Estimating Consumer Price Inflation by Household

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Aim Of The Study

- Seek to shed light on 2 issues:

  1. How do personal inflation rates differ across age?

  2. Why do inflation expectations differ across age?

Related Research

- Aguiar and Hurst (2007)
- Malmendier and Nagel (2013)
- Ueno and Namba (2013)
- Abe and Shintani (2014)

Method

- We combine 3 data sources in our analysis:

    1. A survey that asks individuals about their views on inflation (both past and present) and the sources of their views on inflation.

    2. Individual-level purchase data over a 2-year period (2012-2013) collected via a home scanner.

    3. Demographic data on the same individuals as above (sex, age, income, etc)

- We are able to match data from the 3 datasets - the survey data and the home scanner data - for 13384 individuals.

Data Source 1: The Survey

- Survey conducted by Intage in March 2014 and March 2015.

- Sample taken from individuals using scanner to record their daily purchases → can connect survey data with actual purchase data.

- Data collected through survey include answers to 33-item questionnaire regarding prices.

Data Source 2: The Purchase Data

- Records individual's purchase history over the period 2012-2013.

- Data collected includes:

  - JAN code of product purchased

  - Quantity of product purchased

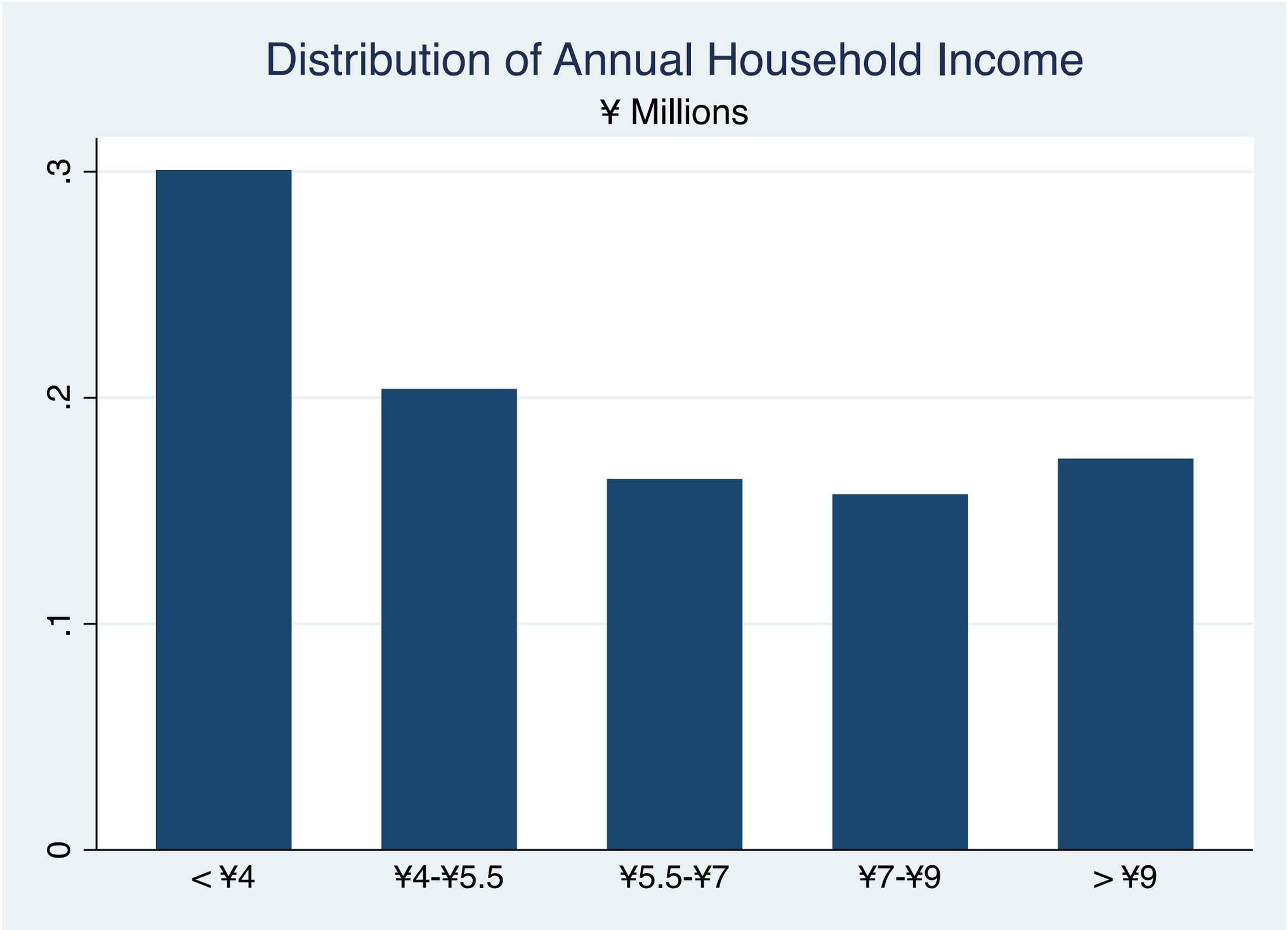
  - Price of product

  - Where the product was purchased

Sample Statistics (2014)

Variable	Obs	Mean	Std. Dev.	Min	Max
General					
Age	15507	32.68	12.14	17	69
Male	15507	0.50	0.50	0	1
Married	15507	0.68	0.47	0	1
Highest Education					
Junior/Middle School	15507	0.01	0.12	0	1
High School	15507	0.26	0.44	0	1
Technical High School	15507	0.04	0.19	0	1
Technical School	15507	0.12	0.33	0	1
Junior College	15507	0.12	0.33	0	1
College	15507	0.39	0.49	0	1
Graduate School	15507	0.04	0.20	0	1
Employment					
Regular Employee	15507	0.38	0.49	0	1
Self Employed/Owner	15507	0.07	0.26	0	1
Contract Employee	15507	0.07	0.26	0	1
Other Employees	15507	0.03	0.17	0	1
Part Time/Arubaito	15507	0.16	0.37	0	1
Stay-At-Home	15507	0.18	0.39	0	1
Student	15507	0.02	0.13	0	1
Not Employed	15507	0.09	0.28	0	1

Income Distribution (2014)



The Survey: Sample Statistics (2014)

- 一年後の物価は現在と比べ何%程度変わると思いますか。(「物価」とは、あなたが購入する食品、衣服、日用品、家電製品、自動車、外食、旅行、電気・ガス・水道代、教育費、医療費等を含めた様々な価格全般のことです)

