1999). Also, females, young and middle-aged, middle income, and highly educated households update their expectations more quickly (Table 8). This result makes sense since young and more educated households have more to learn about the prospects of their future jobs. In Panel A of Table 9, we show how the heterogeneity of income forecasts has evolved over the years through dummies for each half-decade. It is clear that the heterogeneity of personal income growth forecasts decreased significantly over the years. This result is consistent with the evidence found by Primiceri and van Rens (2009), who find that the increases in earnings' inequality over the last 25 years was the result of predictable changes in earnings.

Again, it is interesting to see how the relationship between inflation expectations and income growth expectations has changed over different periods and policy regimes. Next we re-estimate the model, allowing for the coefficient for the inflation expectation term to change at each half-decade. We show the coefficients for each half-decade in Panel B of Table 9. The time-varying coefficients' estimates show that during the period 1978-1985 households incorporated a great degree of their inflation forecasts to determine their income growth expectations. However, this tendency decreased after 1985, and in the 2000's there is no longer an effect of inflation expectations on income growth forecasts. These are good news for policy-makers and central banks because it means that, in recent years, households no longer feed the vicious cycle of inflation expectations and wage demands.

4.4 Model Fit

As we discussed before, several explanations and models have been offered to explain the evolution of inflation expectations and its heterogeneity, including: a) rational expectations, b) adaptive expectations, and c) different life experiences. In relation to the previous alternatives in the literature, our model includes heterogeneity in the use of information both in terms of observable information (demographic groups attach different importance to their lifetime experiences and have different bias for their expectations) and unobservable information (people update information differently with some groups being "faster learners" than others). Therefore we can think of our model as essentially a model with heterogeneous information and dynamic updating features. The question is how relevant are these additional features and how much do they add to our understanding relative to previous explanations?

For this purpose, we compare the Efron's R-square and McFadden Pseudo R-square of our model with those of the alternative models. The Efron's R-square is a measure of how much of the variability in the data is explained by the model and is built in relation to square deviations from the mean. The McFadden Pseudo R-square compares the likelihood of the model to that of the null model, which is a bivariate normal model of expectations that just considers a constant. This model is the equivalent of assuming people never update their expectations with time-varying information and that heterogeneity of expectations does not differ across demographic groups or over different years. Another way to think about these two metrics is that the Efron's R-square considers only deviations from the mean, while the Pseudo R-square cares about how the model

fits the whole probability distribution. In the case of our bivariate normal model that translates into how well the model's three parameters – the mean, variance, and the correlation between the private information in the two periods - fit the entire joint distribution of the data.

We compute both the (Efron's) R-square and the Pseudo R-square for a model that also includes the information of future inflation in the next period, i.e., a purely forward-looking model. This model differs from rational expectations, because it considers that agents can be systematically biased by a constant term. We can think of this alternative as a biased rational expectations model. We also report these statistics for a model that includes both a constant and the inflation rate observed in the last quarter, which can be thought of as a model of biased adaptive expectations. Finally, we consider a model that allows for a constant and the individual lifetime inflation rate, as suggested by Malmendier and Nagel (2011a).

The R-squares and Pseudo R-squares of our model and its three alternatives are shown in Table 10 as measures of their fit for the expectation of inflation at the 1 year and 5-10 year horizons and the personal income expectations for the next year. We focus on the R-square and Pseudo R-square of the models computed for the agents within the 25th and 75th percentiles. We choose this option because parametric models are better at explaining the center of the distribution than their tails. In the case of inflation expectations, there are a considerable number of individuals reporting inflation rates far from the historical experience of the last 35 years and those predictions are hard to explain by any economic model. Therefore, focusing on the population closer to the center of the distribution insures our analysis is not plagued by outliers.

Based on the Efron's R-square, shown in the first three columns of Table 10, we see that our model does slightly better than the alternatives for each of the three expectations, in particular for 1-year ahead inflation expectations, in explaining deviations from the mean. Amongst the alternatives, all three models perform equally well. However, our model has a much higher Pseudo R-square value than any of the alternatives, showing that previous models explain only a small part of the individual-level heterogeneity of inflation predictions and its updating process.

