The Formation of Consumer Inflation Expectations: Evidence From Japan's Deflation Experience

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Abstract

Using a new micro-level dataset we investigate the relationship between the inflation experience and inflation expectations of individuals in Japan. We focus on the period after 1995, when Japan began its era of deflation. Our key findings are fourfold. Firstly, we find that inflation expectations tend to increase with age. Secondly, we find that measured inflation rates of items purchased also increase with age. However, we find that age and inflation expectations continue to have a positive correlation even after controlling for the individual-level rate of inflation. Further analysis suggests that the positive correlation between age and inflation expectations is driven to a significant degree by the correlation between cohort and inflation expectations, which we interpret to represent the effect of historical inflation experience on expectations of future inflation rates.

Keywords: Inflation Expectations, Panel Data, Japan

1 Introduction

Since at least the time of Keynes (1936), economic agents' expectations of future inflation rates have played a pivotal role in macroeconomics. Woodford (2011) describes the central importance of inflation expectations to modern macroeconomic models due to the intertemporal nature of economic problems, while Sargent (1982) and Blinder (2000) highlight the dependence of monetary policy on these expectations. However, despite the important role of inflation expectations, their formal inclusion in macroeconomic models is usually ad-hoc with little empirical justification.

This study takes the position that understanding the underlying drivers of inflation expectations is of great importance and we focus on the case of Japan. The formation of inflation expectations in Japan is an important topic of study because of the many lessons it potentially holds for other advanced economies. Japan has experienced deflation since the mid-1990s. By now, a generation of young adults has grown up without ever having experienced inflation. How do their expectations differ from those of earlier generations who experienced high levels of inflation and even hyperinflation? How has the young generation's experience of deflation affected their expectations of inflation in the future and what does this imply for other advanced economies experiencing prolonged periods of deflation?

The results of this study also hold implications for monetary policy. Many, such as Ahearne et al. (2002), Ito and Mishkin (2006) and Hoshi and Kashyap (2013), argue that monetary policy was an important contributor to Japan's prolonged deflation. From this perspective it becomes important to understand to what extent monetary policy can affect inflation expectations and what the implications for monetary policy are in an environment where deflation has taken root.

Recent research suggests that inflation expectations are formed in complicated ways that elude the simplified rules of formal models and are affected by numerous factors. Bryan and Venkatu (2001) document large differences in inflation expectations between men and women while Piazzesi and Schneider (2012) use the Michigan Survey of Con-

sumers to show that old and young households held significantly different expectations of future inflation rates during the late 1970s and argue that this disagreement led to greater borrowing and lending among households. In the case of Japan, Ueno and Namba (2013) find that the age profile of inflation expectations follows an inverted U-shape.

The early literature on the formation of expectations was dominated by the theory of adaptive expectations, in which economic agents use past data on a given variable to form expectations of the variable's future values. This approach to the formation of expectations of economic variables was exemplified by Friedman (1957), but fell out of favor with the rising influence of the Lucas Critique (Lucas (1976)) and rational expectations.

Nevertheless, recent research has revisited the idea that economic agents rely heavily on past data when forming expectations about the future. For example, Malmendier and Nagel (2015) propose that actual inflation rates experienced in the past play an important role in the formation of individuals' future inflation expectations. Using micro data from the Michigan Survey of Consumers, they estimate an adaptive leaning model in the tradition of Marcet and Sargent (1989) with a twist that allows individuals to overweight the inflation data realized in their own lifetimes. They show that differences in experienced inflation rates can predict differences in future inflation expectations.

In their seminal work, Friedman and Schwartz (1963) argued that the experience of the Great Depression had a profound impact on people's beliefs about the capitalist system and its future. More recently, Cogley and Sargent (2008) argue that large macroeconomic shocks, such as the Great Depression, leave very long-lasting impressions on people's beliefs and that a significant period of time is required to correct these pessimistic beliefs. Giuliano and Spilimbergo (2014) argue that the experience of a recession in early adulthood makes individuals more likely to favor economic redistribution later in life.

While the notion that economic agents might overweight data that they have personally experienced has only recently been explored in the discussion of inflation expec-

tations, evidence for such behavior has been documented in other areas. For example, Vissing-Jorgensen (2004) reports that during the stock-market boom of the late 1990s young retail investors with little investment experience displayed the highest expectations for future stock returns. In an experimental setting, Smith et al. (1988) find that asset market bubbles and crashes are less likely when subjects have experienced bubbles and crashes in previous trading sessions and Haruvy et al. (2007) find that inexperienced subjects tend to extrapolate recent price movements. These results suggest the use of adaptive expectations, especially among agents with less experience, in forming future expectations. Furthermore, the results of Greenwood and Nagel (2009) suggest that these results may not be limited to the laboratory. They show that during late 1990s' technology bubble inexperienced mutual fund managers tended to hold the riskiest portfolios and exhibited trend-chasing behavior.

This study seeks to build on previous research on the effect of experience on the formation of future inflation expectations. We combine micro data to investigate whether the variation in inflation expectations across age groups is driven by an age effect or a cohort effect that reflects past experiences. We show that at least part of the positive correlation between inflation expectations and age can also be understood as a positive correlation between inflation expectations and cohort (i.e. older cohorts display higher inflation expectations).

Carroll (2006) offers one theory of how inflation expectations are formed. Using an epidemiological model in which individuals absorb news about the economy from the same news media at different points in time, he shows how inflation expectations may spread throughout an economy in the same way that a disease might spread throughout a population. One way to interpret his model is as providing micro foundations for the aggregate inflation expectations equations generated by the model of Roberts (1998) and the sticky information model of Mankiw and Reis (2002).

Mankiw et al. (2004) document considerable disagreement about expected future inflation rates among both consumers and professional forecasters and point to the co-

movement of the disagreement in expectations with other macro variables as suggestive evidence that the variation in inflation expectations may be important in explaining macroeconomic dynamics. Their analysis of the data leads them to conclude that consumers do not form their expectations of future inflation using rational expectations. On the other hand, they also conclude that a simple adaptive expectations model is inadequate as a model of future inflation expectations formation. Neither the extreme sophistication of rational expectations nor the simplicity of naive adaptive expectations is quite able to capture inflation expectation dynamics adequately, a conclusion shared by Roberts (1998).

Johannsen (2014) documents that demographic groups exhibiting greater dispersion in experienced inflation rates also exhibit greater dispersion in future expected inflation rates. He shows that this empirical result is consistent with a model of imperfect information in which households' own rates of inflation serve as signals about the aggregate inflation rate of the macroeconomy. Furthermore, he argues that the models of Carroll (2006) and Mankiw et al. (2004) cited above are unable to generate this positive correlation between the dispersion in experienced inflation and the dispersion in inflation expectations.

One issue with studies that analyze inflation expectations, and particularly those that use data from surveys such as the Michigan Survey of Consumers, including Carroll (2006), Mankiw et al. (2004) and Johannsen (2014), is that consumers are asked about their views on "prices in general" whereas from a theoretical perspective what is arguably most important is individuals' expectations of the prices that are likely to affect their behavior - namely the prices of goods that they purchase. In contrast to the Michigan Survey of Consumers, the survey used in this study asks respondents about the prices of goods that they commonly purchase.

Furthermore, we use individuals' actual purchasing data over a two-year period to construct individual-level inflation rates which can be matched to individuals' views regarding future inflation rates. We find that although there is significant variation in

inflation rates actually experienced across age groups, this variation is not enough to explain the variation in inflation expectations.

The remainder of the paper is organized as follows. In section 2 we describe the dataset used and present summary statistics. In section 3 we construct examine inflation rates and inflation expectations across age and in Section 4 we formally investigate the relationship between inflation expectations and age. Section 5 attempts to separate the effects of age on expectations from the effect of cohort on expectations and Section 6 discusses the implications of our findings. Finally, Section 7 concludes.

2 Data and Summary Statistics

2.1 Data

This first part of this study combines three micro-level datasets of the same 13000 individuals.[1] The first dataset is a panel dataset of consumers' purchase histories.[2] Individuals scan the barcode of every item they purchase using a portable home scanner and record the quantity purchased, purchase price and purchase channel (i.e. supermarket, convenience store, etc.) of purchased items. We use the purchase data for the two-year period covering 2012-2013, containing a total of more than 33 million transactions.

The second dataset we employ is a dataset of the same individuals containing demographic, educational and financial information.[3] In particular, this dataset allows us to identify each individual's age, gender, level of education and income group.

The third and final source of data that we use is a survey about prices and inflation using the same individuals as above. The survey questions respondents regarding their perceptions of past prices changes, future price changes and their knowledge of economic and financial matters.

[1] All three datasets were provided by Intage, a Japanese market research firm.
[2] The SCI Survey.
[3] The Intage Profiler Dataset.

2.2 Descriptive Statistics

Table 1 presents sample statistics of selected key demographic, educational and financial variables used in this study. In contrast to surveys that ask respondents about their perceptions of the changes in prices *generally*, the survey employed in this study asked respondents specifically about the prices of goods that they usually buy. Respondents were asked to indicate the range in which they believed the prices of goods that they usually purchased would change over the next year. The responses from the 2014 survey are presented in Table 2.

As can be observed in Table 2, fewer than 2% of respondents expected to experience deflation in the following year. Although 22% of respondents did not expect any change in the prices of items that they purchase, two-thirds expected inflation of at least 2%, even though the official inflation rate at the time was only 1.5% and had exceeded this level only once (August-September 2008) during the previous 16 years. In fact, 9% of respondents believed that the inflation rate of prices they faced would exceed 10%.

3 Age and Inflation Expectations

3.1 Age Profile of Inflation Expectations

Figure 1 uses the same data as Table 2 to plot the distribution of inflation expectations over age using the responses to the survey in 2014. One can observe that the proportion of respondents who believe that prices will increase by at least 5% increases with age, while the proportion of respondents who believe that there will be deflation or stable prices decreases with age. While approximately 40% of young respondents believe that they will experience deflation or flat prices during the next year, only 20% of older respondents believe so. Why should there be such a large difference in the inflation expectations of young people compared to older people?

3.2 Why Do Older People Expect Higher Inflation?

One possible reason is that older individuals have higher levels of income than younger individuals and the apparent relationship between age and inflation expectations in Figure 1 simply reflects a correlation between income and inflation expectations. However, Figure 2, which plots the distribution of inflation expectations over annual household income in 2014, shows a very stable distribution of inflation expectations over levels of household income. This suggests that the relationship between age and inflation expectations observed in Figure 1 is not driven by a relationship between income and inflation expectations.

A second possible reason is that people of different ages purchase their goods through different channels and therefore face different inflation rates for the same goods. This difference in experienced inflation rates might explain the observed differences in inflation expectations across age.