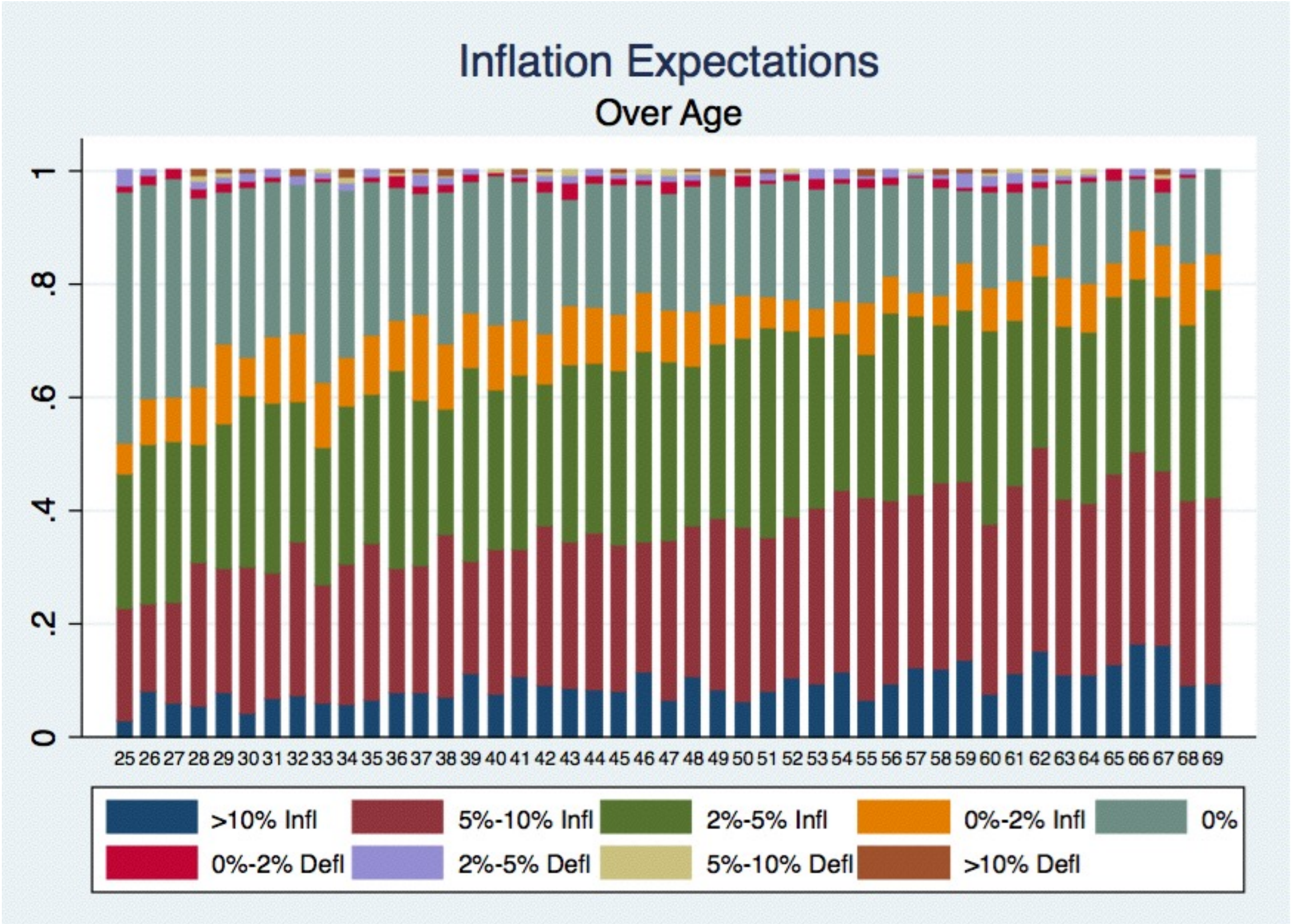
	Percent
10%以上、上がるだろう	9.0
5%から10%程度、上がるだろう	27.8
2%から5%程度、上がるだろう	29.8
0%から2%程度、上がるだろう	8.7
変わらないだろう	22.0
0%から2%程度、下がるだろう	10.8
2%から5%程度、下がるだろう	9.8
5%から10%程度、下がるだろう	5.4
10%以上、下がるだろう	5.1

The Survey: Sample Statistics (2014)

- 物価が一年前と比べて上がった、下がった、変わらないと回答された理由は何ですか。以下から最も当てはまるものを順に3つ選んでください。

Variable	Obs	Mean	Std. Dev.	Min	Max
日常的に購入する品目（食料品、日用雑貨、衣類など）の値段を予想して	13384	0.88	0.32	0	1
たまに購入する品目（家電製品や自動車など）の値段を予想してそう判断	13384	0.49	0.50	0	1
外食の費用（レストランなどの飲食店の値段）を予想してそう判断した	13384	0.44	0.50	0	1
エネルギー価格（ガソリンの値段や電力・ガス料金など）を予想してそう	13384	0.73	0.44	0	1
交通・通信費、医療費、家賃、教育費の値段を予想してそう判断した	13384	0.42	0.49	0	1
新聞、雑誌、テレビなどマスコミ報道をみてそう判断した	13384	0.39	0.49	0	1
インターネットをみてそう判断した	13384	0.14	0.35	0	1
証券会社などで専門家（エコノミスト）の意見を聞いてそう判断した	13384	0.06	0.24	0	1
為替レート（円高や円安）からそう判断した	13384	0.17	0.38	0	1
株価からそう判断した	13384	0.09	0.29	0	1
土地や住宅の値段からそう判断した	13384	0.09	0.29	0	1
勤め先で取り扱う商品の値段からそう判断した	13384	0.05	0.22	0	1
自分の友人や家族、職場の同僚との会話にもとづいてそう判断した	13384	0.11	0.31	0	1
自分や周囲の人の収入（給料）からそう判断した	13384	0.11	0.32	0	1
政府や日銀の政策からそう判断した	13384	0.17	0.38	0	1
その他　具体的に	13384	0.01	0.11	0	1
特になし	13384	0.26	0.44	0	1

Inflation Expectations Over Age (2014)



Age-Group-Level "CPI"

- We divide the sample into 5-year age groups (e.g. 25-30, 30-35, etc).

- We then combine the product (JAN level) data from the scanners of all individuals in a given age group.

- From these aggregated age-group data, we use a Tornqvist index to construct a "CPI" for each age group, which we refer to as the "***Age-Group Price Level***."

Age-Group Price Level: Weighted

Note: Group weights using JAN codes with obs for all groups in given year.

Age-Group Price Level: Unweighted

Note: Unweighted using JAN codes with obs for all groups in given year.

Age-Group Price Level: Summary

- It appears as though people younger than 45 face similar age-group price levels.

- However, from the age of 45 up, older people appear to have higher age-group price levels.