So, overall, all these models do a similar job in explaining the mean value of inflation expectations. However, our model differs a lot in how much of the heterogeneity it explains. This result confirms that demographic heterogeneity and differences in dynamic updating of information are an essential characteristic of inflation expectations.

5 Implications for market outcomes

5.1 Effects of heterogeneity and sticky expectations on inflation

The heterogeneity and persistence of inflation expectations should have strong effects on macroeconomic equilibrium. Benabou and Gertner (1993) show that cost uncertainty reduces the informativeness of prices by scrambling relative and aggregate variations. If agents are less informed, price competition is lower and mark-ups higher. This is a similar intuition to that in the literature on learning and asset prices, where the higher heterogeneity of opinions among agents creates an option price feature which translates into a price-drift (Harris and Raviv, 1993, Sims, 2009).

Here we stick to a search framework similar to Diamond (1987) and Benabou and Gertner (1993), but with major simplifications in order to illustrate how consumers' heterogeneity of information affects the price level set by firms. We posit a simple search model, where buyers accept to buy a product from a store depending on how they think the overall price distribution is. Assume that a store with an homogeneous product is trying to set its optimal price, p. Customer i buy its product if p is below their subjective reserve price, p_i, which is heterogeneously distributed with cdf $F(p_i)$, depending on the customers' private information about what the overall price for the product and whether p is a good-bargain. Therefore the store maximizes its profit function given by:

$$4.1)\ \max_p p\int_p^{\infty} 1\partial F(p_i) = p(1-F(p))$$

In this model, heterogeneous information observed by consumers increases the monopoly power of firms, since there will be a higher mass of consumers willing to buy at high prices. To observe this more clearly, assume that $F(p_i)$ is an uniform distribution between $[0.5-h, 1.5+h]$, where h represents a higher degree of heterogeneity. Now the profit function simplifies to $p(1-\frac{p-0.5+h}{1+2h})$ and the optimal price simplifies to $p=\dfrac{1.5+h}{2}$. Therefore one should expect that heterogeneity of consumer expectations to have a positive effect on the price level of the economy and its inflation rate. The same conclusions persist under much more general frameworks. For instance, a similar proof can be easily worked out if we use any other symmetric distribution of consumer reserve prices besides the uniform, such as a normal distribution.

Also, if agents take a long time to revise their expectations, this should increase the period of time in which firms will be able to charge high prices without losing their consumers. Therefore

higher degrees of "price stickiness" should also be associated with higher markups and more inflation. Let us modify the model summarized in expression 4.1) and assume that now there is a proportion g of consumers with old information and with distribution of reserve prices given by $[0.5-h, 1.5+h]$. g can be interpreted as the proportion of consumer who do not update their information and therefore keep the same reserve prices. There is also a proportion $1-g$ of consumers with new and more precise information on the overall price level and therefore have lower heterogeneity $[0.5-w, 1.5+w]$, where $w < h$. This changes the profit function of the firm to:

4.2) $\max_p p[(1-g)(1-\frac{p-0.5+w}{1+2w}) + g(1-\frac{p-0.5+h}{1+2h})]$.

Now the optimal price of the firm changes to $p = g(\frac{1.5+h}{2}) + (1-g)(\frac{1.5+w}{2})$. Since the heterogeneity of consumers who do not update their information is larger ($w < h$), then the model's price level is clearly increasing in the proportion of consumers with "sticky expectations".

We now test the predictions of this simple framework. Using our learning model estimated from the Michigan survey panel data we obtain two measures of heterogeneity of consumer expectations. The first measure of heterogeneity measures the variance of current inflation forecasts. We use the inter-decile range of the inflation forecasts of the 2nd round interviews, $IDR(\pi^p_{t+4,i}(t))$, as a measure of current heterogeneity in inflation expectations, which is denoted as $heterogeneity_t$. We also include one measure of sticky expectations, the median λ_i, denoted as $sticky_t$ and which shows how slow agents are to update their idiosyncratic expectations term and documents changes in this updating speed over time. Our results are qualitatively similar if we use the the mean value of λ_i instead of the median or the interquantile range as a measure of heterogeneity.