To investigate this possibility we begin by aggregating the 2012 and 2013 purchase data for 5-year age groups and construct an age-group-specific price level that includes only goods that are common to all age groups' consumption baskets. The price level is calculated as a Tornqvist index with the weight applied to each good set equal to that good's share of the age group's total consumption. Figure 3 presents the results. One can observe that younger individuals face similar prices, but that the price level begins to rise from the 40-45 year-old group onwards.

This result is consistent with the work of Abe and Shiotani (2014) who used similar data, but for an earlier period (2004-2006). They found that there is little difference in prices faced by those below age 45, but that prices begin to increase thereafter. On the other hand, this is the opposite pattern to that found by Aguiar and Hurst (2007). In their research of individuals living in the Denver area in 1993-1995, they found that prices paid tend to fall with age.

In order to isolate the effect of price differences from weight differences on the price level across age groups, we calculate an unweighted price index for each age group and

plot the results in Figure 4. One can observe that while the same pattern of an increase in the price level can be observed from age 40-45 onwards, the unweighted price level falls until age 40-45. This suggests that, on average, older individuals pay the highest prices for goods in the common basket. The lowest prices are paid by middle-aged individuals, while younger individuals also tend to pay higher prices.

From the age-group-specific price levels above, we construct age-group-specific inflation rates and plot the results in Figure 5. In addition to the age-group-specific inflation rates, we also plot the mean and median inflation rates of individuals within each age group.

While the levels are different, all three measures convey the same pattern. Firstly, the experienced rate of inflation increases with age until age 55-60. Thereafter, there appears to be a slight decline. Secondly, all age groups experienced deflation, ranging from more than 1% for the youngest group to approximately 0.4% for the 55-60 year-old group. Thus, part of the reason that older individuals expect higher rates of inflation may lie in the fact that they experience higher inflation.

The finding that inflation rates differ across age groups and that they tend to increase with age has potential policy implications. In Japan, many social security benefits are indexed to general inflation. If the actual inflation rate faced by the elderly is above that faced by the general population, then it implies that benefits are declining in real terms.

Interestingly, these results follow a similar pattern to that found by Ueno and Namba (2013) when they investigated inflation rate expectations. They found that inflation expectations in Japan tend to increase with age until approximately age 65 and then begin to fall thereafter. Figure 5 suggests that actual experienced inflation rates tend to follow a similar pattern, although the inflection point appears to occur somewhat earlier, around age 60.

A third possibility for why inflation expectations vary across age groups is that people of different ages consume different baskets and thus experience different rates

of inflation. In order to determine whether the variation in inflation rates across age is driven by variation in inflation rates for the same items or variation in the baskets consumed, we need to decompose the source of variation in inflation rates into its various components. We perform this exercise in the following section.

3.3 Decomposition of the Inflation Rate into Common and Age Group Specific Factors

In order to understand the variation of our measured inflation rates across age groups, we can decompose the inflation rate for each age group in the following manner:

$$\begin{aligned} ln\left(\pi_{jt}\right) &= ln\left(\prod_{n=1}^{N_{jt}} \pi_{njt}^{\omega_{njt}}\right) \\ &= \sum_{n\in C} \omega_{njt} ln\left(\pi_{njt}\right) + \sum_{n\notin C} \omega_{njt} ln\left(\pi_{njt}\right) \end{aligned} \tag{1}$$

where π_{njt} is age group j's inflation rate for item n in period t, given by $\pi_{njt} = \frac{p_{njt}}{p_{njt-1}}$, $\omega_{njt} = \frac{1}{2} \times \left(\frac{p_{njt-1}q_{njt-1}}{\sum_{n=1}^{N_{jt-1}} p_{njt-1}q_{njt-1}} + \frac{p_{njt}q_{njt}}{\sum_{n=1}^{N_{jt}} p_{njt}q_{njt}} \right)$ and p_{njt} and q_{njt} represent the price and quantity of item n for age group j in time period t. C refers to the basket of goods that are consumed by all age groups, and N_{jt} is the total number of different items consumed by the members of age group j in period t.

Defining $\overline{\omega_{nt}}$ as the weight of item n in the aggregate basket (i.e. using all of the data) and $\overline{ln(\pi_{nt})}$ as the change in the natural logarithm of the price of item n calculated using the aggregated data (i.e. the change in the natural logarithm of the average price of item n in year t using all of the data), we can rewrite Equation 1 as

$$\begin{aligned} ln\left(\pi_{jt}\right) &= \sum_{n\in C} \omega_{njt} ln\left(\pi_{njt}\right) + \sum_{n\notin C} \omega_{njt} ln\left(\pi_{njt}\right) \\ &= \sum_{n\in C} [\overline{\omega_{nt}} + \Delta\omega_{njt}][\overline{ln(\pi_{nt})} + \Delta ln(\pi_{njt})] + \sum_{n\notin C} \omega_{njt} ln\left(\pi_{njt}\right) \end{aligned} \tag{2}$$

where $\Delta\omega_{njt}$ and $\Delta ln(\pi_{njt})$ are the deviations of ω_{njt} and $ln(\pi_{njt})$ from their aggregate values, so that $\Delta\omega_{njt} \equiv \omega_{njt} - \overline{\omega_{nt}}$ and $\Delta ln(\pi_{njt}) \equiv ln(\pi_{njt}) - \overline{ln(\pi_{nt})}$. Expanding Equation 2 gives

$$\begin{aligned} ln\left(\pi_{jt}\right) &= \sum_{n\in C}[\overline{\omega_{nt}} + \Delta\omega_{njt}][\overline{ln(\pi_{nt})} + \Delta ln(\pi_{njt})] + \sum_{n\notin C}\omega_{njt} ln\left(\pi_{njt}\right) \\ &= \sum_{n\in C}\overline{\omega_{nt}}\overline{ln(\pi_{nt})} + \sum_{n\in C}\Delta\omega_{njt}\overline{ln(\pi_{nt})} + \sum_{n\in C}\overline{\omega_{nt}}\Delta ln(\pi_{njt}) \\ &+ \sum_{n\in C}\Delta\omega_{njt}\Delta ln(\pi_{njt}) + \sum_{n\notin C}\omega_{njt} ln\left(\pi_{njt}\right) \end{aligned} \tag{3}$$

The first term on the right-hand side is a common term that is the same for all age groups. We refer to it as the "common component" and it is simply the part of the aggregate inflation rate that comes from the common basket (i.e. the log inflation rate for the basket of goods which all age groups consume). The second term captures the variation in the weights applied for each group and we will refer to this term as the "weight effect." The third term captures the variation in the actual inflation rates experienced by each group and we refer to it as the "price effect." The fourth term is a cross term that we refer to as the weight-price effect and the final term is the part of each group's inflation rate that comes from goods that are not in the common basket, which we call the "group-specific basket." A breakdown of each age group's inflation rate in to the terms of Equation 3 is presented in Figure 6.

One can observe that the price and weight-price effects do not vary much across age groups, with the exception being the 65-70 year old group. The largest variation appears to occur in the weight and group-specific basket components. However, we should not read too much into the variation in the group-specific basket component as it is highly dependent on how the age groups are defined. Defining groups more narrowly will reduce the items that are common to all groups and mechanically increase the group-specific basket component. On the other hand, the weight effect appears to persist even if we change the definition of the age groups. For example, using 10-year

age groups rather than 5-year age groups (so that the common basket includes more items and the group-specific baskets fewer items) results in the decomposition of Figure 7. As one can observe, variation in the group-specific basket component shrinks, but the weight effect continues to display significant variation across age groups. Thus, our results suggest that much of the variation in inflation rates across age groups is due to differences in the amounts bought of goods in the common basket.

4 The Effect of Experienced Inflation on Inflation Expectations

In this section we seek to investigate whether the variation in experienced inflation rates documented in the previous two sections can account for the variation observed in inflation expectations. In particular, we investigate whether or not the positive correlation between age and inflation expectations remains after we have controlled for the fact that older individuals experience higher rates of inflation. Our data do not allow us to observe an individual's expected inflation rate directly. We can observe only his expected inflation rate within a given range, as described in Table 2. Thus, we have interval-coded data where our central variable of interest, the expected inflation rate y_i^* of individual i over following year, cannot be observed. All that can be observed is a range in which it falls. We assume an individual's expected inflation rate for the following year is determined by the individual's age as well as other factors, $\mathbf{x_i}$, so that it can be described in the following manner.

$$y_i^* = \text{Age}_i\beta + \mathbf{x_i}\gamma + \varepsilon_i \tag{4}$$

where $\varepsilon_i \sim N(0, \sigma^2)$. As shown in Amemiya (1973), the parameters of this linear model, namely (β, γ) and σ, can be estimated via maximum likelihood in the same way that one would estimate a Tobit model. In particular, the log likelihood function is given by the following:

$$
\begin{aligned}
lnL \;=\; & 1[y_i = 9]\log\left[\Phi\left(\frac{-0.1 - \text{Age}_i\beta - \mathbf{x_i}\gamma}{\sigma}\right)\right] + \\
& 1[y_i = 8]\log\left[\Phi\left(\frac{-0.05 - \text{Age}_i\beta - \mathbf{x_i}\gamma}{\sigma}\right) - \Phi\left(\frac{-0.1 - \text{Age}_i\beta - \mathbf{x_i}\gamma}{\sigma}\right)\right] + \\
& \vdots \\
& 1[y_i = 1]\log\left[1 - \Phi\left(\frac{0.1 - \text{Age}_i\beta - \mathbf{x_i}\gamma}{\sigma}\right)\right] \qquad (5)
\end{aligned}
$$

where $y_i = j$ corresponds to the individual's selecting the jth interval from Table 2 for their expected inflation. Our key focus will be on the impact of the individual's age on his inflation expectations. Since, as we documented above, age and experienced inflation are correlated, we will need to control for the individual's experienced rate of inflation. The results of estimating this interval regression are reported in Table 3.

One can observe that the coefficient on age is precisely estimated and is always positive, implying that for each additional year of age the average expected rate of inflation over the following year increases by 0.05 percentage points. This may not appear large at first, but consider that it implies that individuals aged 60 expect, on average, inflation for the following year to be 1.5 percentage points higher than individuals aged 30, all else equal. The point estimate does not vary much as we add control variables to the model. The positive correlation between age and expected inflation appears to be robust, even controlling for factors such as experienced inflation, income, education and information.

A second interesting result is that, even though it is always positive and the value does not vary greatly from model to model, the estimated coefficient on the individual inflation rate is never statistically significant. This suggests that, once we control for age, an individual's experienced inflation rate over the previous year has no effect on his expected inflation rate for the following year. There may be a relationship between actual experienced inflation rates and individuals' expected future inflation rates, but from these results it does not appear to be a simple one.