- The unweighted age-group price level allows us to distinguish the contribution of prices and the contribution of quantities to the age-group price level. The unweighted age-group price level gives an average pure price effect.

- The pattern of the unweighted age-group price level over age suggests that young people pay higher prices for their goods and that the price paid falls until age 45.

- Similar to the weighted age-group price level, the prices paid increase from age 45 until age 60.

Individual-Level Inflation Rates

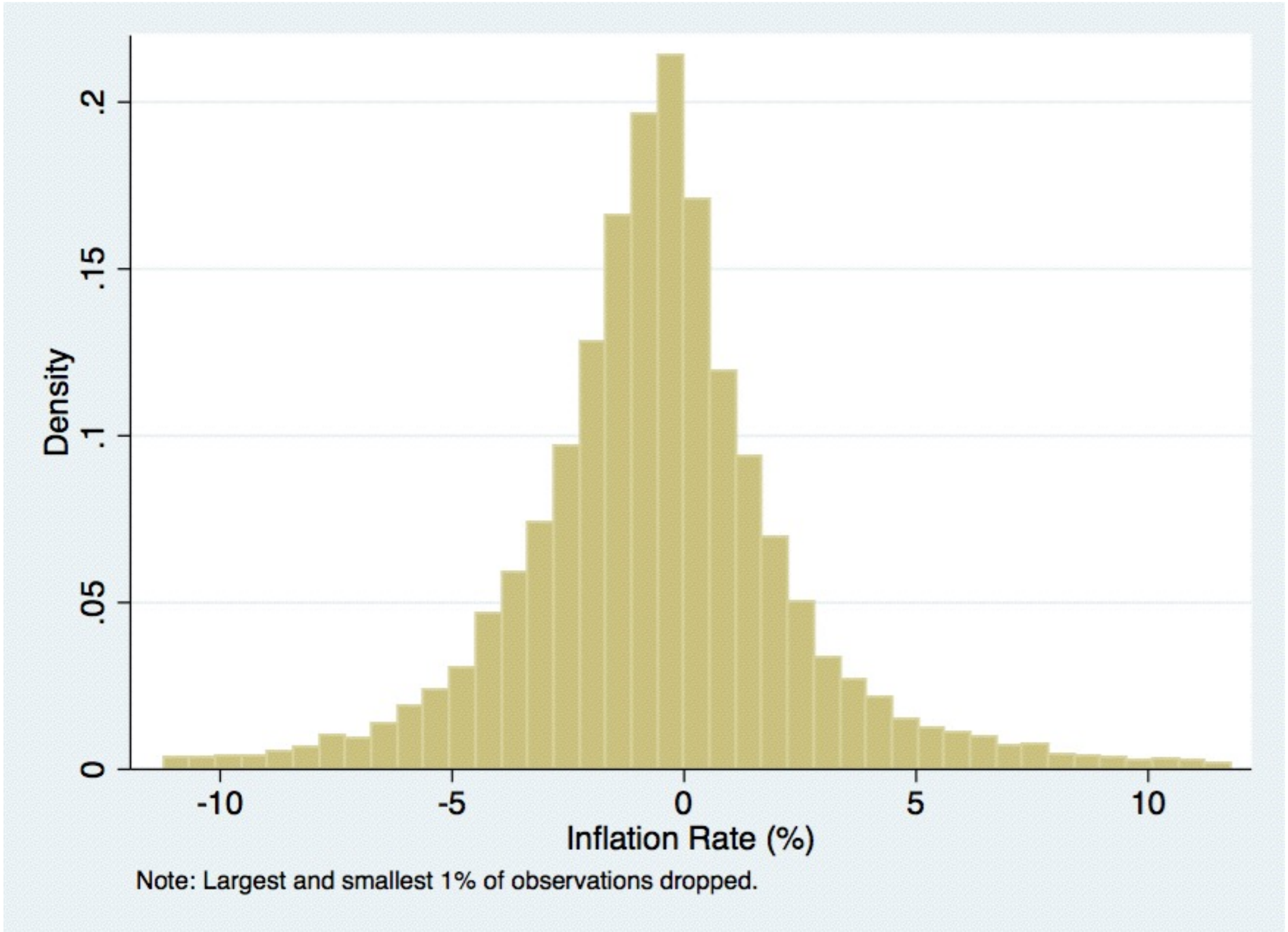
- Using the scanner data, we apply Tornqvist weights to construct an inflation rate for each individual from the JAN-level data, which we refer to as the "***Individual-Level Inflation Rate***."

- The weight used for each product is the product's share in total expenditure ***for the individual*** in a given year.

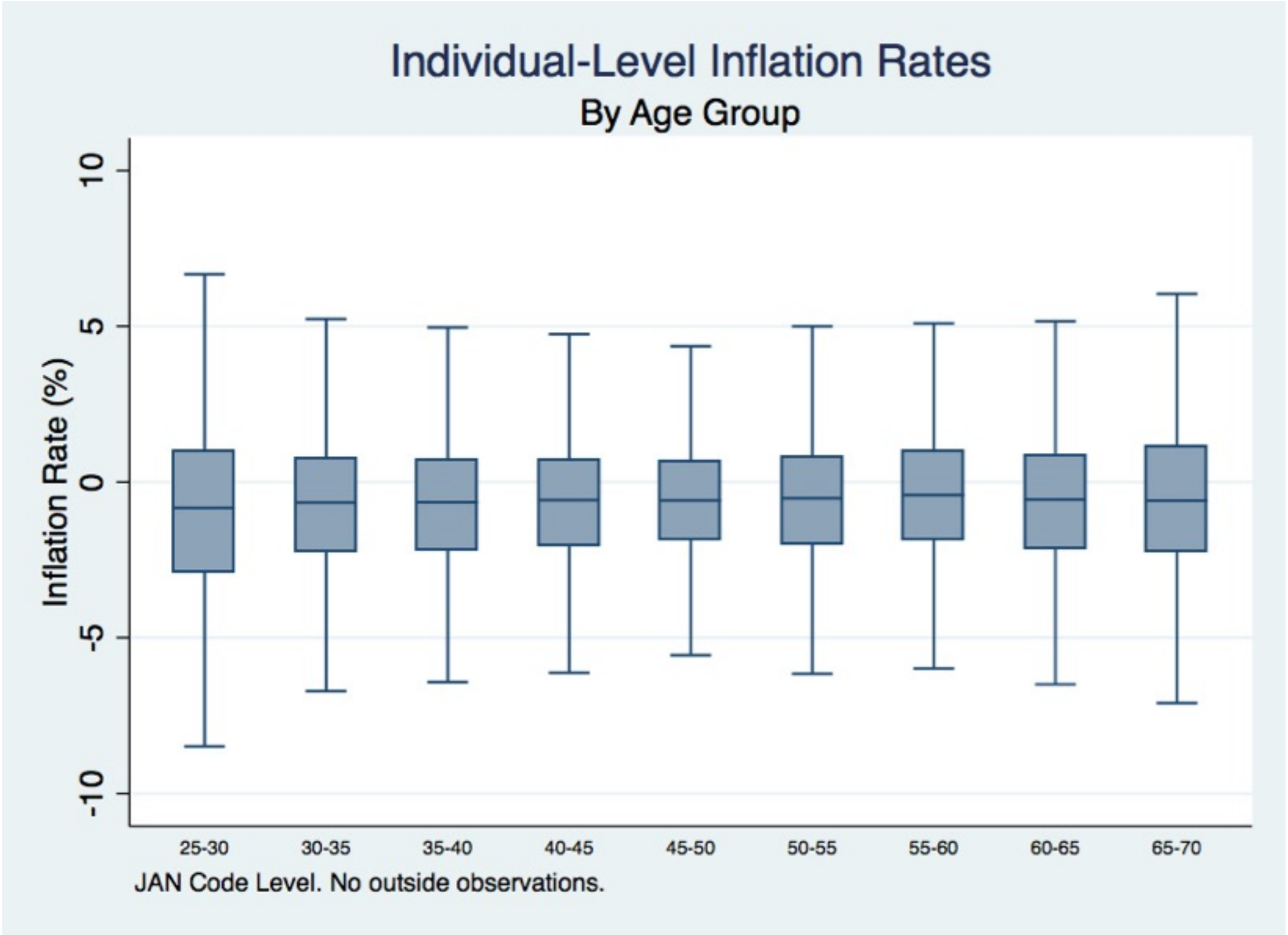
- Total expenditure is calculated by summing up all the purchase data for an individual in a given year.

