Online Appendix for:
Demographic Trends and the Transmission of Monetary Policy

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Link to most recent version

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Abstract

In this online appendix, I report the description of the data cleaning and preparation process as well as several robustness checks of the empirical analysis of the paper.

Keywords: Monetary policy, age structure, consumption heterogeneity, Phillips curve
JEL classification: E31, E52, J11

A Data sources

A.1 CEX

The expenditure data necessary to compute age-group level weights are obtained from the Consumer Expenditure Survey (CEX). The survey is run by the Bureau of Labor Statistics and covers expenditures, income, and demographic characteristics of households in the United States since the beginning of the 80s and it is the main source of data for the construction of the U.S. Consumer Price Index.

The CEX contains two modules: the Interview and the Diary. The first covers the entire household consumption bundle and the respondents are interviewed for a maximum of four consecutive quarters regarding the purchases over the previous three months. The second focuses more on daily expenditures such as groceries and personal products for two consecutive survey reference weeks.

Household expenditures are collected at Universal Classification Code (UCC) level for about 600 categories. Moreover, demographic characteristics such as age, education, gender, race, etc. are included as well. Since the Diary and Interview surveys contact different households each year, to obtain the full consumption profiles the households are aggregated into age groups based on the age of the respondent.

The UCC level is the most disaggregated expenditure level available in the survey. These categories can be aggregated into less granular categories as, in increasing order, the Entry Level Items (ELI), the Item Strata, and the Expenditure Class. As an example, the UCC categories *White bread (020110)* and *Bread other than white (020210)* can be aggregated into the ELI *Bread (FB011)* and then into the Item Strata *Bread (FB01)* which is one of the components of the Expenditure Class *Bakery products (FB)*. The concordance across levels is provided by the BLS in the document "CPI requirements for CE" Appendix B.

Since the data on the frequency of adjustment provided by Nakamura and Steinsson (2008) are provided at the ELI level, the expenditure data at the UCC level from CEX are aggregated at the ELI level as well. Out of the 272 categories in Nakamura and Steinsson (2008), I have a match for 263 ELIs which can be further aggregated into 180 Item Strata or 67 Expenditure Classes.

To compute the expenditure shares for each product category at the age-group level, I proceed in the following way. First, I compile the consumption data from the two surveys of the CEX. From the Interview survey, I obtain information about each household interviewed

month and year, monthly expenditures at the UCC level for the previous three months as well as its demographic characteristics. Similarly, from the Diary survey, I gather data on household weekly expenditure (at the UCC level as well) and its demographic characteristics. The Interview data file is then appended to the Diary to get the whole sample of UCCs.

Then, in line with the BLS procedure and following the instructions in the document "CPI Requirements of CE", several adjustments are performed on the expenditure data.

Homeowner insurance/maintenance/major appliance. The housing expenses on insurance, maintenance, and major appliances need to be corrected to take into account that these expenditures include an investment component for homeowners. Therefore, in line with BLS, the homeowner's total expenditure on the corresponding UCC categories is multiplied by a factor of 0.43 to isolate the consumption portion. The factor is based on the likelihood that renters will purchase these types of appliances and perform these types of home maintenance and improvement.

Medical care. The BLS redistributes the weights from private health insurance and the Medicare premium to the other medical care services using the National Health Expenditure (NHE) tables produced by the Center for Medicare and Medicaid Services (CMS). Since this information is not publicly available, I follow Cravino et al. (2020a) by taking the redistributing factors from the NHE *Table 20 Private Health Insurance Benefits and Net Cost; Levels, Annual Percent Change and Percent Distribution, Selected Calendar Years 1960-2015*.[1] The factors from this table allow us to redistribute the expenditures from private health insurance and Medicare premiums to health care service categories, such as nursing homes and adult day services.

Used cars and trucks. Expenditures on used cars and trucks should only reflect dealer value added. However, the data on trade-in values of cars and trucks are not provided by the CEX. Therefore, as in Cravino et al. (2020a) which found that the ratio of trade-in values and other sales of vehicles to spending on used cars and trucks is around 1/2, I reduce the spending on used cars and trucks to half to isolate only the dealer value added.

Gasoline. In the CEX data total gasoline expenditures are available only for one UCC category (470111). However, Nakamura and Steinsson (2008) computes the frequency of price adjustment for three different ELIs: *Regular Unleaded Gasoline (TB011)*, *Midgrade Unleased Gasoline (TB012)* and *Premium Unleased Gasoline (TB013)*. Since the price stickiness parameters are similar among the three categories (88.6, 87.6, and 86.9 respectively), the

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[1]See the link `https://www.cms.gov/research-statistics-data-and-systems/statistics-trends-and-reports/nationalhealthexpenddata/nhe-fact-sheet.html`

expenditure weight of total gasoline is matched with the average frequency of price adjustment for the three ELIs.