A third interesting result, captured in columns (4)-(6), is that knowledge of or interest in economic issues does appear to affect inflation expectations. Respondents were asked about their knowledge of the Bank of Japan's 2% inflation target introduced in January 2013, their level of interest in economic issues generally, Abenomics[4], and their knowledge of the Statistics Bureau's CPI. Responses to all these questions are entered as dummy variables in the regression model of Table 3. The base category for "Knows About BOJ?s 2% Inflation Target" is "knows well about the BOJ target," for "Interested In Economic Issues" it is "is interested and follows the news," for "Knows About Abenomics" it is "knows well about Abenomics," and for "Interested In CPI" it is "interested in the CPI and follows it."

Looking first at column (4), one can see that those with greater knowledge of the BOJ's 2% inflation target reported higher expected inflation rates. This result suggests that an explicit inflation target from the central bank may be effective in affecting the inflation expectations of consumers. In column (5), when we add variables measuring the degree of interest that respondents have on economic issues in general, we find that those with greater interest have higher expected inflation rates. On the other hand, the effect of the BOJ's inflation target is weakened.

In column (6), the estimated coefficients on the "Knows About Abenomics" variables suggest that those with more knowledge of Abenomics have higher inflation expectations. In fact, the estimated difference in expected inflation between those who know about Abenomics well and those who know nothing about it is more than 3 percentage points, a remarkable difference. Similarly, those who take a greater interest in the Statistics Bureau's published CPI figures also report higher expected inflation rates.

However, it appears as though once knowledge of Abenomics and the CPI are accounted for, neither particular knowledge of the BOJ's 2% inflation target nor general interest in economics has a statistically significant effect on expected inflation. But since many of these variables are highly correlated it is difficult to dismiss the possibility that the central bank's inflation target does affect consumers' inflation expectations. Fur-

[4]The economic policies of the Abe administration, made public in December 2012

thermore, if the 2% target were affecting inflation expectations one would expect the effect depend on the individual's level of inflation expectations. In particular, one might expect the effect to be positive for those with inflation expectations below the BOJ's target and negative for those with expectations above the BOJ's target. We investigate this matter further in the appendix and our results suggest that inflation targeting is indeed effective in moving inflation expectations towards the target range. We also show that the effect of inflation targeting is different between younger and older individuals. In particular, inflation targeting is more effective in reducing high inflation expectations among older individuals and more effective in raising low inflation expectations towards the target range among younger individuals.

5 Disentangling Age Effects from Cohort Effects

Thus far we have observed a robust correlation between age and inflation expectations, even controlling for actual experienced inflation. What could account for this correlation? One possibility is that those of the same age have shared historical experiences and what appears to be a correlation between age and inflation expectations might actually be a correlation between shared historical experiences and inflation expectations. In particular, it may be the case that experiences of high inflation affect the inflation expectations of individuals long into the future. This perspective was emphasized by Ryder (1965), who argued that "each cohort has a distinctive composition and character reflecting the circumstances of its unique origination and history." For the question at hand the shared history of interest is the macroeconomic (particularly inflation) history experienced by each cohort and we can imagine that those who have experienced episodes of high inflation may carry with them an upward bias to their inflation expectations throughout their lives. In contrast, young Japanese, who have only ever experienced low rates of inflation, may underestimate the potential of higher inflation rates in the future.

5.1 Individuals' Experienced Lifetime Inflation Rates

This perspective reinterprets the age effect observed in our data as a cohort effect. However, estimating the effects of age, cohort and time in a simple linear additive model is not possible because, by definition, $Age = Cohort + Time$, resulting in multicollinearity. Researchers have attempted various approaches to overcome this difficulty. Most studies, such as Deaton and Paxson (1994) and McKenzie (2006) ultimately rely on one normalization or another to separate the three effects of age, cohort and time. In response to these approaches, Heckman and Robb (1985) argue that age, cohort and time in the above equation are simply proxies for variables that we are interested in but may not be able to measure directly. Their recommendation is that the researcher define clearly how age, cohort or time is related to the variable of interest (in this case, expected inflation) and try to measure the underlying relationship more directly. In our present case, we propose that the relationship between age and inflation expectations is a convenient substitute for the relationship between the actual inflation rate experienced by an individual and his inflation expectations. This occurs because different age groups tend to consume different baskets and the "age effect" is in essence a "basket effect."

On the other hand, the "cohort effect" reflects the impact of the experience of economic events shared by people at a particular point in history. It may be the case that individuals' expectations of future inflation outcomes are influenced by their experiences of inflation in the past. Those who have experienced high rates of inflation may assign higher probabilities to future high inflation outcomes and may view high inflation as a greater threat than those who have not experienced high inflation. Figure 8 summarizes the Japanese inflation experience since World War II. One can observe periods of very high inflation immediately after the war and again in the wake of the oil shocks of the 1970s. One can also observe significantly higher average inflation rates in the decades after War War II compared to the last 30 years.

In short, Figure 8 shows that, generally speaking, older individuals have experienced higher inflation rates during their lifetimes than younger individuals in Japan. Thus,

the observed correlation between age and inflation expectations from Table 3 may be masking a correlation between experienced inflation and inflation expectations. What we would like to investigate is the individual's experienced rate of inflation over his lifetime. However, we do not have these data. We can, however, investigate the relationship between the inflation rate of the macroeconomy over an individual's lifetime and his expected future inflation rate. But in order to do this, we need a parsimonious way of summarizing the rate of inflation experienced by an individual over his lifetime. In the spirit of Honkapohja and Mitra (2003) and Malmendier and Nagel (2015), we use a weighted average of the inflation rate over the individual's lifetime. In order to capture the idea that the most recent data is most relevant for the individual while past data is less important, we assign the largest weight to the most recent period and reduce the weights as we go further into the past. This weighted average of past inflation for individual i aged a in year t is thus calculated as

$$\pi^{w}_{iat} = \sum_{s=0}^{a} \frac{a+1-s}{T_a} \pi_{t-s} \tag{6}$$

where $T_a = \sum_{s=0}^{a} (a+1-s) = \frac{(a+2)(a+1)}{2}$.

One can interpret this specification as a special case of the model presented in Marcet and Sargent (1989). In our version, individuals use only inflation data generated during their own lifetimes and place more importance on recent inflation rates than on data from further in the past. In Table 4 we rerun the regressions of Table 3, but replace age with the average inflation rate of the macroeconomy over the individual's lifetime. We use the inflation rate excluding imputed rent because it is longer and the two series are very similar. One can observe a strong correlation between the weighted average inflation rate over an individual's lifetime and his future expected inflation rate, even after controlling for his actual experienced rate of inflation over the previous year. The estimated coefficients on the weighted lifetime inflation rate suggest that a one percentage point increase in the weighted lifetime inflation rate increases future inflation expectations by 0.7 to 0.86 percentage points. These results suggests that, indeed, the observed

correlation between age and inflation expectations of Table 3 may reflect the impact of the individual's historical inflation experience on his future inflation expectations.

5.2 Additional Evidence From a Panel Data Analysis

One shortcoming of the analysis thus far is that we have relied on cross-sectional data. To really tackle the issue of linear dependency among age, cohort and time we need to include a time series dimension to the above analysis. To this end we use the *Consumer Confidence Survey*, a household-level dataset conducted monthly since 2004 by the Cabinet Office of the Japanese government. Households are surveyed for 15 months continuously before being replaced in the survey. Similarly to the survey used above, respondents are asked to provide their expectations for the change in prices of the goods that they usually buy over the following year by selecting the appropriate range. The responses to the March 2014 survey are presented in Table 5.[5] Compared to the sample used earlier in this study, inflation expectations are higher. Table 6 compares demographic data on the two samples.

The first point to notice is that the respondents in the Consumer Confidence Survey (CCS) are older. Since the CCS is aimed at the household head, the sample displays a far greater representation of men than does the Intage data. Since the household income data are not collected in the same way it is difficult to make exact comparisons, but when we adjust the income data for the CCS to be similar in definition to the Intage data, it appears as though the respondents in the CCS have lower income levels in general.

Thus, it appears as though the two samples represent slightly different underlying populations and this must be considered when interpreting the coefficients estimated using the CCS. While the CCS offers a advantage over the Intage data because it allows us to exploit the time series dimension of the data, it also comes with a disadvantage as we can no longer observe the actual inflation rates experienced by individuals as we could in the Intage dataset. One may worry that by not controlling for the actual inflation rate experienced by households we are introducing a bias into our estimates.

[5] We use the March 2014 survey because it matches the timing of the survey used earlier in the paper.

However, the results from Table 3 and Table 4 suggest that once our variables of interest are included, the actual inflation experienced is uncorrelated with the expected rate of inflation and thus there ought not to be any significant bias. Nevertheless, the fact that we cannot control for the individual's inflation rate must be kept in mind in interpreting the results that follow.

Figures 9 through 11 introduce graphically the elements of the data upon which we will focus. Figure 9 graphs the mean response to the question regarding inflation expectations summarized in Table 5 across age for selected cohorts. Thus, the graph does not describe mean inflation expectations, but rather the mean range of inflation expectations as described in Table 5, with "1" corresponding to the lowest expected range of inflation (less than -5%) and "7" corresponding to the highest expected range of inflation (greater than 5%).[6] One can observe a consistent pattern regardless of which cohort we look at. As the cohort gets older its inflation expectations tend to rise.

Figure 10 graphs the mean expected inflation range over time for selected age groups. Here one can observe a rising trend between 2004 and 2015 for all age groups, with significant volatility at the monthly level.

Finally, Figure 11 graphs the mean expected inflation range across cohorts for selected age groups. Here, too, we observe a rising trend in inflation expectations as we move from older cohorts (those born in earlier years) to younger cohorts (those born in later years). While suggestive, one cannot make any hard conclusions from these graphs. For example, while Figure 11 appears to show that inflation expectations rise as we move from older to younger cohorts, Figure 10 suggests that this may have been driven by a general rise in inflation expectations across all age groups and cohorts over time.

In order to analyze the issue more formally, Table 7 estimates an interval regression model similar to that of Table 3 using the CCS data. Column (1) uses the weighted lifetime inflation rate as calculated in equation 6 as the key explanatory variable. The

[6] In 2009 the ranges used to inquire about inflation expectations were changed. In order to use as much data as possible, we convert the post-2008 data to be consistent with the pre-2009 data. Thus, the ranges described here are different from those in Table 5.

point estimate suggests that a 1 percentage point increase in the weighted lifetime inflation rate increases the expected future inflation rate of an individual by 0.22 percentage points. This implies that the difference in (weighted) lifetime inflation of 2.5 percentage points between the 1948 cohort and the 1977 cohort would result in a difference in expected inflation over the next year of 0.55 percentage points. This compares with a point estimate of 0.7-0.86 in Table 3. This difference may be partly due to differences in the underlying populations from which the data were drawn, but another is that the results in Table 7 include time dummy variables, where the model in Table 3 was estimated on cross-sectional data, making it impossible to control for time effects.