- The price for each product is calculated as the mean price of the product in the given year paid by the individual (total amount spent on product divided by the total quantity of the product purchased).

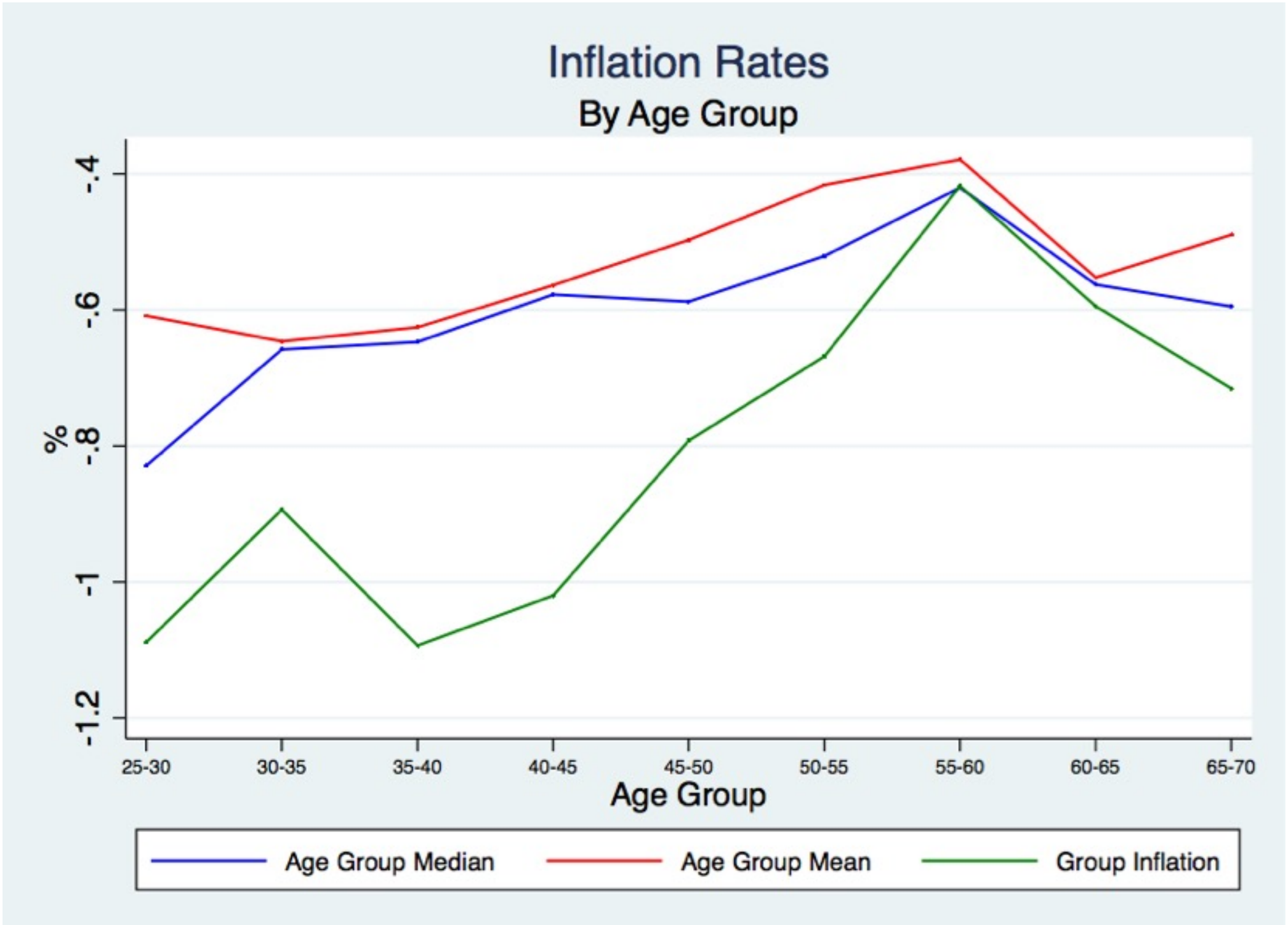
Individual-Level Inflation Rates



Individual-Level Inflation Rates



Age-Group Inflation Rates



Age-Group Inflation Rates: Summary

- Although there is variation across age, all age groups experienced deflation.

- We see a similar pattern in the age group inflation rate across age to the one we observed in the age-group price level across age - just as the age-group price level increases with age, age group inflation rates also increase with age.

- However, unlike the pattern observed in age-group price levels, the increase in age-group inflation rates appears to begin from the 25-30 group.

- Furthermore, it appears as though the age-group inflation rates begin to decrease after the age of 60.