We run a regression of next quarter inflation on $median[\pi^p_{t+4,i}(t)]$, $heterogeneity_t$, and $sticky_t$. We also condition our regression on other variables affecting inflation, such as inflation of the previous quarter, π_{t-1}, and the inflation volatility in the last semester, $|\pi_{t-1} - \pi_{t-2}|$. The results for the effects of the expectations at one year horizon and five-to-ten years on the next quarter's inflation are shown in the two panels of Table 11. Both $heterogeneity_t$ and $sticky_{i,t}$ are highly significant in explaining the inflation in the next quarter at the 1 year or 5-10 year horizons. It is also noticeable that median inflation expectation, $median[\pi^p_{t+4,i}(t)]$, has no discernible effect on future inflation. Therefore, using only median/mean expectations and ignoring the heterogeneity and persistence of idiosyncratic beliefs neglects important information.

6 Conclusions

We propose a model where agents provide inflation forecasts based on observable information - such as the previous inflation rates - and unobservable information. In our model, upon receipt of new information, agents may update both the public information as well as their private information. Using the panel data of the Michigan Survey of Consumers, we show that individuals are highly heterogeneous in their updating of inflation expectations. However, over the years, the heterogeneity of expectations for both short-term and long-term inflation has decreased substantially. Also, in the recent decades, agents rely more on previous observed inflation to forecast future inflation rates. This result is consistent with studies that find inflation and earnings' structure became easier to predict in more recent years (Stock and Watson, 2007).

During the 2000's the previous period inflation rate matters more for the one-year horizon inflation forecast than for long-term inflation expectations. This shows that although contemporary consumers expect inflation to be more persistent in the short-term, there is a greater confidence in the ability of the Federal Reserve to revert those shocks over the long term. In a similar way, personal income forecasts during the 2000's are less sensitive to subjective inflation expectations. The interplay between wages and inflation – a common feature of the wage-inflation spiral of the 1970s – seems therefore to have diminished in the last decade.

One notable finding is that individuals differ in how quickly they update their expectations of inflation. In particular, women, ethnic minorities, and less educated agents are slower to update their expectations, giving a larger focus to previous life experience rather than to recent events. These groups are also less prone to change their idiosyncratic private beliefs in the following semesters. This slowness in the updating of new information could explain why these groups systematically report inaccurate expectations. Finally, we relate how learning about inflation and belief heterogeneity is related to market equilibrium of consumer goods and financial markets. We show that the heterogeneity of new idiosyncratic information and "sticky expectations" by consumers can increase the next quarter's inflation. This evidence is consistent with models where consumers search for "best-bargains" (Benabou and Gertner, 1993).

However, our most important result is that our model vastly outperforms other models in explaining the heteroscedasticity and updating of agents' expectations. Expectation differences

across agents are large and persistent over time. Demographic heterogeneity and differences in dynamic updating of information are therefore an essential characteristic of inflation expectations and the most salient feature observed over the last three decades of expectations data.

This conclusion is relevant for improvements in future macro modelling of agents' reactions, since it shows heterogeneity is a much more essential feature of the data than the dichotomy between rational expectations versus backward looking expectations or adaptive updating. Several structural macro models do not have a stable equilibrium when there is heterogeneity of inflation expectations and updating (Giannitsarou, 2003), implying that standard monetary policy is unable to make inflation converge to the best possible outcome (Orphanides and Williams, 2003). Also, heterogeneous learning dynamics imply that monetary and fiscal policy has different effects on agents' savings (agents that believe in higher future inflation will save and invest less), as well as on the steady-state rate of government deficits (Evans, Honkapohja and Marimon, 2001). Therefore, our finding that agents' learning about inflation is highly heterogeneous should have important implications for the simulation of realistic macro models and policy-making.