In column (1) of Table 7 we used the weighted inflation rate over an individual's lifetime to summarize their inflation experience, but one may argue that a better measure of inflation experience is the weighted inflation rate during the individual's *adult* life, since that is when he is most likely to be affected by the state of the macroeconomy. To investigate this, column (2) uses the weighted inflation rate since the age of 18 rather than the weighted lifetime inflation rate as the key explanatory variable. At 0.177, the estimated coefficient is smaller than that of column (1), but not by much. In column (3), we re-estimate the model of column (2), but restrict the sample to those above the age of 27 to avoid biases that might arise due to the fact that, for younger individuals, their weighted inflation rates since the age of 18 is dominated by recent inflation rates. This leaves the estimated coefficient almost completely unchanged.

Columns (4)-(6) estimate the models of columns (1)-(3), but use unweighted inflation rates rather than weighted inflation rates. The estimated coefficients are smaller, but the general patterns are similar. In all 6 cases, the inflation experience variable is precisely estimated and suggests that those with higher inflation rates over their lifetimes tend to have higher inflation expectations.

These results are consistent with those from Table 4. Furthermore, they follow a pattern found in Malmendier and Nagel (2015), who estimated a learning-by-doing model on data for the U.S., that past inflation experiences are related to expectations

of future inflation rates.

5.3 Exploiting Within Cohort Variation

The results in the previous section rely on the assumption that the age effect is largely a basket effect. It is possible, however, that the age effect may also be capturing other important determinants of inflation expectations. For example, perceptions of inflation may change as individuals approach retirement and begin to rely on pensions for income. By ignoring these possible factors the analysis in the previous section may be combining the cohort and age age effects. In order to test whether or not the inflation rate experienced over one's lifetime affects one's future inflation expectations or not, we would like to measure the difference in inflation expectations between two individuals alike in every way except for their inflation experiences.

The Intage dataset allows us to use this approach as it includes a question asking individuals if they have ever lived outside of Japan and, if so, where and for how long.[7] Ideally, one would like to know when the individual lived overseas so that one could calculate the inflation rate experienced during the individual's time outside of Japan. Unfortunately, we do not have this information, but we can test whether those who have lived overseas have different inflation expectations from those who have never lived overseas by including dummy variables in the regressions of Table 3. The results are reported in Table 8.

The estimated coefficients suggest that those who have lived for at least a year overseas have inflation expectations that are around 0.4 percentage points lower than those who have not lived overseas for at least a year. This result suggests that social experience does affect individuals' inflation expectations, but whether it is differential experiences of inflation that drive this result or some other aspect of social life cannot be deduced from these data.

[7] Individuals can select more than one year, more than five years or more than ten years.

5.4 Estimating Cohort Effects Using the Intrinsic Estimator

We mentioned above that the central difficulty to estimating age, cohort and time effects is that the various approaches employed require the researcher to make an arbitrary normalization in order to break the multicollinearity among the variables. The practical difficulty is that the researcher usually has very little to guide him in selecting one normalization over another and estimated results tend to be very sensitive to the normalization selected.

One approach that attempts to overcome this problem is the *Intrinsic Estimator* of Yang et al. (2004). This estimator is essentially a principal components approach which shows that any normalization used to identify age, cohort and time effects separately can be understood as a common component and an arbitrary linear trend. This common component is referred to as the intrinsic estimator. Applying the intrinsic estimator to the Consumer Confidence Survey returns the estimates presented in Figures 12 through 14.[8]

Figure 12 suggests that age has an impact on inflation expectations that is independent of the cohort effect. Inflation expectations increase with age until one's late 60s, before declining until one's late 80s. After that inflation expectations appear to stabilize. Combining this with our earlier result that an individual's short-term inflation experience has no effect on their inflation expectations suggests that age affects inflation expectations through some channel other than the consumption basket.

In Figure 13, one can see that cohorts born prior to 1925 have the largest estimated coefficients, while those born after 1985 have the smallest estimated coefficients. Contrasting the inflation experiences of these two groups, one finds that those in the first group were aged 20-45 during Japan's hyperinflation of the decade following the end of World War II. These individuals were of an age at which they certainly would have been acutely aware of the effects of high inflation. On the other other hand, those in

[8] Application of the estimator requires aggregating the individual-level data into age-group-level data. To this end, we assign to each individual an inflation expectation equal to the midpoint of the range selected in Table 5 and then use the mean of this midpoint as the inflation expectation of each age-group.

the the latter group were no older than 10 when Japan's inflation rate first approached zero during the mid-1990s. In other words, they have known nothing but extremely low levels of inflation. The estimated coefficients suggest that the cohort effects alone increase inflation expectations in excess of one percentage point for the older generation compared to the younger generation.

What about the cohorts in between? The variation in the estimated cohort effects is far more subdued for these cohorts and the estimated coefficients are generally not statistically different from each other, but the estimated cohort effects reach a local minimum with the 1943 cohort and a local maximum with the 1970 cohort. In general, it appears that one can draw a distinction between the 1930-1954 cohorts, who have relatively small estimated coefficients, and the 1960-1980 cohorts, who have larger estimated coefficients. The first group was aged 20-44 at at the time of the 1973 oil shock that caused inflation to soar, while those in the latter group would have been no older than 12 when this happened. Based on this alone, it seems strange that the latter group should have higher inflation expectations, but, as can be seen in Figure 8, the inflation rate remained elevated through most of the 1970s, a period during which the older members 1961-1981 cohorts would have reached the *impressionable years*.

A large literature in social psychology has formed around the *impressionable years hypothesis*, which suggests that core attitudes, beliefs and values, including economic and political views, are formed during early adulthood and remain largely unchanged through the rest of an individual's life. According to Krosnick and Alwin (1989), a large degree of socialization occurs between the ages of 18 and 25. Giuliano and Spilimbergo (2014) find that experiencing a recession during this stage of life affects how individuals view the role of luck and effort in success in life, which in turns leads them to favor income redistribution and left-leaning political parties.

The 1930-1954 cohort would have reached such a stage during 1948-1979, a period in which the inflation rate averaged approximately 9% and included the two oil shocks. The 1960-1980 cohorts would have reached such a stage during 1978-2005, when the

inflation rate averaged slightly over 1%. This result appears to contradict the hypothesis that historically higher inflation experiences increases future inflation expectations and, indeed, should caution one in assigning a causal interpretation to inflation experience. Nevertheless, the temptation to dismiss the cohort effect entirely should be tempered by three observations.

Firstly, although the 1930-1954 cohort experienced higher inflation than the 1960-1980 during the impressionable years, they experienced it further back in time. If the model in Equation 6, which proposes that the effects of inflation experience die down over time, is a good description of the inflation-expectation formation process, then the longer passage of time since the 1930-1954 cohort experienced the high inflation of 1948-1979 would have reduced its effect on this group's inflation expectations.

Secondly, although inflation rates were lower during 1978-2005, this period does include the asset bubble of the late 1980s. How the inflation of asset prices affects inflation expectations more generally has not been well-studied, but it is interesting to note that there is a increase in the cohort effects for the 1969-1972 cohorts, who would have been exactly within their impressionable years during the bubble period.

Thirdly, although the estimated coefficients of the cohort effects are lower for the 1930-1954 cohorts than for the 1960-1980 cohorts, the difference is almost never statistically significant. In fact, the only cohort effects within the 1960-1980 group that are statistically significantly different from those of the 1930-1980 group are those for the 1969-1972 cohorts mentioned in the previous paragraph as entering their impressionable years during the bubble of the late 1980s.

The main takeaway from Figure 13 is that the largest cohort effects are those of cohorts that experienced extremely high inflation rates and the smallest cohort effects are those of cohorts who have only ever experienced deflation and very low rates of inflation.

6 Inflation Expectations In An Era Of Deflation

Japan has experienced deflation for the last two decades. The results of this study suggest that the deflationary experience has pushed down consumers' inflation expectations and that this effect has been most dramatic for those who have grown up in the era of deflation. Figure 13 suggests a sharp break in the cohort effect on inflation expectations from the mid-1980s and the most striking difference in the inflation experience of the cohorts before this break and the cohorts after this break is that the younger cohorts have lived almost entirely in a period of deflation.

One implication of these results is that the longer the era of deflation continues, the lower will the population's inflation expectations become. Subdued inflation expectations will become more and more entrenched as aging ensures that those who have experienced periods of high inflation become a smaller part of the population. Low inflation expectations may become entrenched as the public memory of high inflation fades. To the extent that it is a goal of monetary policy to raise inflation expectations, taking more aggressive action earlier on can reduce the risk allowing low inflation (and even deflation) expectations to become entrenched through experience and requiring more aggressive action in the future.

Fortunately, the results of the appendix suggest that monetary policy is not impotent in the face of this trend. Inflation targeting appears to be as effective on younger individuals as it is on older individuals, although the manner in which in affects expectations may be different. In particular, inflation targeting appears to reduce high inflation expectations among older individuals and raise low inflation expectations among younger individuals towards the target range.

7 Conclusion

This study uses a new dataset on inflation expectations, combined with individual-level purchase data and demographic data to construct age-group-specific price levels and

age-group-specific inflation rates. Our results show that the price level for the common basket of goods tends to be constant until age 40-45 and then begins to rise thereafter, possibly peaking at age 65. The household inflation rate also varies across age groups and generally rises with age, reaching a peak at age 55-60.

In investigating the source of variation in inflation rates across age, we found that the most important source of variation comes from differences in weights - i.e. differences in the amounts consumed of different goods in the same common basket. This suggests that older individuals face higher inflation rates, not so much because they consume items with high inflation rates that younger workers do not consume (although this is one source of the variation), but because they consume more of the high inflation rate items that all other age groups also consume (although in smaller quantities).

However, even though older individuals experience higher rates of inflation, we found that the difference in inflation rates across age-groups is not sufficient to explain the positive correlation between inflation expectations and age. Even controlling for the household's experienced rate of inflation, we continue to find a statistically significant positive correlation between age and expected inflation rates.

We also investigated the relationship between knowledge of the central bank's inflation targeting policy and inflation expectations and found that individuals who are more informed about the central bank's policy are relatively more likely to have inflation expectations that fall within the central bank's target range. While not conclusive, this suggests that the Bank of Japan's communication strategy my have been effective in altering inflation expectations. The finding that the central bank's inflation targeting policy appears more effective at altering low inflation expectations among younger individuals than older individuals raises the possibility that this is a tool of monetary policy that will grow more important over time.