Decomposing Age-Group Inflation Rates

- In order to understand why age-group inflation rates vary, we decompose the inflation rate into 4 parts:

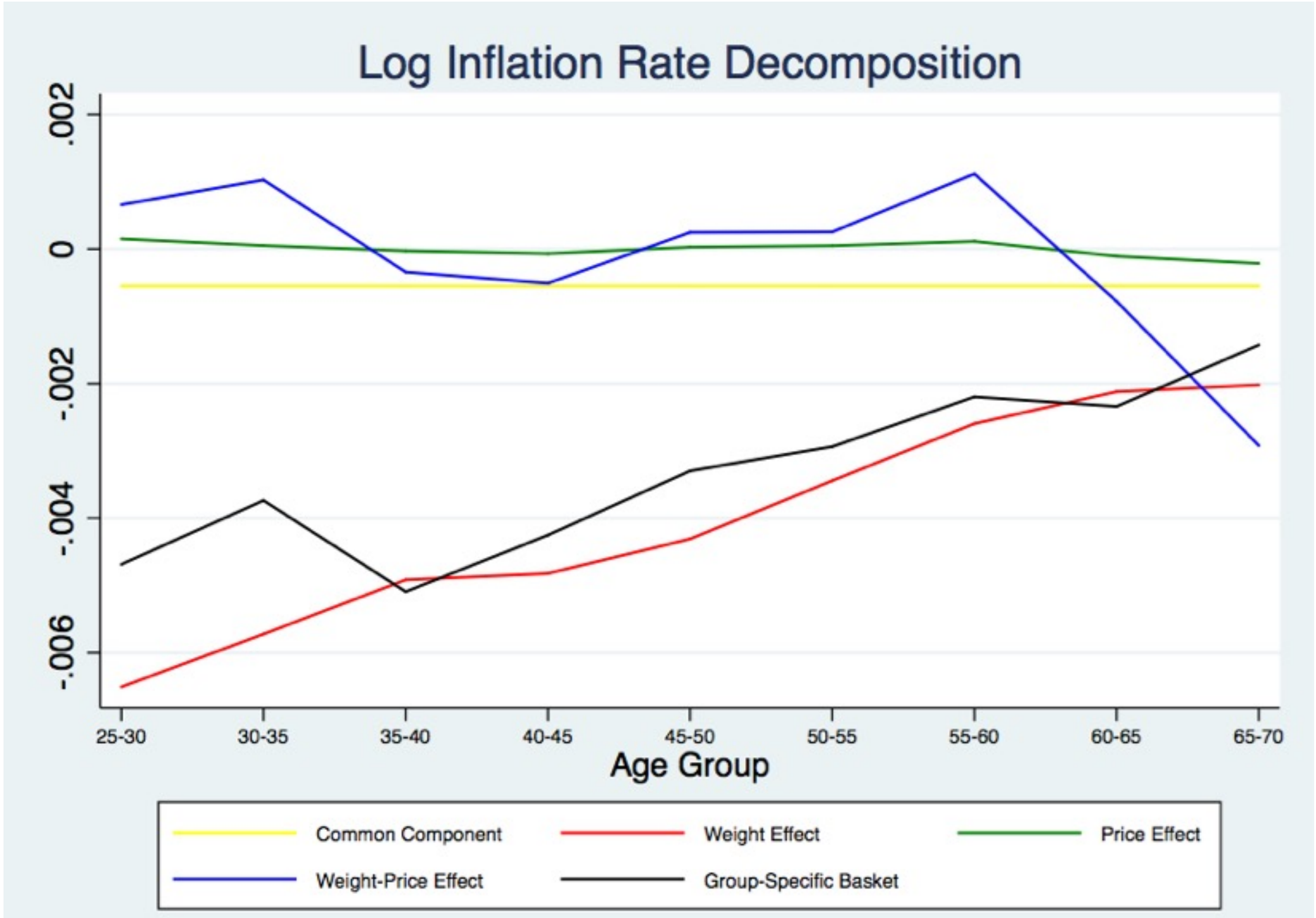
1. An average inflation rate (common to all groups)

2. A deviation of the group's prices of goods from average prices in the common basket.

3. A deviation of the group's weights on goods from the average weights in the common basket.

4. A group-specific basket component.

Decomposing Age-Group Inflation Rates



Decomposing Age-Group Inflation Rates

- Most of the variation across age appears to be driven by 2 effects:

    1. the weight effect - differences in amounts consumed of goods that all age groups consume
    2. the group-specific basket effect - differences in the actual goods consumed by each age group

- However, it is important to observe that the more groups we divide the sample into, the smaller is the common set on goods that is consumed by all groups → bias the group-specific effect.

Expected Inflation and Age

- What is the effect of age on inflation expectations?

	Group
10%以上、上がるだろう	1
5%から10%程度、上がるだろう	2
2%から5%程度、上がるだろう	3
0%から2%程度、上がるだろう	4
変わらないだろう	5
0%から2%程度、下がるだろう	6
2%から5%程度、下がるだろう	7
5%から10%程度、下がるだろう	8
10%以上、下がるだろう	9

Ordered Logit: Expected Inflation and Age

	(1)	(2)	(3)	
Age	-0.024***	-0.024***	-0.024***	-0.020***
	(0.001)	(0.001)	(0.002)	(0.002)
Individual Inflation Rate		-0.003	-0.004	-0.003
		(0.004)	(0.004)	(0.004)
Male			0.117**	0.224**
			(0.045)	(0.046)
Married			-0.054	-0.049
			(0.040)	(0.040)
Knows About Abenomics				0.129***
				(0.034)
Interested in Econ. Issues				0.057***
				(0.017)
Interested in CPI				0.174***
				(0.027)
Knows About BOJ Target				0.022
				(0.027)
Occupation	No	No	Yes	Yes
Income Dummies	No	No	Yes	Yes
Education Dummies	No	No	Yes	Yes
Obs	13384	13384	13384	13384
Pseudo-R2	0.008	0.008	0.010	0.015

Logit Results

- There is a strong negative relationship between age and the expected inflation of the following year ➡ variable **positive** relationship between age and future inflation expectations.

- This result exists even after controlling for actual inflation over the past year.

- Might this pattern of increasing inflation expectations over age be related to the different inflation experiences across age? - Is this a relationship between age and expected inflation or cohort and expected inflation?

Age Effect vs Cohort Effect

- Consider the relationship between age and cohort:

$$\text{Age} = \text{Cohort} + \text{Time}$$

- This multicollinearity makes it impossible to distinguish age, cohort and time effects.

- McKenzie (2006) suggests a strategy of differencing linear equations and making identifying assumptions to disentangle the age, cohort and time effects.

Identifying Age Effects

- First, assume that inflation expectations can be modeled in the following way:

$$\pi^{e}_{ic_{j-k+1}a_j t_k} = \alpha_{c_{j-k+1}} + \beta_{a_j} + \gamma_{t_k} + \varepsilon_{ic_{j-k+1}a_j t_k}$$

where **c** describes the cohort, **a** the age and **t** is the time period.