Finally, I aggregate households into age groups and calculate the relative expenditure shares. The Interview and the Diary survey different households but both modules provide data on the age of the respondent so the grouping is rather straightforward. I then compute the average expenditure for each UCC category at age group in the calendar year. The fact that a respondent interviewed in February will report personal consumption not only for January but also for November and December of the previous year needs to be taken into account. Similar to what the Bureau of Labor Statistics (BLS) does for the computation of the official Consumer Price Index (CPI), I create a variable called MO_SCOPE to control for the number of months a household reports expenditures during a calendar year. Therefore, this variable takes value 1 if the household is interviewed in February and value 3 if it is interviewed from April onwards. In the Diary survey, there is no distinction between the survey period and the expenditure reference period. Hence, the variable MO_SCOPE is always equal to 3 for the households in the Diary survey since all their purchases refer to the same calendar year in which they are interviewed. The weekly expenditures are multiplied by 13 to convert them into quarterly expenditures.

Following the BLS procedure, I can then use the formula below to compute the average expenditure for each UCC category k at each age group level a. First, for household i at age group a, I aggregate over all the expenditures on good k during the calendar year. Second, the household total expenditures are weighted by the sampling weights, fwt, provided by BLS to make the survey sample representative of the U.S. population. Third, the weighted household expenditures are summed up at the age group level. Fourth, to obtain the monthly average income spent on good k by decile d, we divide the annual weighted household expenditures for category k by the sum of the weighted number of months household at age group a reported expenditures during the calendar year. Then, to annualize the average UCC category expenditure at the age group level it is sufficient to multiply the monthly average expenditure by twelve:

$$X_k^a = \frac{\sum_i fwt_i^a \sum_t c_{i,k,t}^a}{\sum_i fwt_i^a \ MO\_SCOPE_i^a} \times 12 \tag{1}$$

where fwt_i^a is the frequency weight for household i at age group a, $c_{i,k,t}^a$ refers to the annual consumption on UCC category k by household i at age group a and $MO\_SCOPE_i^a$ identifies the number of months per year household i reported its expenditures.

In the final step, I compute the age group level average expenditure for each UCC category. I then aggregate the UCC categories according to the constructed concordance between UCC categories and ELIs to get the age group level average expenditure X_j^a for each of the 259 ELIs and the corresponding expenditure share $\omega_j^a = \frac{X_j^a}{\sum_k X_j^a}$.
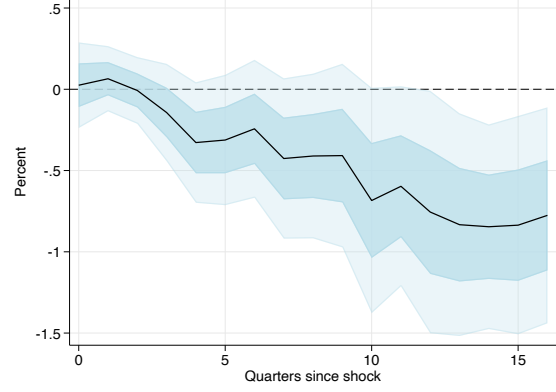
B   Robustness for the regional responses

Figure 1: Impact of monetary policy on regional variables, dropping states
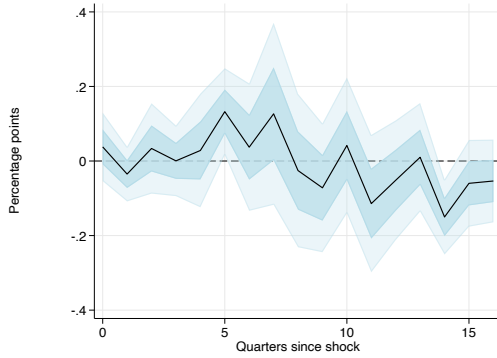
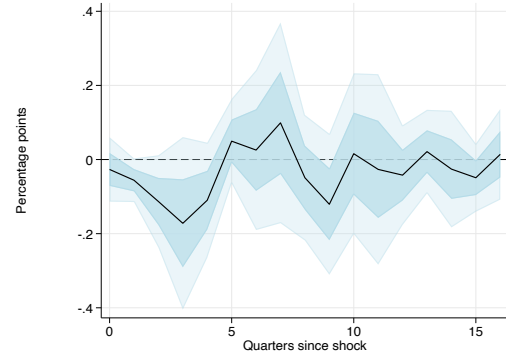A. Real personal income excluding Alaska, North Dakota, Wyoming, Vermont, District of Columbia
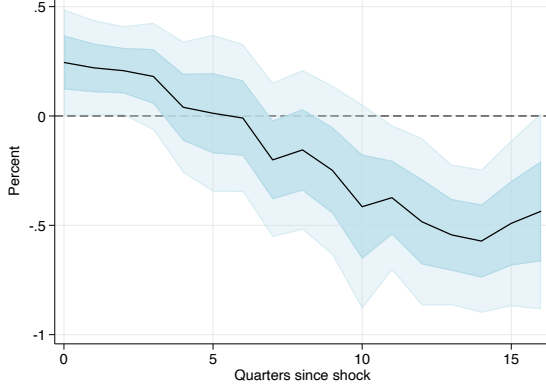
B. Real personal income excluding Florida