Finally, using the Japanese Consumer Confidence Survey, we investigated the possibility that the positive correlation between age and inflation expectations is due to shared historical inflation experiences, akin to a cohort effect, rather than a true age

effect. We found that individuals' expectations of future inflation rates are strongly correlated with the inflation rate of the macroeconomy over their lifetimes, suggesting that, at least to some degree, individuals' expectations of future inflation rates are influenced by the inflation rates that they have actually experienced. This conclusion was supported by the finding that living for an extended time outside of Japan appears to have an effect on future inflation expectations, implying that economic experiences do affect future expectations. Also, using the intrinsic estimator to estimate cohort effects directly, we found that variation in cohort effects could be matched to historical inflation episodes.

These findings carry implications for both monetary policy and the structure of the social safety net. In the case of monetary policy, while it appears that communication of an inflation target may affect individuals' inflation expectations, there is little that a central bank can do to change the historically experienced inflation rates of individuals. On the other hand, to the extent that the central bank can affect inflation outcomes, it does have the power to change the historically experienced inflation rates of *future* generations. Furthermore, as Japan's population continues to age, more and more of the population will have experienced only low rates of inflation (or even deflation), making it more difficult to raise expectations to a level that the central bank believes is appropriate.

On the matter of the social safety net, our results raise the question of whether social security and retirement benefits should be indexed to the general rate of inflation or adjusted higher for older individuals, who face higher inflation rates than the general population. Choosing the latter would place an even greater burden on the country's public finances and the questions of fairness and prudence in the management of public resources would need to be carefully considered.

References

Naohito Abe and Kyosuke Shiotani. Who faces higher prices? an empirical analysis based on japanese homescan data. *Asian Economic Policy Review*, 9(1):94–115, 2014.

Mark Aguiar and Erik Hurst. Life-cycle prices and production. *The American Economic Review*, 97(5):1533–1559, 2007.

Alan G Ahearne, Joseph Gagnon, Jane Haltmaier, Steven B Kamin, Christopher J Erceg, Jon Faust, Luca Guerrieri, Jennifer E Roush, John H Rogers, Nathan Sheets, et al. Preventing deflation: lessons from japan's experience in the 1990s. *FRB International Finance Discussion Paper*, (729), 2002.

Takeshi Amemiya. Regression analysis when the dependent variable is truncated normal. *Econometrica: Journal of the Econometric Society*, pages 997–1016, 1973.

Alan S Blinder. Central-bank credibility: Why do we care? how do we build it? *American Economic Review*, pages 1421–1431, 2000.

Michael F Bryan and Guhan Venkatu. The curiously different inflation perspectives of men and women. *Economic Commentary*, (Nov), 2001.

Christopher D Carroll. The epidemiology of macroeconomic expectations. In Larry Blume and Steven Durlauf, editors, *The Economy as an Evolving Complex System, III*. Oxford University Press, 2006.

Timothy Cogley and Thomas J Sargent. The market price of risk and the equity premium: A legacy of the great depression? *Journal of Monetary Economics*, 55(3): 454–476, 2008.

Angus S Deaton and Christina Paxson. Saving, growth, and aging in taiwan. In *Studies in the Economics of Aging*, pages 331–362. University of Chicago Press, 1994.

Milton Friedman. *A Theory of the Consumption Function*. Oxford & IBH Publishing Company, 1957.

Milton Friedman and Anna Jacobson Schwartz. *A monetary history of the United States, 1867-1960*. Princeton University Press, 1963.

Paola Giuliano and Antonio Spilimbergo. Growing up in a recession. *The Review of Economic Studies*, 81(2):787–817, 2014.

Robin Greenwood and Stefan Nagel. Inexperienced investors and bubbles. *Journal of Financial Economics*, 93(2):239–258, 2009.

Ernan Haruvy, Yaron Lahav, and Charles N Noussair. Traders' expectations in asset markets: experimental evidence. *The American Economic Review*, 97(5):1901–1920, 2007.

James Heckman and Richard Robb. Using longitudinal data to estimate age, period and cohort effects in earnings equations. In *Cohort analysis in social research*, pages 137–150. Springer, 1985.

Seppo Honkapohja and Kaushik Mitra. Learning with bounded memory in stochastic models. *Journal of Economic Dynamics and Control*, 27(8):1437–1457, 2003.

Takeo Hoshi and Anil Kashyap. *What Stopped Japan's Economic Growth? Prescriptions for the Revival (Nani ga Nihon no Keizai Seichō o Tometa no ka–Saisei e no Shohōsen)*. Nihon Keizai Shimbun, 2013.

Takatoshi Ito and Frederic S Mishkin. Two decades of japanese monetary policy and the deflation problem. In *Monetary Policy with Very Low Inflation in the Pacific Rim, NBER-EASE, Volume 15*, pages 131–202. University of Chicago Press, 2006.

Benjamin Kramer Johannsen. Inflation experience and inflation expectations: Dispersion and disagreement within demographic groups. 2014.

John Maynard Keynes. *The general theory of interest, employment and money*. London: Macmillan, 1936.

Jon A Krosnick and Duane F Alwin. Aging and susceptibility to attitude change. *Journal of personality and social psychology*, 57(3):416, 1989.

Robert E Lucas. Econometric policy evaluation: A critique. In *Carnegie-Rochester conference series on public policy*, volume 1, pages 19–46. Elsevier, 1976.

Ulrike Malmendier and Stefan Nagel. Learning from inflation experiences*. *The Quarterly Journal of Economics*, page qjv037, 2015.

N Gregory Mankiw and Ricardo Reis. Sticky information versus sticky prices: A proposal to replace the new keynesian phillips curve. *Quarterly Journal of Economics*, pages 1295–1328, 2002.

N Gregory Mankiw, Ricardo Reis, and Justin Wolfers. Disagreement about inflation expectations. In *NBER Macroeconomics Annual 2003, Volume 18*, pages 209–270. The MIT Press, 2004.

Albert Marcet and Thomas J Sargent. Convergence of least squares learning mechanisms in self-referential linear stochastic models. *Journal of Economic theory*, 48(2):337–368, 1989.

David J McKenzie. Disentangling age, cohort and time effects in the additive model*. *Oxford Bulletin of Economics and Statistics*, 68(4):473–495, 2006.

Monika Piazzesi and Martin Schneider. Inflation and the price of real assets. 2012.

John M Roberts. Inflation expectations and the transmission of monetary policy. *Federal Reserve Board FEDS Paper*, (98-43), 1998.

Norman B Ryder. The cohort as a concept in the study of social change. *American Sociological Review*, pages 843–861, 1965.

Thomas J Sargent. The ends of four big inflations. In *Inflation: Causes and effects*, pages 41–98. University of Chicago Press, 1982.

Vernon L Smith, Gerry L Suchanek, and Arlington W Williams. Bubbles, crashes, and endogenous expectations in experimental spot asset markets. *Econometrica: Journal of the Econometric Society*, pages 1119–1151, 1988.

Yuko Ueno and Ryoichi Namba. Disagreement and biases in inflation expectations of japanese households (in japanese). ESRI Discussion Papers No.300. Economic Research Institute. Cabinet Office. Government of Japan., 2013.

Annette Vissing-Jorgensen. Perspectives on behavioral finance: Does" irrationality" disappear with wealth? evidence from expectations and actions. In *NBER Macroeconomics Annual 2003, Volume 18*, pages 139–208. The MIT Press, 2004.

Michael Woodford. *Interest and prices: Foundations of a theory of monetary policy*. Princeton University Press, 2011.

Yang Yang, Wenjiang J Fu, and Kenneth C Land. A methodological comparison of age-period-cohort models: the intrinsic estimator and conventional generalized linear models. *Sociological methodology*, 34(1):75–110, 2004.

8 Tables

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.
Age	47.36	11.886	17	69
Male	0.518	0.5	0	1
Married	0.687	0.464	0	1
Completed High School	0.259	0.438	0	1
Completed Technical High School	0.036	0.187	0	1
Completed Technical College	0.12	0.325	0	1
Completed Junior College	0.119	0.324	0	1
Completed College	0.397	0.489	0	1
Completed Graduate School	0.043	0.202	0	1
Regular Employee	0.391	0.488	0	1
Self Employed/Owner	0.074	0.262	0	1
Contract Employee	0.072	0.259	0	1
Other Employee	0.03	0.17	0	1
Part Time/Arubaito	0.155	0.362	0	1
Stay-At-Home	0.176	0.381	0	1
Student	0.012	0.11	0	1
Unemployed	0.09	0.286	0	1
Household Income < ¥4 Million	0.301	0.459	0	1
Household Income ¥4 Million-¥5.5 Million	0.203	0.402	0	1
Household Income ¥5.5 Million-¥7 Million	0.162	0.369	0	1
Household Income ¥7 Million-?9 Million	0.158	0.365	0	1
Household Income > ¥9 Million	0.174	0.379	0	1
N		13384		

Table 2: Inflation Expectations

Interval	Inflation Rage	Mean	Std. Dev.	Min.	Max.
1	$>10\%$	0.09	0.287	0	1
2	5% to 10%	0.278	0.448	0	1
3	2% to 5%	0.298	0.457	0	1
4	0% to 2%	0.087	0.282	0	1
5	Approximately 0%	0.22	0.414	0	1
6	-2% to 0%	0.012	0.108	0	1
7	-5% to -2%	0.01	0.098	0	1
8	10% to -5%	0.003	0.054	0	1
9	$<$ -10%	0.003	0.051	0	1
N		13384			

Table 3: Interval Regressions: Inflation Expectations and Age

	(1)	(2)	(3)	(4)	(5)	(6)
Age	0.050***	0.050***	0.050***	0.044***	0.042***	0.041***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Individual Inflation Rate		0.005	0.006	0.006	0.005	0.005
		(0.008)	(0.008)	(0.009)	(0.009)	(0.008)
Male			-0.243*	-0.399***	-0.422***	-0.392***
			(0.099)	(0.101)	(0.101)	(0.100)
Married			0.077	0.080	0.066	0.047
			(0.087)	(0.087)	(0.087)	(0.087)
Knows About BOJ's 2% Inflation Target						
Knows About Inflation Target Generally				-0.268	-0.125	0.219
				(0.139)	(0.146)	(0.161)
Has Heard About Target				-0.516***	-0.181	0.341
				(0.143)	(0.159)	(0.178)
Has Not Heard About Target				-1.158***	-0.669***	-0.015
				(0.164)	(0.182)	(0.203)
Interested In Economic Issues						
Not Deeply Interested, But Follows News					-0.141	0.149
					(0.109)	(0.112)
Follows The News When Necessary For Work					-0.678***	-0.281
					(0.152)	(0.156)
Follows The News When Has Free Time					-0.543***	-0.058
					(0.125)	(0.133)
No Interest At All					-0.951***	-0.315
					(0.174)	(0.186)
Knows About Abenomics						
Knows Generally About Abenomics						-0.357*
						(0.175)
Has Heard About Abenomics						-0.504**
						(0.192)
Has Not Heard About Abenomics						-3.201***
						(0.527)
Interested In CPI						
Knows What CPI Is And Sometimes Checks						-0.615***
						(0.180)
Knows What CPI Is But Not Interested						-1.207***
						(0.186)
Does Not Know What CPI Is						-1.177***
						(0.209)
Occupation Dummies	No	No	Yes	Yes	Yes	Yes
Education Dummies	No	No	Yes	Yes	Yes	Yes
Income Group Dummies	No	No	Yes	Yes	Yes	Yes
Observations	13384	13384	13384	13384	13384	13384
χ^2	314.73	315.09	411.82	484.56	535.97	651.68