- Further, assume that the error term takes the form

$$\varepsilon_{ic_{j-k+1}a_j t_k} = \delta_{ic_{j-k+1}} + \eta_{ic_{j-k+1}a_j t_k}$$

with the two components iid and independent of each other.

Identifying Age Effects

- We then take the average of inflation expectations over cohorts:

$$\overline{\pi}^{e}_{c_{j-k+1}a_j t_k} = \alpha_{c_{j-k+1}} + \beta_{a_j} + \gamma_{t_k} + \overline{\varepsilon}_{c_{j-k+1}a_j t_k}$$

- Our unit of analysis is no longer the individual, but the cohort - individual fixed effects have been eliminated through the averaging process.

Identifying Age Effects

- Consider the above equation for cohort 1 in time time periods 1 and 2:

$$\bar{\pi}^{e}_{c_1 a_1 t_1} = \alpha_{c_1} + \beta_{a_1} + \gamma_{t_1} + \bar{\varepsilon}_{c_1 a_1 t_1}$$

$$\bar{\pi}^{e}_{c_1 a_2 t_2} = \alpha_{c_1} + \beta_{a_2} + \gamma_{t_2} + \bar{\varepsilon}_{c_1 a_2 t_2}$$

- and take their difference:

$$\Delta_t \bar{\pi}^{e}_{c_1 a_2 t_2} = \bar{\pi}^{e}_{c_1 a_2 t_2} - \bar{\pi}^{e}_{c_1 a_1 t_1} = \left(\beta_{a_2} - \beta_{a_1}\right) + \left(\gamma_{t_2} - \gamma_{t_1}\right) + \Delta_t \bar{\varepsilon}_{c_1 a_2 t_2}$$

- We have eliminated the cohort effect.

Identifying Age Effects

- Consider the above differenced equation for cohort 2 in time time periods 1 and 2:

$$\Delta_t \bar{\pi}^e_{c_2 a_3 t_2} = \bar{\pi}^e_{c_2 a_3 t_2} - \bar{\pi}^e_{c_2 a_2 t_1} = \left(\beta_{a_3} - \beta_{a_2}\right) + \left(\gamma_{t_2} - \gamma_{t_1}\right) + \Delta_t \bar{\varepsilon}_{c_1 a_3 t_2}$$

and take the difference between the 2 cohorts:

$$\Delta_c \Delta_t \bar{\pi}^e_{c_2 a_3 t_2} = \Delta_t \bar{\pi}^e_{c_2 a_3 t_2} - \Delta_t \bar{\pi}^e_{c_1 a_2 t_2} = \left(\beta_{a_3} - \beta_{a_2}\right) - \left(\beta_{a_2} - \beta_{a_1}\right) + \Delta_c \Delta_t \bar{\varepsilon}_{c_2 a_3 t_2}$$

- We have now eliminated both the cohort and time effects.

Identifying Age Effects

- Generalizing this expression leads to

$$\Delta_c \Delta_t \bar{\pi}^e_{c_{j-k+2} a_{j+1} t_k} = \left(\beta_{a_{j+1}} - \beta_{a_j}\right) - \left(\beta_{a_j} - \beta_{a_{j-1}}\right) + \Delta_c \Delta_t \bar{\varepsilon}_{c_{j-k+2} a_{j+1} t_k}$$

- This gives the second derivative, or the change in slope, of the age effect between two age groups.

- We can estimate $\left(\beta_{a_{j+1}} - \beta_{a_j}\right) - \left(\beta_{a_j} - \beta_{a_{j-1}}\right)$ via OLS:

$$\hat{\beta}_{a_{j+1}} = \frac{1}{T-1} \sum_{k=2}^{T} \Delta_c \Delta_t \bar{\pi}^e_{c_{j-k+2} a_{j+1} t_k}$$

- where $\hat{\beta}_{a_{j+1}}$ is our estimate of $\left(\beta_{a_{j+1}} - \beta_{a_j}\right) - \left(\beta_{a_j} - \beta_{a_{j-1}}\right)$.

Identifying Cohort Effects

- We can use similar techniques to eliminate the age and time effects and find the second derivative of the cohort effects:

$$\Delta_{c,-t}\Delta_c\bar{\pi}^e_{c_j a_{k+j-1} t_k} = \left(\alpha_{c_j} - \alpha_{c_{j-1}}\right) - \left(\alpha_{c_{j-1}} - \alpha_{c_{j-2}}\right) + \Delta_{c,-t}\Delta_c\bar{\varepsilon}_{c_j a_{k+j-1} t_k}$$

- We can then use OLS to estimate $\hat{\alpha}_{c_j}$, our estimator for $\left(\alpha_{c_j} - \alpha_{c_{j-1}}\right) - \left(\alpha_{c_{j-1}} - \alpha_{c_{j-2}}\right)$

$$\hat{\alpha}_{c_j} = \frac{1}{H_j} \sum_{k=\max(3-j,1)}^{\min(A-j+1,T-1)} \Delta_{c,-t}\Delta_c\bar{\pi}^e_{c_j a_{k+j-1} t_k}$$