C. Inflation rate excluding Alaska, North Dakota, Wyoming, Vermont, District of Columbia
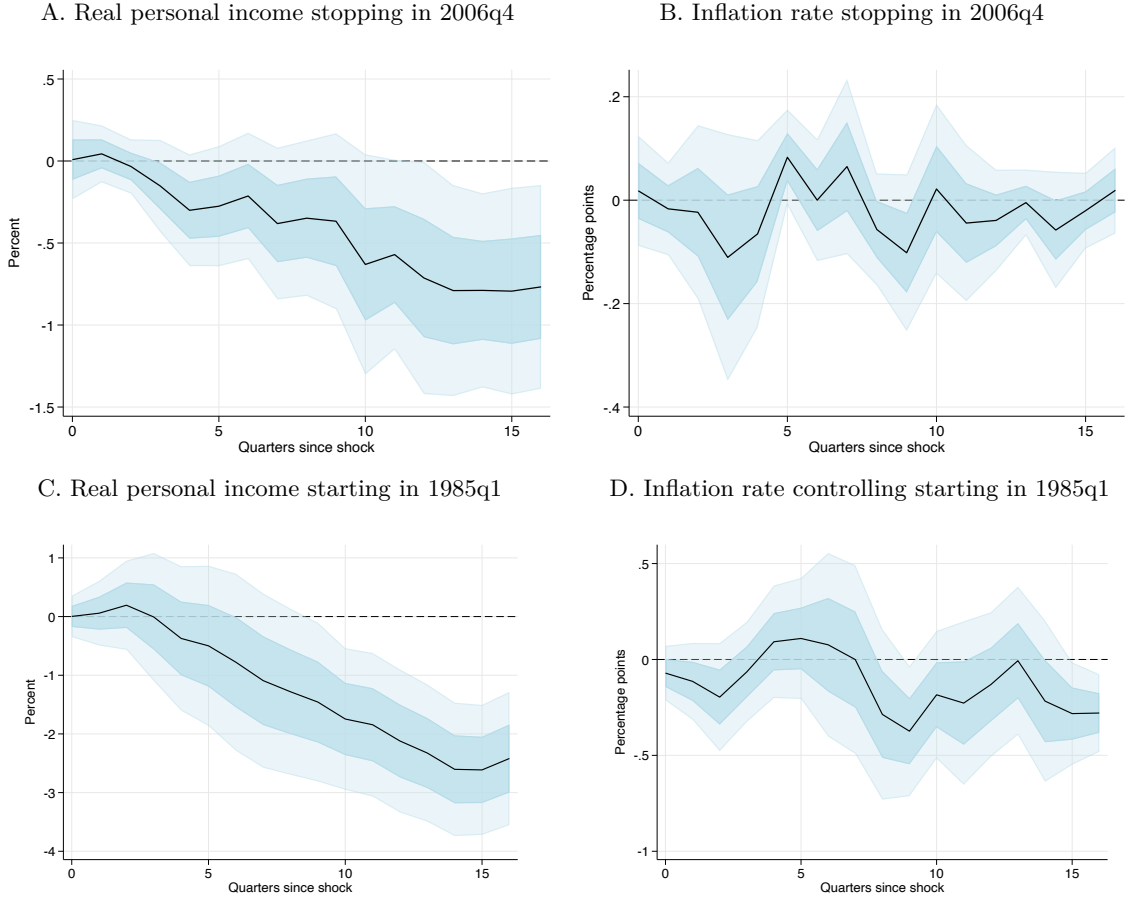
D. Inflation rate excluding Florida

Notes: Each panel reports the interaction coefficients between the monetary policy shock and the dummy identifying the top 20% of the services/manufacturing production ratio distribution using as dependent variable either the state-level real personal income or the inflation rate. The dark shaded area and the light shaded area represent the 68% and the 95% confidence intervals respectively. The horizontal axis is in quarters.

In this section, I consider a number of robustness checks to the baseline specification. First, I repeat the same empirical analysis excluding the five smallest states by population, i.e., Alaska, North Dakota, Vermont, Washington D.C., and Wyoming as well as Florida. As can be seen in Figure 1, this has basically no effect on the interaction coefficients both for real personal income (top row) and inflation (bottom row).