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Interval Regressions: Inflation Expectations and Inflation Experience I

	(1)	(2)	(3)	(4)
Weighted Lifetime Inflation Rate	0.860***	0.860***	0.848***	0.696***
	(0.054)	(0.054)	(0.062)	(0.064)
Individual Inflation Rate		0.005	0.006	0.004
		(0.009)	(0.009)	(0.009)
Male			-0.202*	-0.358***
			(0.101)	(0.102)
Married			0.126	0.086
			(0.089)	(0.088)
			(0.089)	(0.088)
Occupation Dummies	No	No	Yes	Yes
Education Dummies	No	No	Yes	Yes
Income Group Dummies	No	No	Yes	Yes
Information Dummies	No	No	No	Yes
Observations	12748	12748	12748	12748
χ^2	250.34	250.64	344.94	582.66

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Inflation Expectations (Consumer Confidence Survey)

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
$>$ 10%	0.057	0.231	0	1
5% to 10%	0.261	0.439	0	1
2% to 5%	0.46	0.498	0	1
0% to 2%	0.132	0.338	0	1
Approximately 0%	0.046	0.209	0	1
-2% to 0%	0.018	0.135	0	1
-5% to -2%	0.018	0.131	0	1
10% to -5%	0.006	0.079	0	1
$<$ -10%	0.003	0.052	0	1
N		5515		

Table 6: Demographic Comparisons

	CCS		Intage Survey	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Age	61.373	14.634	47.36	11.886
Male	0.782	0.413	0.518	0.5
Household Inc. < ¥4 Mil	0.578	0.494	0.301	0.459
Household Inc. ¥-¥5.5 Mil	0.142	0.349	0.203	0.402
Household Inc. ¥5.5-¥7.5 Mil (¥5.5-¥7 Mil)	0.135	0.342	0.162	0.369
Household Inc. ¥7.5-¥9.5 Mil (¥7-¥9 Mil)	0.07	0.255	0.158	0.365
Household Inc. > ¥9.5 Mil (> ¥9 Mil)	0.075	0.263	0.174	0.379
N	5674		13384	

Numbers in parentheses indicate income range for Intage Survey

Table 7: Interval Regressions: Inflation Expectations and Age

	(1)	(2)	(3)	(4)	(5)	(6)
Weighted Lifetime Inflation Rate	0.219***					
	(0.006)					
Weighted Inflation Rate Since 18		0.177***	0.176***			
		(0.008)	(0.008)			
Lifetime Average Inflation Rate				0.152***		
				(0.004)		
Average Inflation Rate Since 18					0.106***	0.093***
					(0.003)	(0.003)
Household Head Male	0.165***	0.154***	0.154***	0.172***	0.165***	0.158***
	(0.012)	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Income Type Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Income Group Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	345083	309406	309110	345083	345038	325527
χ^2	100841.61	93194.20	93045.48	100507.96	100622.84	97008.07

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Interval Regressions: Overseas Experience and Inflation Expectations

	(1)	(2)	(3)	(4)	(5)	(6)
Age	0.050***	0.050***	0.051***	0.046***	0.043***	0.043***
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
Overseas > 1 Year	-0.433*	-0.434*	-0.304	-0.347	-0.370*	-0.388*
	(0.178)	(0.178)	(0.179)	(0.179)	(0.179)	(0.177)
Individual Inflation Rate		0.012	0.013	0.012	0.012	0.012
		(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Male			-0.256*	-0.398***	-0.417***	-0.392***
			(0.109)	(0.111)	(0.111)	(0.110)
Married			0.045	0.045	0.031	0.004
			(0.095)	(0.095)	(0.095)	(0.094)
Occupation Dummies	No	No	Yes	Yes	Yes	Yes
Education Dummies	No	No	Yes	Yes	Yes	Yes
Income Group Dummies	No	No	Yes	Yes	Yes	Yes
Knows About BOJ Target	No	No	No	Yes	Yes	Yes
Interested In Economic Issues	No	No	No	No	Yes	Yes
Knows About Abenomics	No	No	No	No	No	Yes
Interested In CPI	No	No	No	No	No	Yes
Observations	11273	11273	11273	11273	11273	11273
χ^2	259.28	260.91	335.47	384.67	425.17	511.61

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Multinomial Logit: Inflation Expectations and Information

	(1)	(2)	(3)
Expected Inflation > 10%			
Knows About Inflation Target Generally	0.073	0.133	0.643***
	(0.144)	(0.152)	(0.177)
Has Heard About Target	0.384*	0.512**	1.201***
	(0.150)	(0.170)	(0.198)
Has Not Heard About Target	0.292	0.386	1.097***
	(0.175)	(0.199)	(0.228)
10% > Expected Inflation > 5%			
Knows About Inflation Target Generally	0.581***	0.576***	0.638***
	(0.119)	(0.125)	(0.135)
Has Heard About Target	0.842***	0.895***	1.056***
	(0.124)	(0.138)	(0.150)
Has Not Heard About Target	0.562***	0.631***	0.839***
	(0.143)	(0.160)	(0.175)
5% > Expected Inflation > 2%			
Knows About Inflation Target Generally	0.493***	0.419***	0.426***
	(0.114)	(0.119)	(0.128)
Has Heard About Target	0.675***	0.596***	0.622***
	(0.119)	(0.132)	(0.142)
Has Not Heard About Target	0.541***	0.484**	0.513**
	(0.138)	(0.154)	(0.167)
Expected Inflation = 0			
Knows About Inflation Target Generally	0.673***	0.575***	0.603***
	(0.132)	(0.137)	(0.149)
Has Heard About Target	1.273***	1.086***	1.111***
	(0.135)	(0.149)	(0.164)
Has Not Heard About Target	1.519***	1.209***	1.186***
	(0.151)	(0.168)	(0.186)
0% > Expected Inflation > -2%			
Knows About Inflation Target Generally	0.618	0.635	0.989*
	(0.375)	(0.384)	(0.406)
Has Heard About Target	1.099**	1.114**	1.465**
	(0.377)	(0.414)	(0.459)
Has Not Heard About Target	1.101**	1.069*	1.381**
	(0.403)	(0.450)	(0.499)
-2% > Expected Inflation > -5%			
Knows About Inflation Target Generally	0.491	0.460	0.681
	(0.380)	(0.391)	(0.432)
Has Heard About Target	0.889*	0.816	1.043*
	(0.378)	(0.429)	(0.467)
Has Not Heard About Target	0.651	0.520	0.736
	(0.436)	(0.502)	(0.542)
-5 % > Expected Inflation > -10%			
Knows About Inflation Target Generally	0.953	0.918	1.047
	(0.767)	(0.829)	(0.953)
Has Heard About Target	1.226	1.111	1.480
	(0.784)	(0.874)	(1.006)
Has Not Heard About Target	0.781	0.684	0.842
	(0.928)	(0.998)	(1.165)
-10% > Expected Inflation			
Knows About Inflation Target Generally	0.947	1.100	1.971*
	(1.101)	(1.093)	(1.004)
Has Heard About Target	1.423	1.647	3.052**
	(1.096)	(1.161)	(1.076)
Has Not Heard About Target	3.203**	3.251**	4.638***
	(1.082)	(1.177)	(1.102)
Observations	13220	13220	13220
Pseudo R^2	0.019	0.024	0.031

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10: Multinomial Logit: Effect Of Inflation Targeting Across Age

	30 And Younger			Older Than 30		
	(1)	(2)	(3)	(4)	(5)	(6)
Expected Inflation > 10%						
Knows About Inflation Target Generally	-0.100	0.116	0.666	0.083	0.133	0.651***
	(0.565)	(0.567)	(0.673)	(0.149)	(0.158)	(0.184)
Has Heard About Target	0.103	0.423	0.982	0.380*	0.497**	1.205***
	(0.558)	(0.618)	(0.728)	(0.155)	(0.177)	(0.206)
Has Not Heard About Target	0.257	0.635	1.199	0.291	0.374	1.106***
	(0.547)	(0.628)	(0.757)	(0.184)	(0.210)	(0.240)
10% > Expected Inflation > 5%						
Knows About Inflation Target Generally	0.395	0.312	0.240	0.586***	0.592***	0.681***
	(0.411)	(0.420)	(0.450)	(0.124)	(0.130)	(0.141)
Has Heard About Target	1.017*	1.056*	1.047*	0.809***	0.875***	1.065***
	(0.397)	(0.432)	(0.474)	(0.129)	(0.144)	(0.157)
Has Not Heard About Target	0.443	0.603	0.613	0.562***	0.647***	0.888***
	(0.411)	(0.466)	(0.520)	(0.152)	(0.171)	(0.186)
5% > Expected Inflation > 2%						
Knows About Inflation Target Generally	0.979*	0.926*	0.707	0.466***	0.397**	0.438**
	(0.405)	(0.411)	(0.433)	(0.119)	(0.125)	(0.134)
Has Heard About Target	1.276**	1.248**	0.935*	0.623***	0.555***	0.622***
	(0.394)	(0.426)	(0.451)	(0.124)	(0.139)	(0.150)
Has Not Heard About Target	0.993*	1.025*	0.586	0.506***	0.470**	0.553**
	(0.405)	(0.454)	(0.485)	(0.147)	(0.165)	(0.178)
Expected Inflation ≤ 0						
Knows About Inflation Target Generally	1.338**	1.192**	0.969*	0.615***	0.536***	0.652***
	(0.436)	(0.444)	(0.486)	(0.133)	(0.138)	(0.152)
Has Heard About Target	2.111***	1.810***	1.560**	1.175***	1.023***	1.148***
	(0.425)	(0.459)	(0.513)	(0.137)	(0.152)	(0.168)
Has Not Heard About Target	2.138***	1.720***	1.332*	1.428***	1.171***	1.258***
	(0.428)	(0.482)	(0.542)	(0.157)	(0.176)	(0.194)
Observations	1270	1270	1270	12114	12114	12114
Pseudo R^2	0.034	0.046	0.063	0.016	0.019	0.025

Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

9 Figures

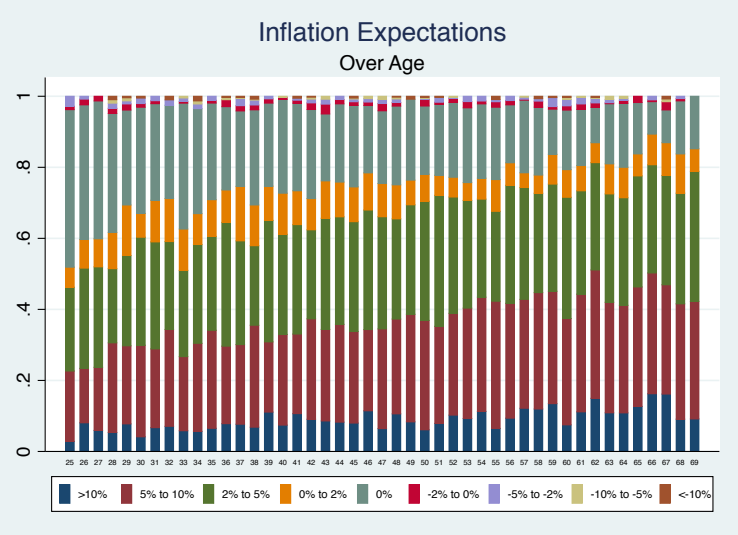


Figure 1: Distribution of Inflation Expectations Over Age

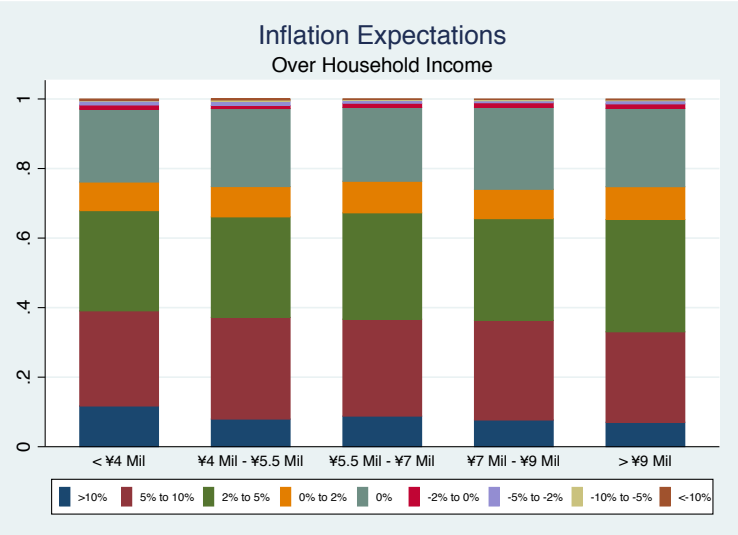


Figure 2: Distribution of Inflation Expectations Over Annual Household Income

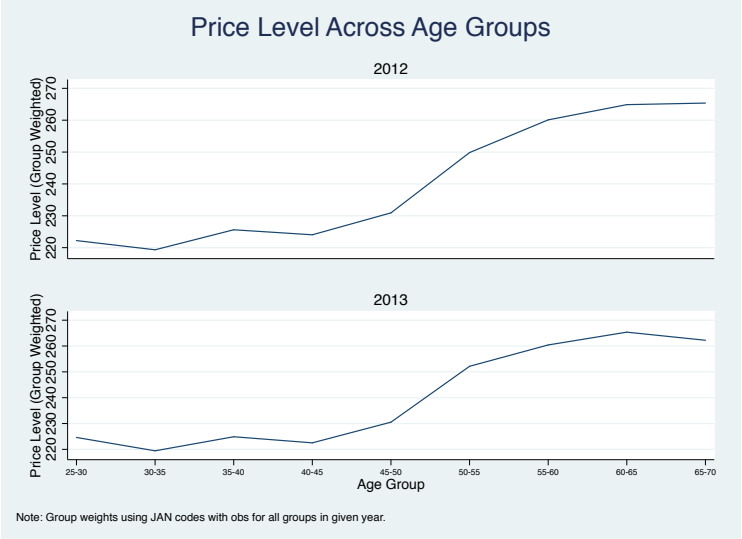


Figure 3: Weighted Price Level Of Common Basket

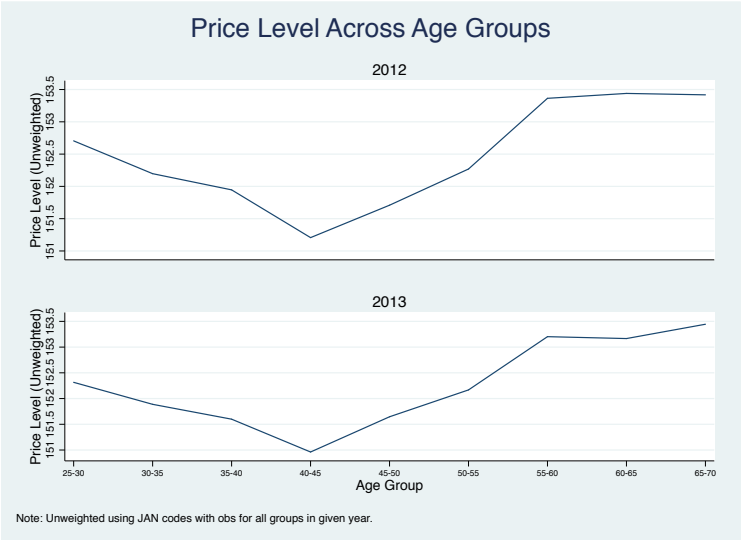


Figure 4: Unweighted Price Level Of Common Basket



Figure 5: Inflation Rate by Age Group

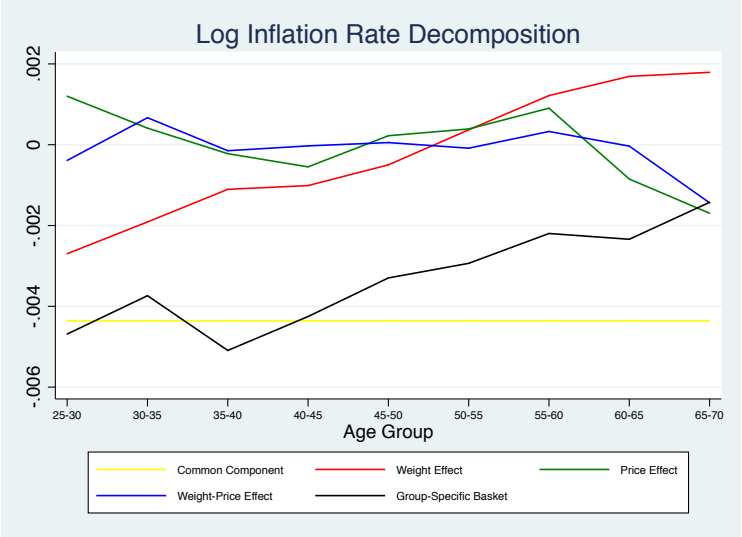


Figure 6: Decomposition of Inflation Rate (5-Year Age Groups)

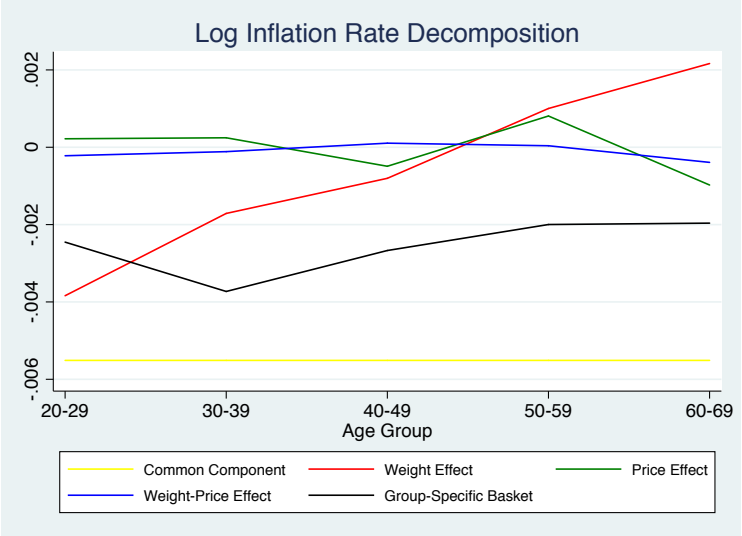


Figure 7: Decomposition of Inflation Rate (10-Year Age Groups)