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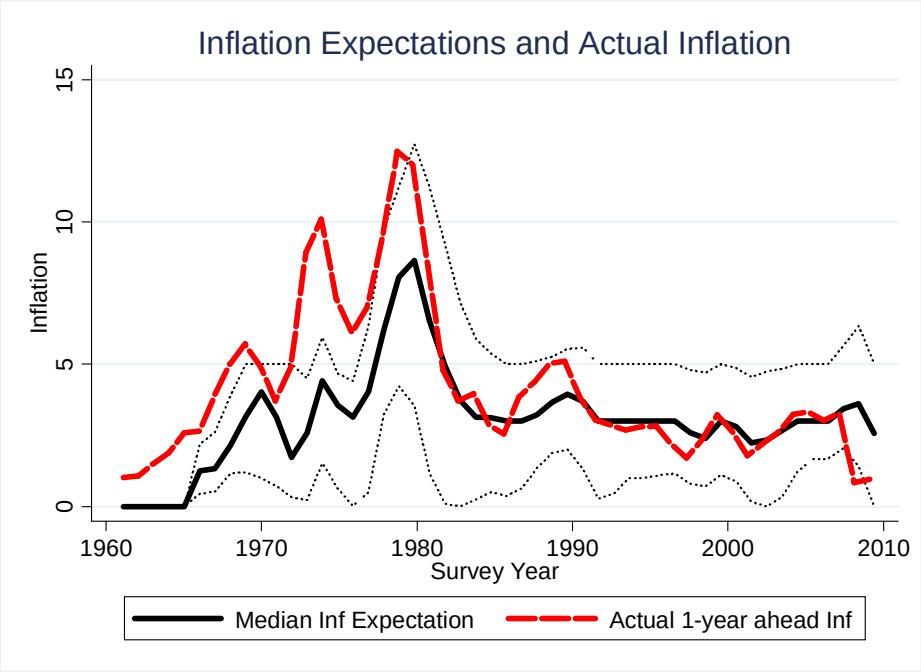

Figure 1: The figure shows the median inflation expectations as well as the 25th and 75th percentiles of the corss-sectional data. Realized one-year ahead inflation also reported.

Table 1: Heterogeneity in 1-year Inflation Expectations by Various Demographics

	First Survey All Years	Second Survey All Years
Female	0.963***	1.074***
	(0.0456)	(0.0462)
Asian	0.105	0.744***
	(0.188)	(0.191)
Black	1.184***	0.944***
	(0.0852)	(0.0868)
Hispanic	1.117***	1.057***
	(0.121)	(0.123)
Young[a]	1.067***	0.453***
	(0.0716)	(0.0732)
Mid-age	0.790***	0.424***
	(0.0606)	(0.0624)
Lowest Income tercile	0.922***	0.724***
	(0.0761)	(0.0773)
Middle Income tercile	0.386***	0.152**
	(0.0647)	(0.0658)
Education	-0.118***	-0.150***
	(0.00976)	(0.00990)
Inflation in Survey Month	0.401***	0.437***
	(0.0334)	(0.0280)
Realized 1-yr ahead Inflation	-0.0970***	0.0698***
	(0.0328)	(0.0260)
Constant	3.492***	3.948***
	(0.273)	(0.230)
Observations	78756	65957
R-squared	0.113	0.139

The table reports OLS estimates of the regression of one-year ahead inflation point forecast expectation on various demographics.

[a] Young is defined as age < 31; Mid-age is defined as age > 30 & age < 61.

Standard Deviations in Parentheses. ***, **, * denote significance at the 1, 5, and 10 percent levels, respectively.