Second, I investigate whether our results are sensitive to altering the beginning and the end of the sample. Coibion (2012) shows how few episodes in the early 80s can be the main drivers of the impulse responses computed using local projection with Romer and Romer

Figure 2: Impact of monetary policy on regional variables, different subperiods

A. Real personal income stopping in 2006q4

B. Inflation rate stopping in 2006q4

C. Real personal income starting in 1985q1

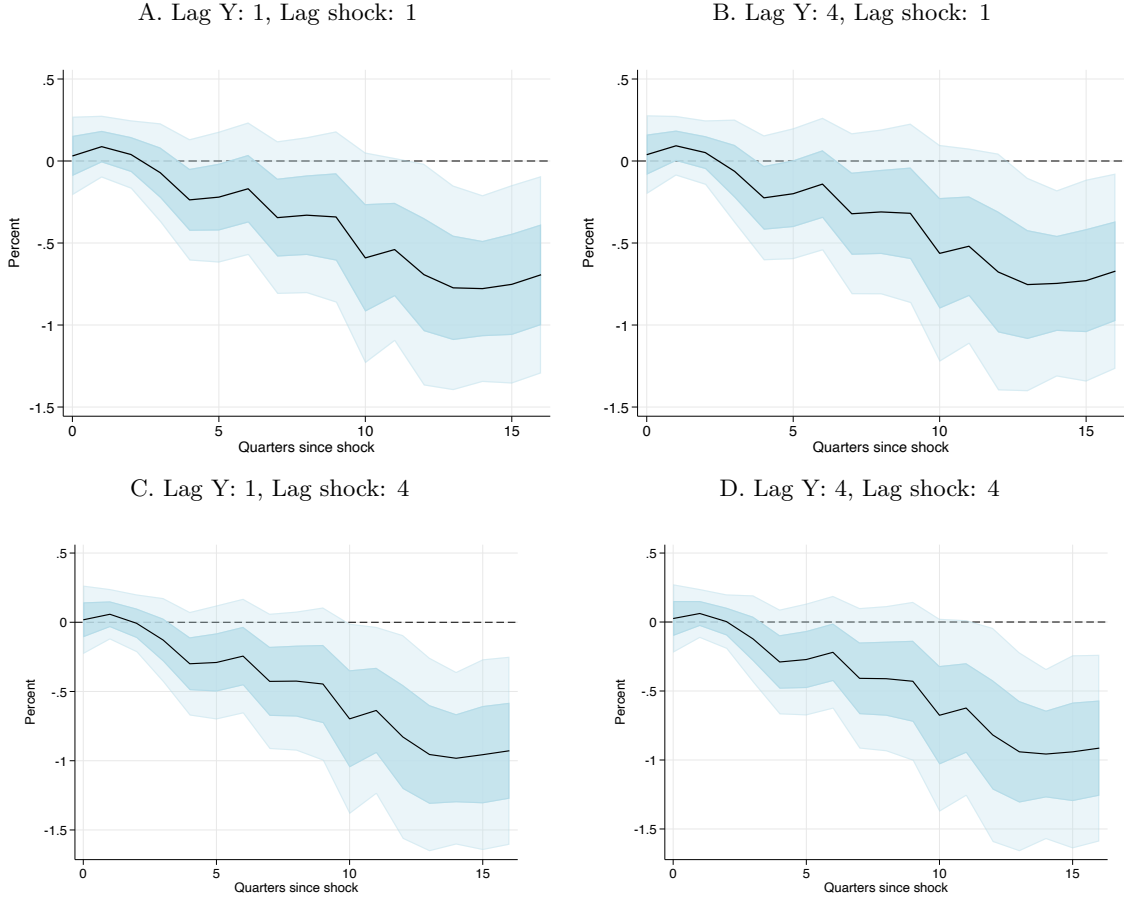D. Inflation rate controlling starting in 1985q1

Notes: Each panel reports the interaction coefficients between the monetary policy shock and the dummy identifying the top 20% of the services/manufacturing production ratio distribution using as dependent variable either the state-level real personal income or the inflation rate. The dark shaded area and the light shaded area represent the 68% and the 95% confidence intervals respectively. The horizontal axis is in quarters.

(2004) shocks. Therefore, I perform the same analysis starting our sample in 1985 as well as truncating all data in 2006 to exclude the financial crisis period. The results are reported in Figure 2. In this case, the results are also robust.

Third, I evaluate whether including different lags of the dependent variable y and the shock might alter the results. I then compute the responses of real personal income and inflation controlling for one lag of y and one lag of the shock, four lags of y and one lag of the shock, one lag of y and four lags of the shock, four lags of y and four lags of the shock. Figure 3 and Figure 4 show the responses. The results are basically unaffected by the alternative lag specifications.