Identifying Time Effects

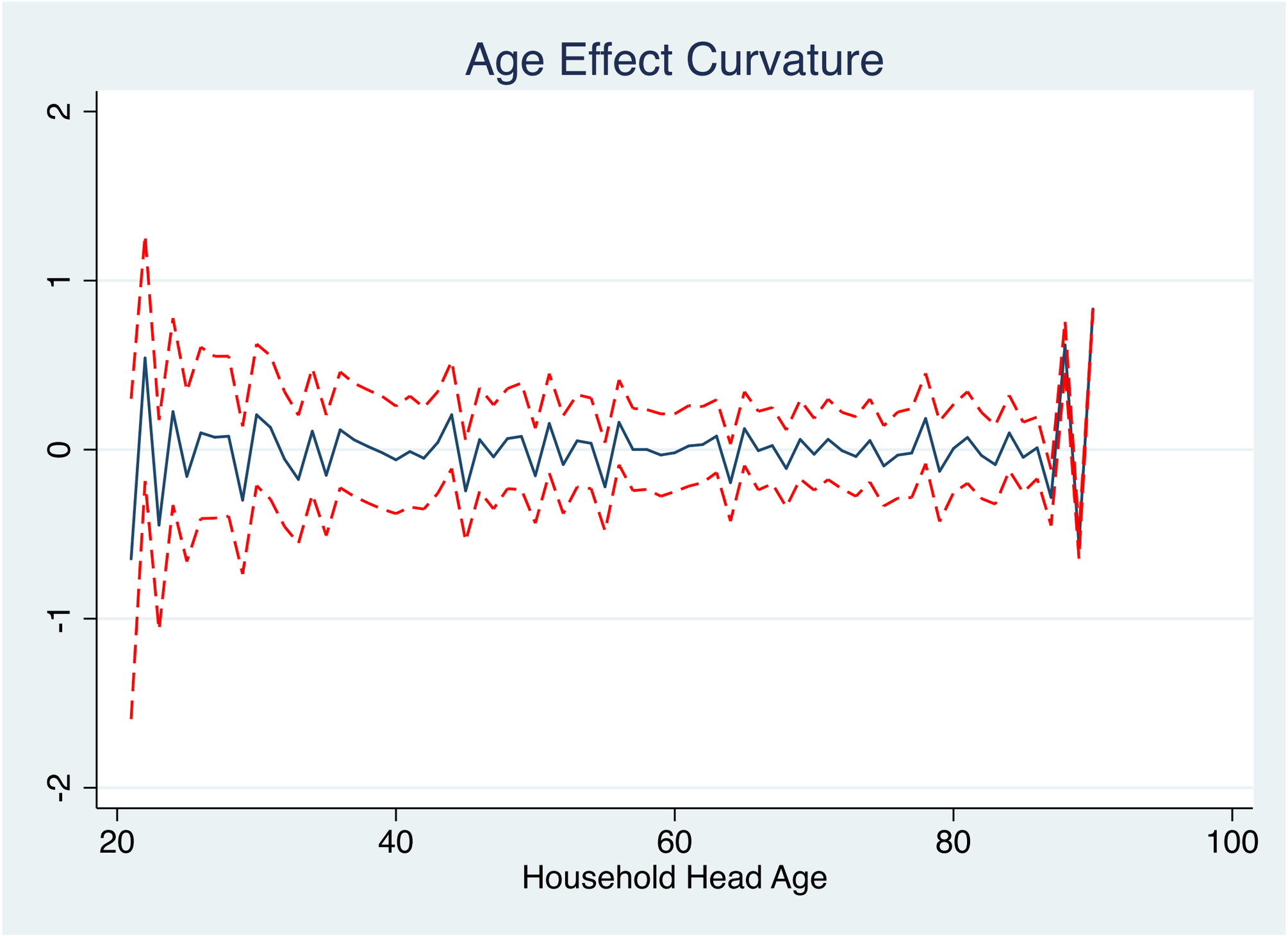
- Finally, we can eliminate the age and cohort effects to find the second derivative of the time effects:

$$\Delta_{-c,t}\Delta_t \overline{\pi}^{e}_{c_{j-k+1}a_j t_k} = \left(\gamma_{t_k} - \gamma_{t_{k-1}}\right) - \left(\gamma_{t_{k-1}} - \gamma_{t_{k-2}}\right) + \Delta_{-c,t}\Delta_t \overline{\varepsilon}_{c_{j-k+1}a_j t_k}$$

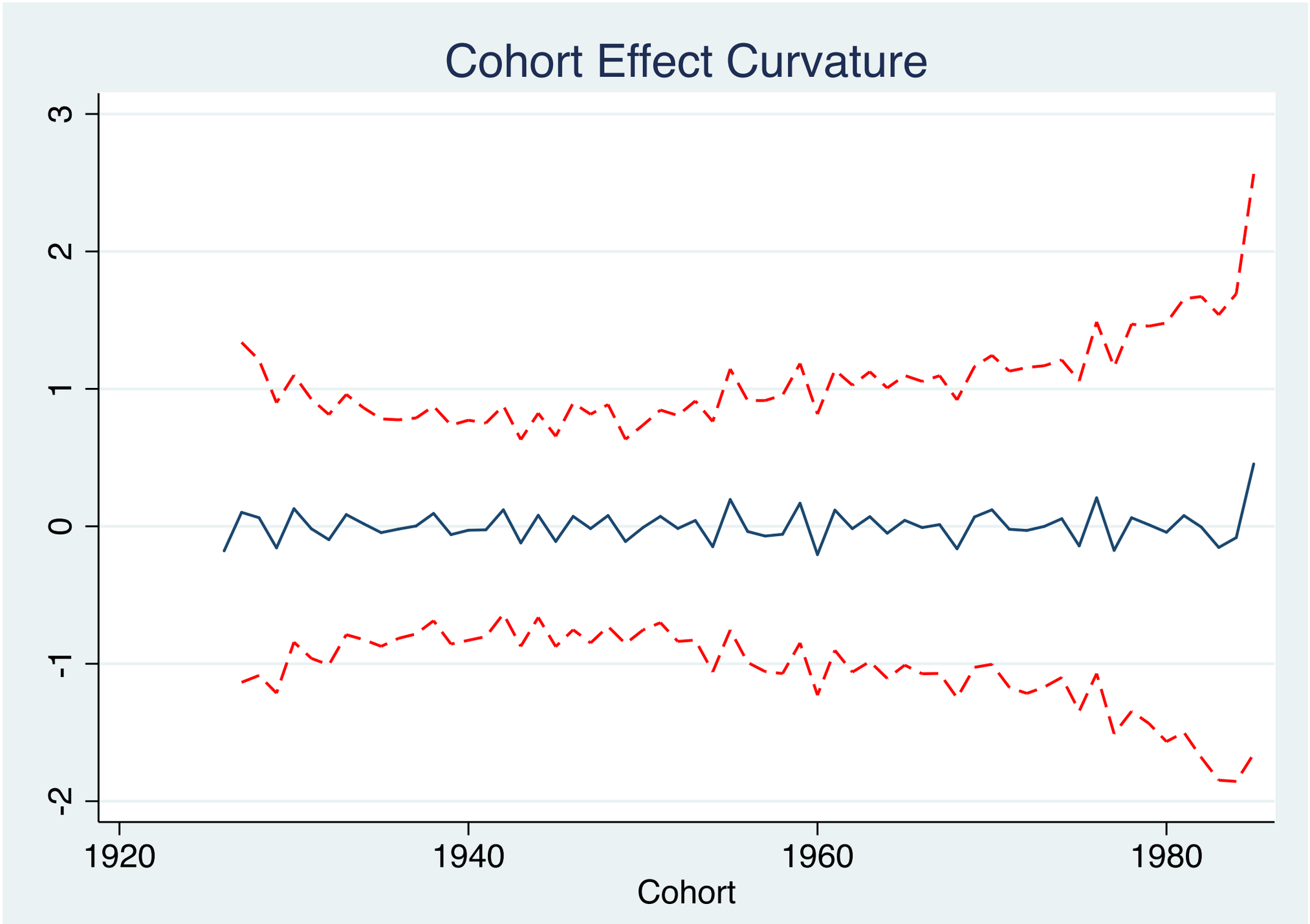
- We can then use OLS to estimate $\hat{\gamma}_{t_k}$, our estimator for $\left(\gamma_{t_k} - \gamma_{t_{k-1}}\right) - \left(\gamma_{t_{k-1}} - \gamma_{t_{k-2}}\right)$.