Table 2: Revisions and Forecast Errors for 1 year Horizon, by Demographics

	Absolute Revision of Point Forecast[a]	Absolute Error[b]	
	All years	1st Survey	2nd Survey
Female	0.487***	1.007***	0.591***
	(0.0374)	(0.0369)	(0.0322)
Asian	0.553***	0.594***	0.602***
	(0.153)	(0.1530)	(0.1320)
Black	0.600***	1.734***	0.767***
	(0.0707)	(0.0688)	(0.0606)
Hispanic	0.306***	1.387***	0.648***
	(0.101)	(0.0989)	(0.0871)
Young[a]	-0.0262	0.183***	-0.0215
	(0.0595)	(0.0578)	(0.0506)
Mid-age	-0.156***	-0.0614	-0.0454
	(0.0509)	(0.0492)	(0.0436)
Lowest Income	0.267***	0.399***	0.263***
tercile	(0.0624)	(0.0618)	(0.0547)
Middle Income	-0.00255	0.0737	0.0478
tercile	(0.0524)	(0.0526)	(0.0460)
Education	-0.117***	-0.218***	-0.134***
	(0.00815)	(0.00789)	(0.00696)
Absolute Error in First Survey	0.648***		0.245***
	(0.00369)		(0.00317)
Actual $\triangle$Inflation between Surveys	0.0512**		
	(0.0212)		
Constant	2.738***	6.200***	4.020***
	(0.123)	(0.116)	(0.104)
Observations	61837	76861	71248
R-square	0.387	0.116	0.18

[a] Defined as |1-yr ahead inflation point forecast reported in Second Survey - 1-yr ahead inflation point forecast reported in First Survey |.

[b] Defined as | Actual realized 1-yr ahead inflation - Respondent's Expectation of 1-yr ahead inflation |

OLS estimates reported of a regression onto various demographics.

Standard Deviations in Parentheses. ***, **, * denote significance at the 1, 5, and 10 percent levels, respectively.

Table 3: Mean expectations

	1-yr Horizon Expectation		5-10 yr Horizon Expectation	
	Coefficient	**Std-error**	**Coefficient**	**Std-error**
Mean expectations, $z_{t'}(t)$ (First Survey):				
π_{t+1}	-0.018	0.015	-	-
$\bar{\pi}_{t+4\times10,t+4\times5}$	-	-	0.397	0.385
$\bar{\pi}_{t-4\times5,t-4\times10}$	-	-	-0.416	0.404
π_{t-1}	0.484***	0.013	0.139***	0.019
constant	3.901***	0.251	0.194	0.629
Mean expectations, $z_{t'}(t)$ (2nd Survey):				
π_{t+1}	0.048***	0.014	-	-
$\bar{\pi}_{t+4\times10,t+4\times5}$	-	-	-0.051	0.032
$\bar{\pi}_{t-4\times5,t-4\times10}$	-	-	-0.134***	0.038
π_{t-1}	0.372***	0.013	0.141***	0.021
constant	3.472***	0.244	-0.989	0.673
log(β):				
Female	0.835***	0.062	0.142***	0.008
Asian	0.162	0.130	0.065**	0.029
Black	0.507***	0.044	0.119***	0.020
Hispanic	0.453***	0.056	0.202***	0.023
Young	0.366**	0.062	0.205***	0.018
Middle Aged	0.347***	0.049	0.091***	0.013
Low Income	0.684***	0.052	0.122***	0.013
Middle Income	0.360***	0.046	0.039***	0.009
education	-0.106***	0.008	-0.022***	0.002
constant	-1.346***	0.175	0.516***	0.073
θ:				
constant	2.414***	0.233	2.683***	0.082

All terms include dummies for half-decade periods.
Robust Huber-White standard-errors. ***, **, * denote significance at the 1, 5, and 10 percent levels, respectively.
N=85350 for 1-yr horizon; N = 59371 for 5-10 yr horizon.