Another source of concern might be that state characteristics other than the service intensity may confound the results. To control for these state characteristics, I extend the

Figure 3: Impact of monetary policy on the regional real personal income, different lags
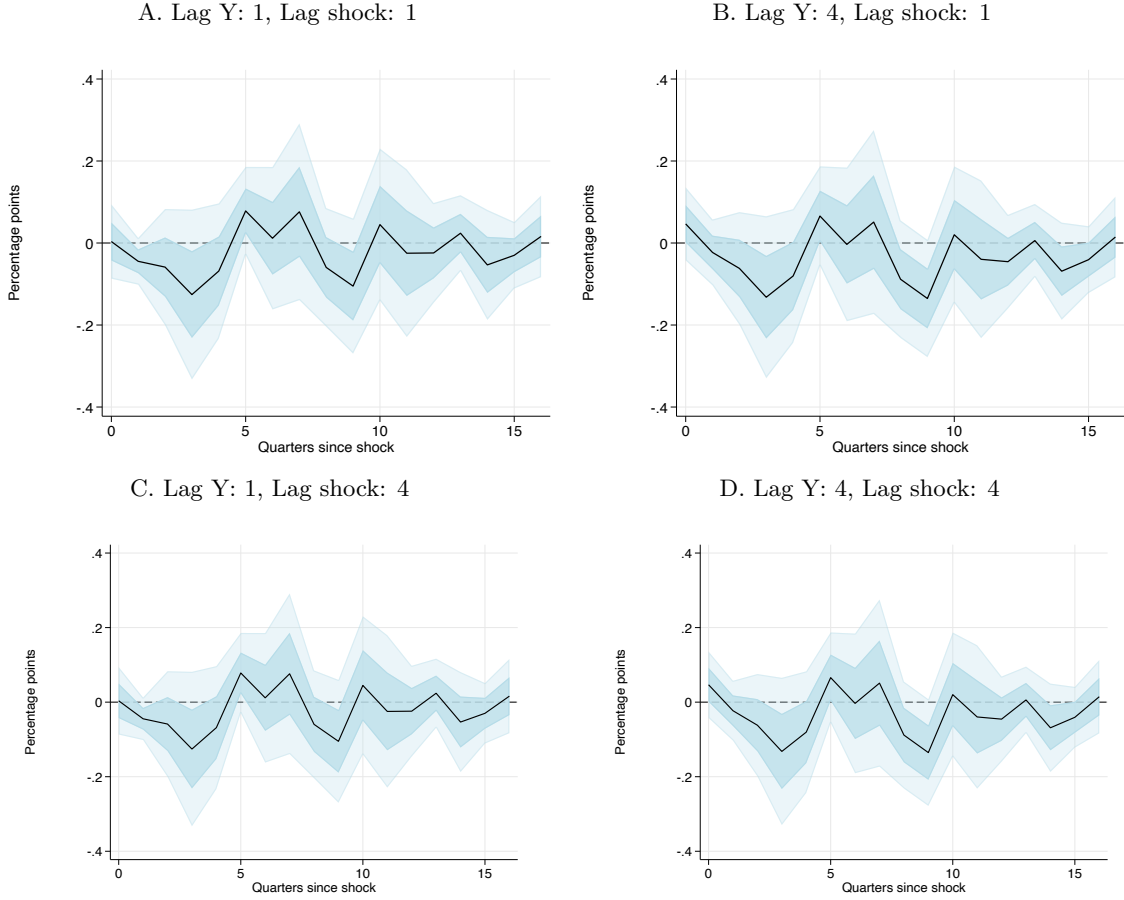
A. Lag Y: 1, Lag shock: 1

B. Lag Y: 4, Lag shock: 1

C. Lag Y: 1, Lag shock: 4

D. Lag Y: 4, Lag shock: 4

Notes: Each panel reports the interaction coefficients between the monetary policy shock and the dummy identifying the top 20% of the services/manufacturing production ratio distribution using as dependent variable either the state-level real personal income. The dark shaded area and the light shaded area represent the 68% and the 95% confidence intervals respectively. The horizontal axis is in quarters.

baseline specification by interacting different control variables with the monetary policy shock[2]. For example, Wong (2021) document that the consumption of young homeowners reacts more strongly to monetary policy shocks. Therefore, I consider different measures of the housing market like house prices and the fraction of mortgages that are adjustable-rate mortgages (ARMs) both retrieved from the FHFA. I also control for the share of male workers, white workers, college-educated workers, small firms (below 249 employees), and young firms (younger than 5 years old) using data from the LEHD. As suggested by Leahy and Thapar (2020), to take into account that the entrepreneurial activities of the middle-aged might lead to different responsiveness across states, I include the log of establishment deaths and births from the BLS. Finally, Cravino et al. (2020a) argues that higher-income households tend to

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[2]The results are not affected if the controls are not interacted with the shocks.