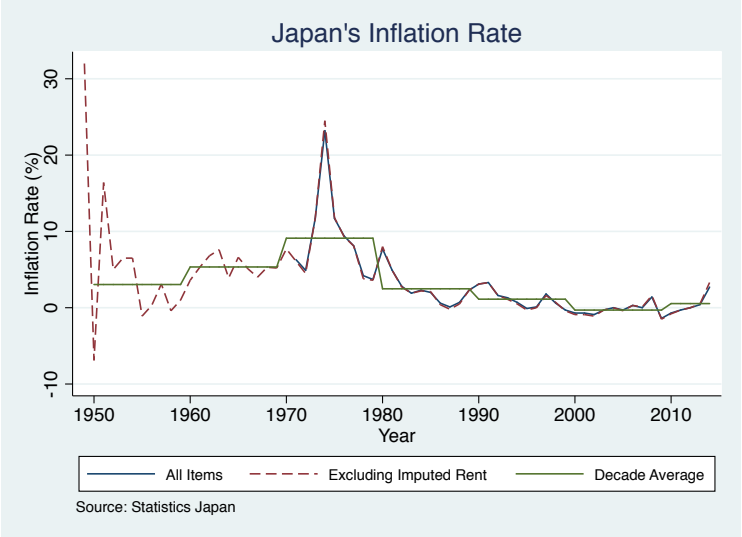


Figure 8: Japan's Inflation History

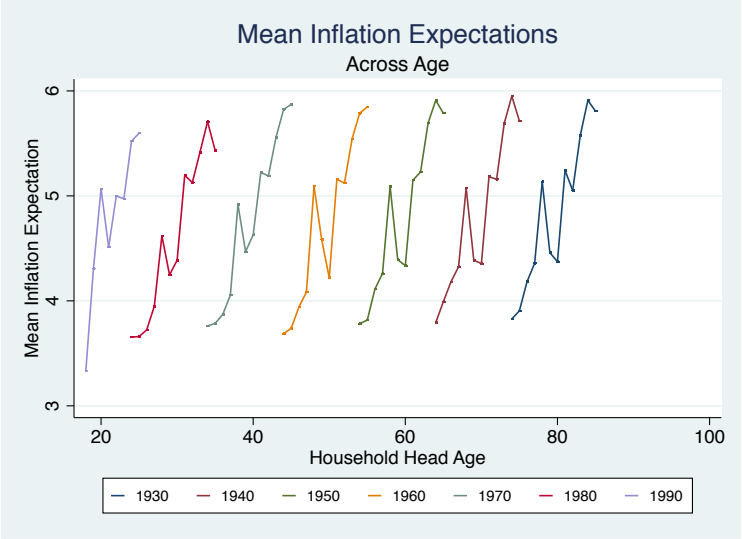


Figure 9: Average Inflation Expectations Across Age

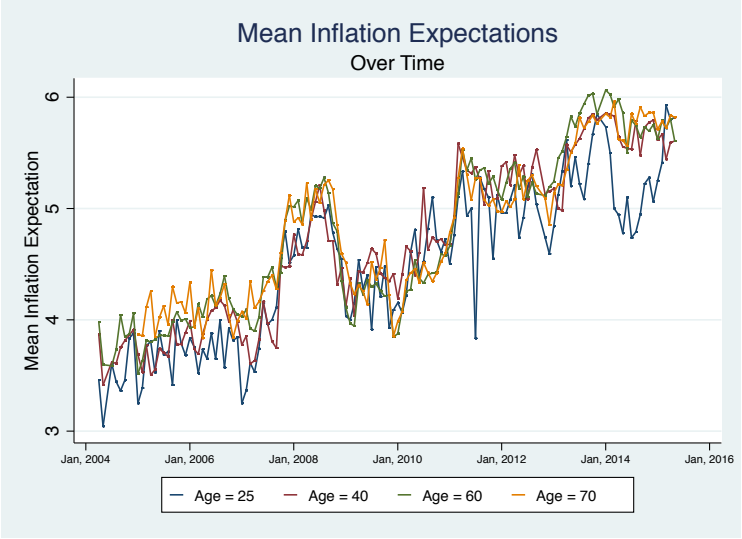


Figure 10: Average Inflation Expectations Over Time

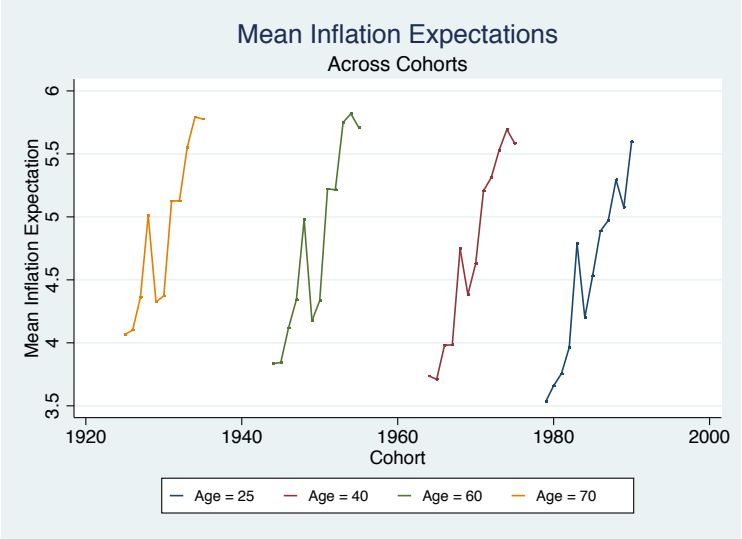


Figure 11: Average Inflation Expectations Across Cohorts

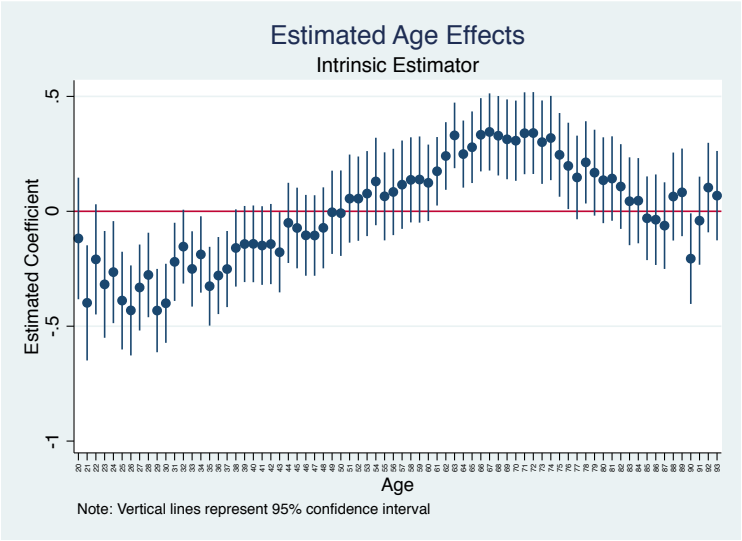


Figure 12: Intrinsic Estimator Age Effects

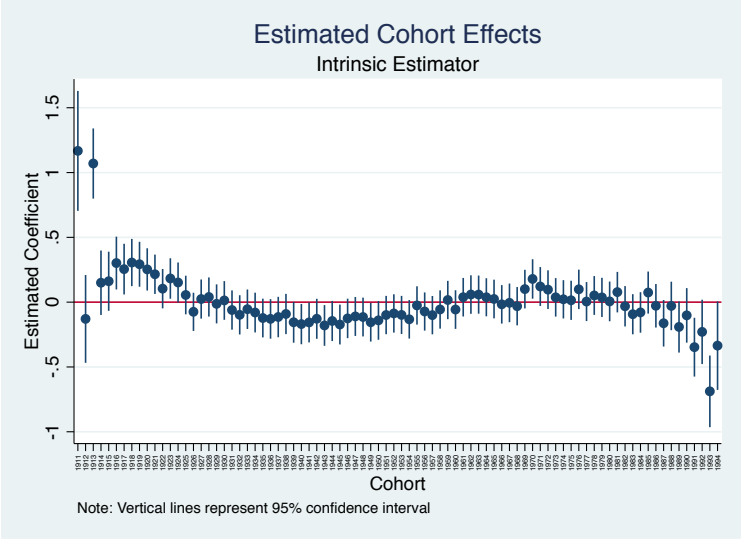


Figure 13: Intrinsic Estimator Cohort Effects

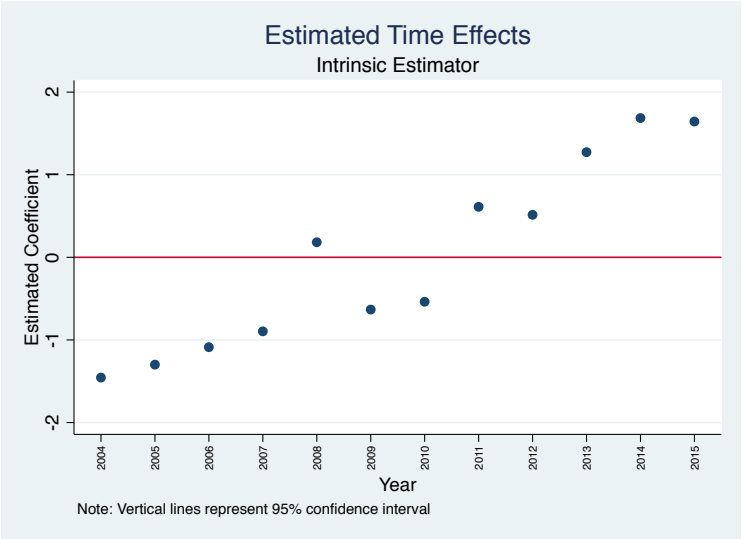


Figure 14: Intrinsic Estimator Time Effects

10 Appendix

In this appendix we investigate more closely the relationship between individuals' knowledge of the Bank of Japan's 2% inflation target and their inflation expectations for the following year. In Table 3 we showed that individuals with more knowledge of the BOJ's inflation target tended to have higher inflation expectations, but that the effect appeared to disappear when we controlled for other information variables, such as knowledge of Abenomics and knowledge of the CPI.

However, as discussed in the text, if the 2% target were affecting inflation expectations one would expect the effect to be positive for those with inflation expectations below the BOJ's target and negative for those with expectations above the BOJ's target. In order to investigate this possibility, we estimate a multinomial logit version of the basic model in Equation 5 and report the results in Table 9.

The three columns of Table 9 correspond to columns (4)-(6) of Table 3 so that, while not reported in Table 9, all the control variables of columns (4)-(6) in Table 3 are included in Table 9. The base category is the expectation that the inflation rate will be within the BOJ's inflation target of 0%-2%. The results show that those most aware of the BOJ's inflation target are relatively less likely to expect an inflation rate outside of the BOJ's target range of 0%-2%. Although the results are generally not statistically significant for cases where the expected inflation rate is less than -2%, this may simply be a matter of small sample size since there are very few individuals who expect inflation rates in this range. The point estimates, however, are largely consistent with the results in the rest of the table. The broad conclusion from this exercise is that individuals who are more knowledgeable of the Bank of Japan's inflation target are relatively more likely to predict that their own inflation rates over the following year will fall within the BOJ's target range rather than any other range.

In Table 10 we estimate the model of 9 separately for those aged thirty or less and those older than thirty.[9] Comparing column (1) with column (4), column (2)

[9]Because of the small sample size of those expecting deflation, we combine those who expect deflation and those who expect 0% inflation into one group.

with column (5) and column (3) with column (6), one will notice that the estimated coefficients are generally larger for the older age group within the inflation expectations categories greater than 5%. This means that knowing about the BOJ's inflation target increases the relative likelihood that an individual will expect inflation with the target range rather than something above 5% relatively more for the older age group than for the younger age group.

On the other hand, the estimated coefficients are smaller for the older age group within the inflation expectations categories less than 5%, suggests that knowing about the BOJ's inflation target increases the relative likelihood that an individual will expect inflation with the target range rather than something in between 2% and 5% or below 0% relatively more for the younger age group than for the older age group. One can interpret these results as implying that the BOJ's inflation target is more effective at moving inflation expectations from high inflation expectations towards the 0%-2% range among older individuals than younger individuals, but that it is more effective at moving expectations from lower inflation expectations towards the 0%-2% range among younger individuals than older individuals. Said differently, this suggests that high inflation expectations are more sticky (with respect to the inflation target) among younger individuals and lower inflation expectations are more sticky among older individuals. Whether this is an age effect or a cohort effect cannot be determined here, but is an interesting question for the future efficacy of monetary policy.