Table 4: Unobserved Heterogeneity

	Coefficient	**Std-error**	**Coefficient**	**Std-error**	**Coefficient**	**Std-error**
	$\log(\sigma^2_{u_i^1})$:		**$\log(\sigma^2_{u_i^2})$:**		**logit(λ):**	
			1 year expectations			
Female	0.288***	0.005	0.301***	0.005	0.006	0.014
Asian	0.218***	0.021	0.268***	0.021	0.127**	0.062
Black	0.422***	0.010	0.341***	0.010	-0.008	0.024
Hispanic	0.345***	0.014	0.239***	0.014	0.192***	0.036
Young	0.060***	0.008	0.011	0.008	-0.079***	0.022
Middle Aged	-0.030***	0.007	-0.012*	0.007	0.041**	0.020
Low Income	0.176***	0.009	0.197***	0.009	-0.026	0.024
Middle Income	0.050***	0.007	0.062***	0.007	0.006	0.021
education	-0.064***	0.001	-0.059***	0.001	0.008***	0.003
π_{t-1}	0.046***	0.002	0.039***	0.002	0.005	0.005
$\lvert\pi_{t-1} - \pi_{t-2}\rvert$	0.041***	0.007	0.090***	0.005	-0.025	0.016
constant	2.249***	0.024	2.077***	0.025	0.547***	0.072
			5-10 year expectations			
Female	0.322***	0.008	0.331***	0.008	-0.053**	0.021
Asian	0.305***	0.031	0.192***	0.030	-0.362***	0.070
Black	0.509***	0.014	0.385***	0.014	-0.079**	0.035
Hispanic	0.414***	0.020	0.255***	0.020	0.008	0.048
Young	0.168***	0.012	0.069***	0.012	0.160***	0.034
Middle Aged	-0.004	0.010	-0.032***	0.010	0.129***	0.031
Low Income	0.304***	0.012	0.241***	0.012	-0.055	0.034
Middle Income	0.077***	0.010	0.104***	0.010	-0.101***	0.029
education	-0.069***	0.002	-0.078***	0.002	-0.006	0.005
π_{t-1}	0.033***	0.003	0.033***	0.003	-0.010	0.009
$\lvert\pi_{t-1} - \pi_{t-2}\rvert$	0.013	0.012	0.024*	0.013	-0.151***	0.035
constant	2.409***	0.045	2.453***	0.048	1.041***	0.136

All terms include dummies for half-decade periods

Table 5: Evolution of Inflation Expectations over Time

	Coef	**Std-error**	**Coef**	**Std-error**	**Coef**	**Std-error**	**Coef**	**Std-error**
	1-yr Expectations				5-10 yr Expectations			
Panel A: **Evolution of unobserved heterogeneity over each half-decade**								
	log($\sigma^2_{u_i^1}$):		**log($\sigma^2_{u_i^2}$):**		**log($\sigma^2_{u_i^1}$):**		**log($\sigma^2_{u_i^2}$):**	
dummy 1978-80	-	-	-	-	-	-	-	-
dummy 1981-85	0.126***	0.012	0.066***	0.016	0.096***	0.024	0.031	0.035
dummy 1986-90	-0.066***	0.016	-0.092***	0.019	-0.111***	0.033	-0.179***	0.043
dummy 1991-95	-0.040**	0.018	-0.111***	0.022	-0.170***	0.032	-0.211***	0.044
dummy 1996-00	-0.197***	0.019	-0.192***	0.023	-0.411***	0.034	-0.391***	0.046
dummy 2001-05	-0.106***	0.019	-0.110***	0.024	-0.419***	0.037	-0.417***	0.048
dummy 2006-09	-0.094***	0.021	-0.053**	0.025	0.000	0.000	0.000	0.000
Panel B: **Changing the effect of lagged inflation over each half-decade**								
	Mean exp., $z_{t'}(t)$ (First Survey):		**$z_{t'}(t)$ (2nd Survey):**		**$z_{t'}(t)$ (First Survey):**		**$z_{t'}(t)$ (2nd Survey):**	
π_{t-1}, 1978-80	0.345***	0.021	0.286***	0.019	0.215***	0.078	0.517***	0.093
π_{t-1}, 1981-85	0.318***	0.016	0.243***	0.017	0.122***	0.019	0.114***	0.024
π_{t-1}, 1986-90	0.356***	0.024	0.209***	0.024	0.077*	0.046	0.048	0.034
π_{t-1}, 1991-95	0.242***	0.050	0.180**	0.091	0.302***	0.046	0.170*	0.102
π_{t-1}, 1996-00	0.451***	0.041	0.464***	0.038	0.168***	0.038	0.203***	0.036
π_{t-1}, 2001-05	0.750***	0.043	0.665***	0.037	0.057	0.044	0.109	0.071
π_{t-1}, 2006-09	0.803***	0.060	0.645***	0.051	0.000	0.000	0.000	0.000

N=85350 for 1-yr horizon; N = 59371 for 5-10 yr horizon.