Figure 4: Impact of monetary policy on the regional inflation rate, different lags

A. Lag Y: 1, Lag shock: 1

B. Lag Y: 4, Lag shock: 1

C. Lag Y: 1, Lag shock: 4

D. Lag Y: 4, Lag shock: 4

Notes: Each panel reports the interaction coefficients between the monetary policy shock and the dummy identifying the top 20% of the services/manufacturing production ratio distribution using as dependent variable either the state-level inflation rate. The dark shaded area and the light shaded area represent the 68% and the 95% confidence intervals respectively. The horizontal axis is in quarters.

purchase goods with stickier prices. Since households' age and income tend to be positively correlated, the results could reflect this mechanism. To control for this, I add the interaction between state GDP per capita and the monetary shocks as an additional regressor. I report all these extra robustness checks in Figures 5 to and Figure 9.

## C External validity and potential alternative channels

The main contribution of the paper is to study how demographic trends can affect monetary policy effectiveness through consumption heterogeneity. I document that older people tend to consume relatively more services and, since services have a higher level of price rigidities, population aging is shifting the economy towards services leading to an overall increase in

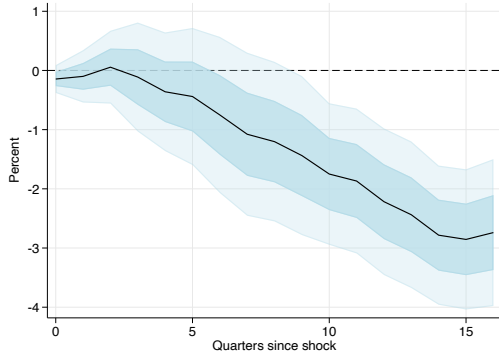**Figure 5:** Impact of monetary policy on regional variables, extra controls

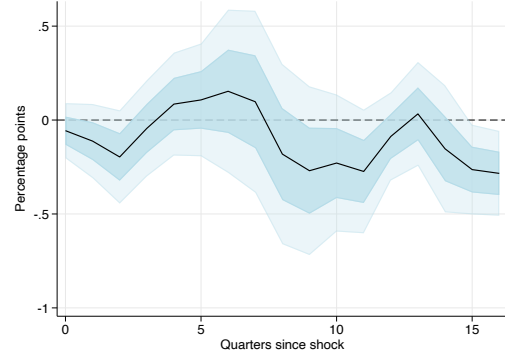A. Real personal income controlling for house prices
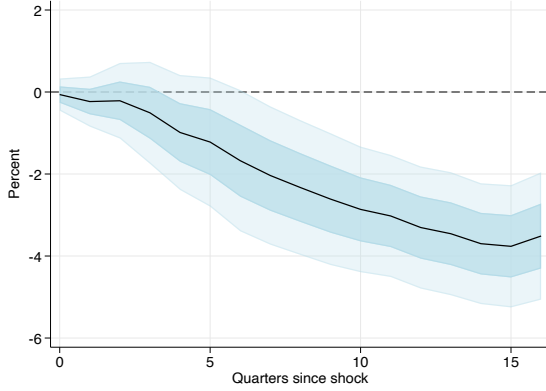
B. Inflation rate controlling for house prices
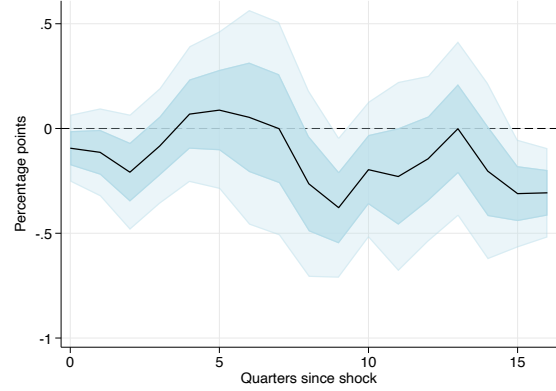
C. Real personal income controlling for fraction of ARMs