$$\hat{\gamma}_{t_k} = \frac{1}{A-1}\sum_{j=2}^{A} \Delta_{-c,t}\Delta_t \overline{\pi}^{e}_{c_{j-k+1}a_j t_k}$$

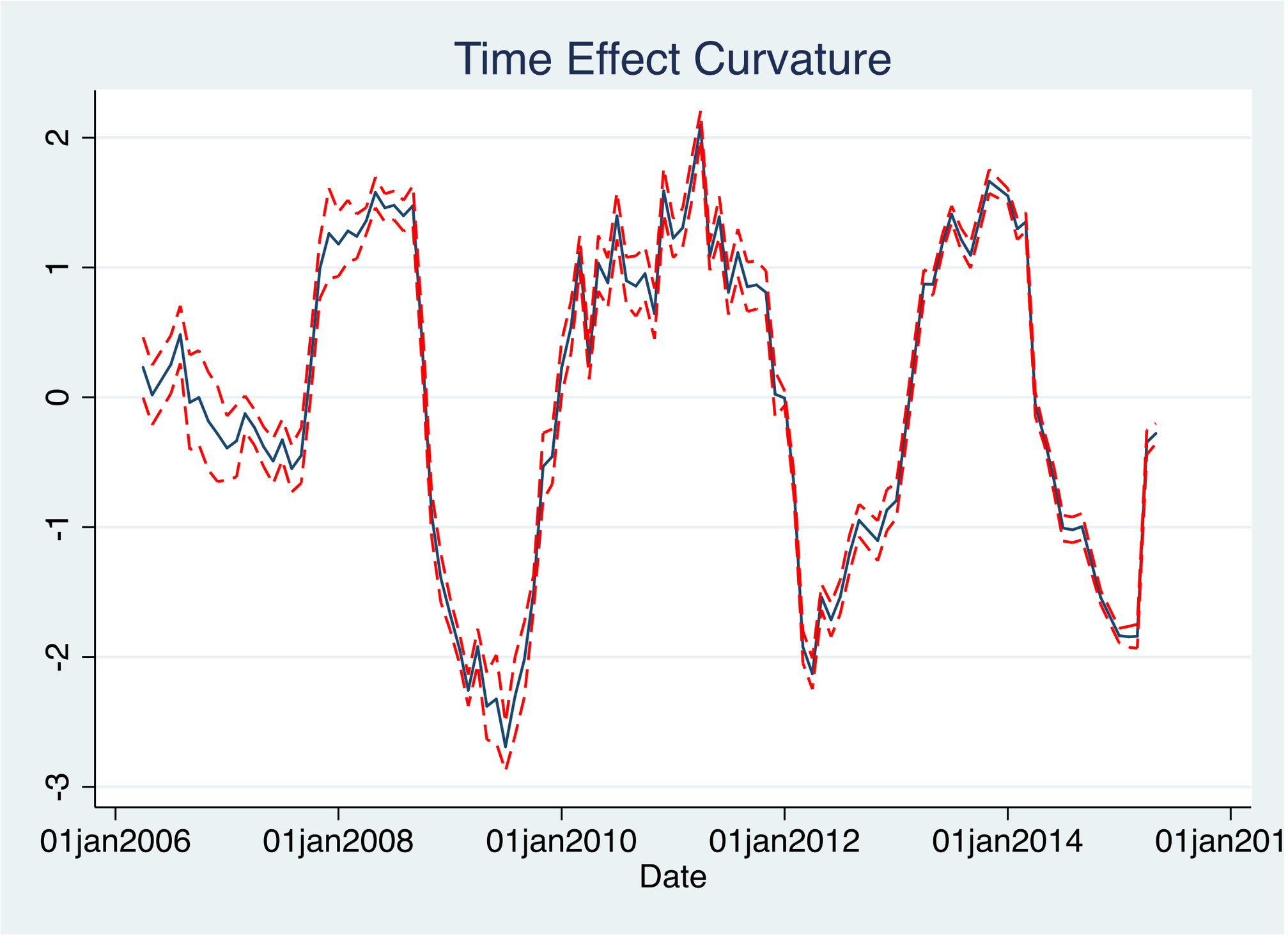
Age Effects


Age Effect Curvature
2
1
0
-1
-2
20
40
60
80
100
Household Head Age

Cohort Effects



Time Effects



Cohort vs Age Effects

- The results suggest that the cohort and age effects are linear.

- However, the time effects appear to be highly non-linear.

- Thus, we can express our original inflation expectations in the following form:

$$
\begin{aligned}
\pi^{e}_{ic_{j-k+1}a_j t_k} &= \alpha_{c_{j-k+1}} + \beta_{a_j} + \gamma_{t_k} + \varepsilon_{ic_{j-k+1}a_j t_k} \\
&= \alpha \text{Cohort}_{ic} + \beta \text{Age}_{it} + \gamma_{t_k} + \varepsilon_{ic_{j-k+1}a_j t_k} \\
&= \alpha \left(\text{Year}_t \text{-Age}_{it} \right) + \beta \text{Age}_{it} + \gamma_{t_k} + \varepsilon_{ic_{j-k+1}a_j t_k} \\
&= \left(\beta - \alpha \right) \text{Age}_{it} + \alpha \text{Year}_t + \gamma_{t_k} + \varepsilon_{ic_{j-k+1}a_j t_k}
\end{aligned}
$$

Cohort vs Age Effects

	Full Sample		Excluding Small Sample Cohorts	
	Baseline Model	Excluding High and Low Inflation	Baseline Model	Excluding High and Low Inflation
Age-Cohort	0.008*** (0.0002)	0.002*** (0.0001)	0.008*** (0.0002)	0.002*** (0.0001)
Year/Cohort	0.305*** (0.004)	0.241*** (0.003)	0.306*** (0.004)	0.242*** (0.003)
Age	0.313*** (0.004)	0.243*** (0.003)	0.314*** (0.004)	0.244*** (0.003)
N	696844	600688	690142	594934
R2	0.2190	0.2738	0.2198	0.2739

*** Significant at 1% level. Robust standard errors reported.

Conclusion

- Significant variation in experienced prices and inflation rates across age groups.

- Older individuals tend to experience higher prices and inflation rates.

- Recently experienced inflation rates appear to have no effect on future inflation rate expectations.

- The positive correlation between age and expected inflation rates appears to be the result of an age effect, with inflation expectations actually declining for older cohorts.