Table 6: Correlates of Income Growth Expectations, and Changes in Income Expectations

	Income exp. in 1st Survey	Income exp. in 2nd Survey	Absolute change in in income expectations
Female	-1.51***	-1.62***	-0.44***
	(0.12)	(0.13)	(0.14)
Asian	0.71	0.17	-0.56
	(0.50)	(0.53)	(0.54)
Black	0.51**	0.65***	0.011
	(0.23)	(0.25)	(0.26)
Hispanic	0.33	0.94***	-0.14
	(0.33)	(0.35)	(0.37)
Young[a]	8.62***	9.06***	7.67***
	(0.19)	(0.21)	(0.223)
Mid-age	4.44***	4.64***	4.40***
	(0.16)	(0.18)	(0.19)
Lowest Income	3.25***	3.13***	2.19***
tercile	(0.20)	(0.22)	(0.23)
Middle Income	0.76***	0.65***	0.023
tercile	(0.17)	(0.182)	(0.19)
Education	0.65***	0.63***	0.35***
	(0.027)	(0.029)	(0.031)
Inflation expectation	0.030***		
in first survey	(0.010)		
Inflation expectation		0.036***	
in second survey		(0.012)	
Change in Inf expectations			
between surveys			
Actual change in income			-0.010***
between surveys (in 000s)			(0.0022)
Absolute Change in inflation			0.19***
expectations between surveys			(0.013)
Realized change in inflation			-0.12
between surveys			(0.074)
Constant	-7.91***	-8.02***	-1.79***
	(0.40)	(0.43)	(0.47)
Observations	71194	65510	55277
R-square	0.051	0.054	0.033

OLS estimates of income growth expectations reported of a regression onto various demographics.
Standard Deviations in Parentheses. ***, **, * denote significance at the 1, 5, and 10 percent levels, respectively.

Table 7: 1-Year Personal Income Growth Expectations

	Coefficient	**Std-error**
mean expectations, $z_{t'}(t)$ **(First Survey):**		
$\pi^{p}_{t+4,i}(t)$	0.068***	0.021
π_{t-1}	0.007	0.048
constant	3.494*	1.852
mean expectations, $z_{t'}(t)$ **(2nd Survey):**		
$\pi^{p}_{t+4,i}(t+1)$	0.039*	0.022
π_{t-1}	-0.250***	0.052
constant	7.128***	1.863
log(β):		
Female	-0.191***	0.050
Asian	0.015	0.060
Black	0.024	0.030
Hispanic	0.063	0.043
Young	1.473	1.040
Middle Aged	1.198	0.958
Low Income	0.563***	0.144
Middle Income	0.141***	0.050
education	0.102***	0.031
constant	-2.025	1.549
$\boldsymbol{\theta}$**:**		
constant	-1.249***	0.124

$N = 69681$
All terms include dummies for half-decade periods.
Robust Huber-White standard-errors. ***, **, * denote significance at the 1, 5, and 10 percent levels, respectively.

Table 8: Unobserved heterogeneity of Personal Income Growth expectations

	Coefficient	**Std-error**	**Coefficient**	**Std-error**	**Coefficient**	**Std-error**
	log($\sigma^2_{u_i^1}$):		**log($\sigma^2_{u_i^2}$):**		**logit(λ):**	
Female	-0.023	0.015	-0.010	0.016	-0.129***	0.044
Asian	-0.021	0.056	-0.029	0.061	0.215	0.170
Black	-0.027	0.026	0.031	0.030	-0.043	0.080
Hispanic	-0.041	0.037	0.052	0.043	-0.024	0.141
Young	0.381***	0.028	0.383***	0.031	-0.203**	0.085
Middle Aged	0.252***	0.027	0.238***	0.030	-0.142*	0.082
Low Income	0.324***	0.023	0.258***	0.025	0.017	0.065
Middle Income	0.076***	0.021	0.032	0.024	0.148**	0.063
education	0.030***	0.004	0.025***	0.004	0.030***	0.010
π_{t-1}	-0.007	0.005	-0.014**	0.006	0.020	0.017
$\lvert\pi_{t-1} - \pi_{t-2}\rvert$	0.038**	0.020	0.028	0.018	-0.042	0.050
constant	2.257***	0.084	2.376***	0.090	0.487*	0.277

All terms include dummies for half-decade periods.