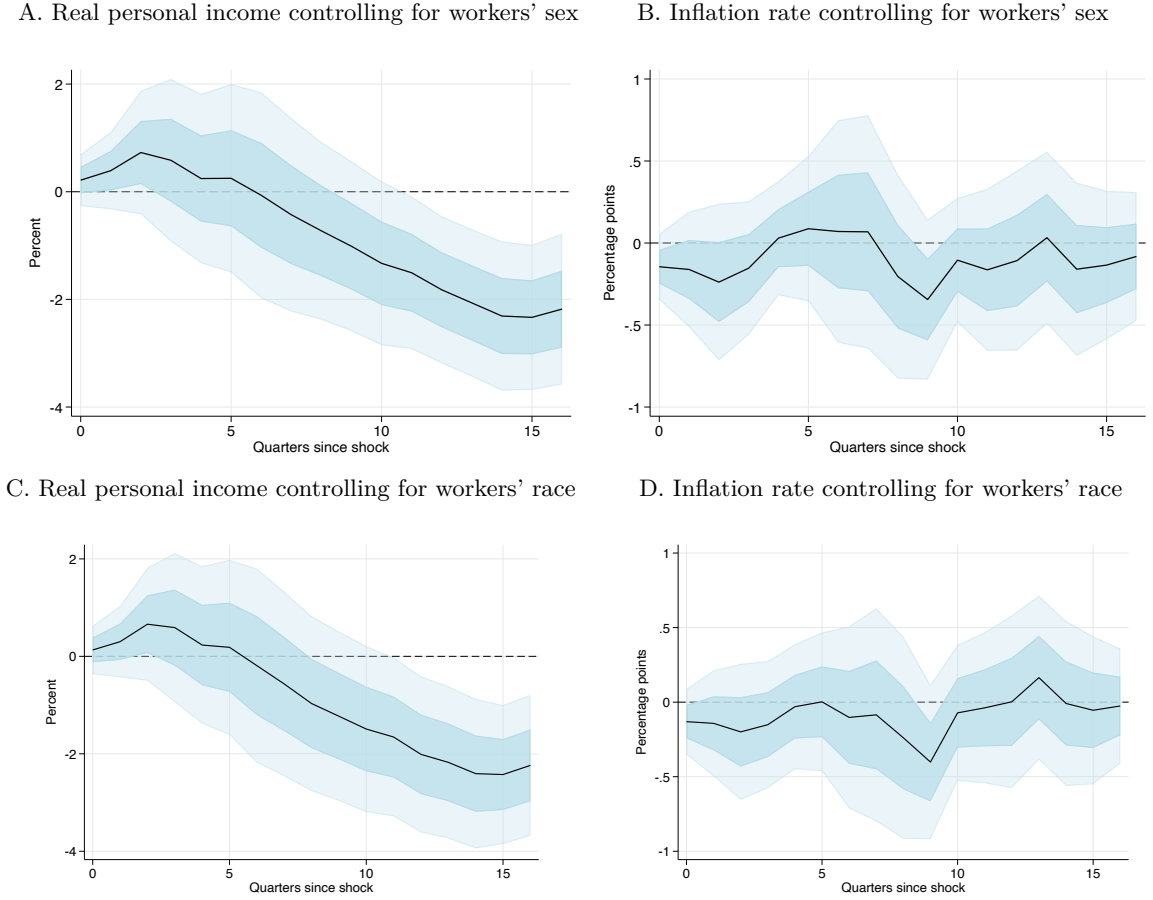D. Inflation rate controlling for fraction of ARMs

Notes: Each panel reports the interaction coefficients between the monetary policy shock and the dummy identifying the top 20% of the services/manufacturing production ratio distribution using as dependent variable either the state-level real personal income or the inflation rate. The dark shaded area and the light shaded area represent the 68% and the 95% confidence intervals respectively. The horizontal axis is in quarters.

price stickiness. The lower aggregate frequency of price adjustments results in an increase in output responsiveness to monetary shocks.

Can the results provided be generalized to other countries? The household-level relationship between price stickiness is documented using a U.S. survey. The same is true for the macroeconomic analysis entirely based on economic and demographic variation among U.S. states. The U.S. has some unique characteristics that could weaken the external validity of the novel channel studied. For instance, a high share of expenditure is devoted to medical expenses.

However, I believe the main findings can be extrapolated to other countries. In a panel of 20 developed countries over the 1970-2007 period, Cravino et al. (2020b) document that

Figure 6: Impact of monetary policy on regional variables, extra controls

A. Real personal income controlling for workers' sex

B. Inflation rate controlling for workers' sex

C. Real personal income controlling for workers' race
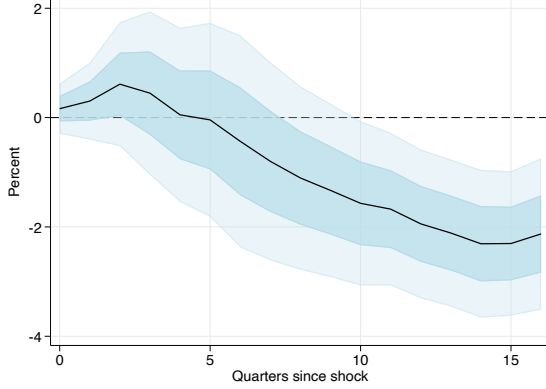
D. Inflation rate controlling for workers' race

Notes: Each panel reports the interaction coefficients between the monetary policy shock and the dummy identifying the top 20% of the services/manufacturing production ratio distribution using as dependent variable either the state-level real personal income or the inflation rate. The dark shaded area and the light shaded area represent the 68% and the 95% confidence intervals respectively. The horizontal axis is in quarters.

population aging is accompanied by the rise in the relative size of the service sector. At the same time, Galesi and Rachedi (2018) adopt a VAR specification for a panel of 25 countries to show that output reacts more to monetary policy shocks in countries that are more intensive in services intermediates. Therefore, the positive relationship between demographic trends, the importance of the service sector, and monetary policy effectiveness have already been confirmed outside the U.S. despite differences in the health system, pension scheme, etc.