Table 9: Evolution of Heterogeneity in Income Expectations over Time

Panel A: **Unobserved heterogeneity over each half-decade (N= 59371)**

	Coefficient	**Std-error**	**Coefficient**	**Std-error**
	log($\sigma^2_{u_i^1}$):		**log($\sigma^2_{u_i^2}$):**	
dummy 1978-80	-	-	-	-
dummy 1981-85	0.066	0.046	0.005	0.052
dummy 1986-90	-0.158***	0.053	-0.200***	0.056
dummy 1991-95	-0.048	0.055	-0.173***	0.062
dummy 1996-00	-0.149***	0.058	-0.223***	0.065
dummy 2001-05	-0.120**	0.059	-0.232***	0.065
dummy 2006-09	-0.239***	0.060	-0.290***	0.071

Panel B: **Effect of expected inflation over each half-decade (N= 69681)**

	mean exp., $z_{t'}(t)$	**(period 1):**	$z_{t'}(t)$	**(period 2):**
$\pi^p_{t+4,i}(t)$, 1978-80	0.199***	0.056	0.097*	0.054
$\pi^p_{t+4,i}(t)$, 1981-85	0.106***	0.041	0.052	0.046
$\pi^p_{t+4,i}(t)$, 1986-90	0.079	0.051	0.050	0.056
$\pi^p_{t+4,i}(t)$, 1991-95	0.029	0.062	-0.100	0.066
$\pi^p_{t+4,i}(t)$, 1996-00	0.079	0.057	0.093	0.065
$\pi^p_{t+4,i}(t)$, 2001-05	-0.064	0.060	0.037	0.059
$\pi^p_{t+4,i}(t)$, 2006-09	-0.062	0.070	0.022	0.071

Table 10: Fit of the Main Model and Alternatives

Model	**Efron's R-square**			**McFadden Pseudo R-square**		
	1-year Inflation	5-10 year Inflation	Income Growth	1-year Inflation	5-10 year Inflation	Income Growth
Heterogeneous information and updating	37.6%	23.8%	10.1%	18.1%	31.3%	21.8%
Purely forward-looking info (rational exp.)	25.1%	21.0%	7.8%	1.6%	0.9%	0.1%
Purely last-quarter info (adaptive exp.	23.6%	22.4%	6.7%	1.8%	1.1%	0.1%
Malmendier-Nagel lifetime experience	31.8%	19.8%	8.4%	0.1%	1.1%	0.2%

Table 11: Effect of Inflation Expectations on Realized Inflation

Panel A: Effect of one-year inflation expectations on the next quarter's inflation, π_{t+1}
N= 125, quarterly observations

	Coefficient	**Std-error**
π_{t-1}	0.834***	0.042
$\lvert\pi_{t-1} - \pi_{t-2}\rvert$	-0.352***	0.135
$Median(\pi^{p}_{t+4,i}(t))$	-0.00009	0.00009
$heterogeneity^{a}_{t}$	0.577***	0.096
$sticky^{b}_{t}$	0.006**	0.002
constant	-1.075***	0.396

Panel B: Effect of long-term (5-10 years) inflation expectations on the next quarter's inflation, π_t
N = 71, quarterly observations

	Coefficient	**Std-error**
π_{t-1}	0.854***	0.067
$\lvert\pi_{t-1} - \pi_{t-2}\rvert$	-0.123	0.140
$Median(\pi^{p}_{t+4\times(5:10),i}(t))$	-0.107	0.113
$heterogeneity_{t}$	0.559***	0.182
$sticky_{i,t}$	6.293***	1.75
constant	-2.381***	0.744

***, **, * denote significance at the 1, 5, and 10 percent levels, respectively.
[a] $heterogeneity_t$ is the inter-decile range of inflation forecasts in the 2nd survey.
[b] $sticky_t$ is the median λ_i (the private information updating parameter).

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