Another source of concern could be that the different price stickiness in the services and the goods sectors are not the only sources of heterogeneity between the two sectors. In the sensitivity analysis of subsection 5.8.7, I evaluate whether other differences might explain the results. I allow the two sectors to differ in labor share, the elasticity of substitution across varieties within sectors (which lead to different mark-ups) and to have the same frequency of

Figure 7: Impact of monetary policy on regional variables, extra controls
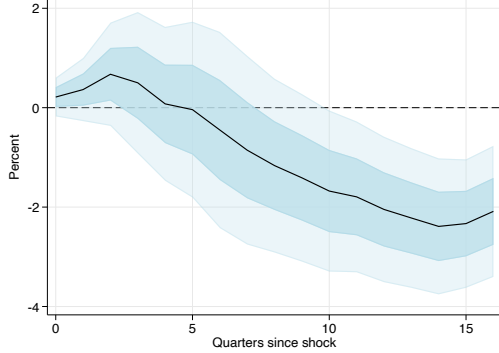
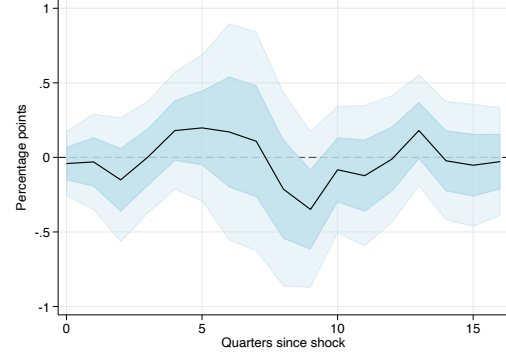A. Real personal income controlling for workers' education

B. Inflation rate controlling for workers' education
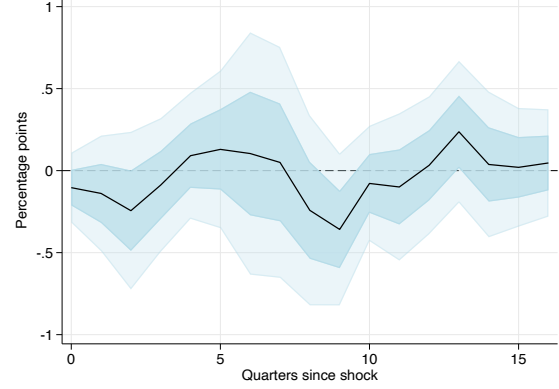
C. Real personal income controlling for firms' size

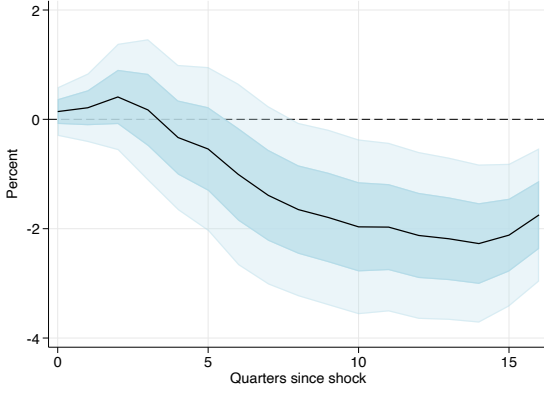D. Inflation rate controlling for firms' size

Notes: Each panel reports the interaction coefficients between the monetary policy shock and the dummy identifying the top 20% of the services/manufacturing production ratio distribution using as dependent variable either the state-level real personal income or the inflation rate. The dark shaded area and the light shaded area represent the 68% and the 95% confidence intervals respectively. The horizontal axis is in quarters.

price adjustments. All the structural differences considered do not affect the main findings and confirm that heterogeneity in price stickiness is the most important channel.

There are other channels that are not currently included in the model and which I plan to study more in-depth in the future. For instance, wage rigidities might differ between services and goods. Moreover, I assume workers supply their labor to both sectors and are free to shift freely between them. Frictions in the labor market might make this adjustment costly probably leading to a stronger response in labor demand. Finally, workers of different ages might systematically differ in their skills or their preferences towards the two sectors leading to additional frictions that could strengthen or weaken the heterogeneous sectoral output response to monetary shocks. The empirical evidence suggests that overall the impact of

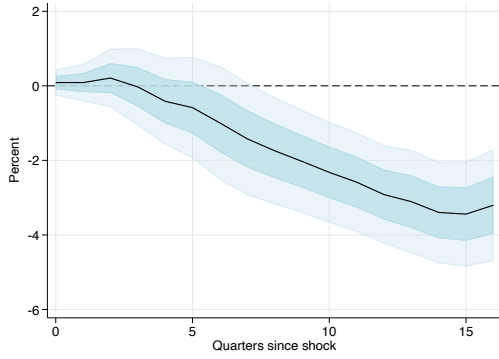**Figure 8:** Impact of monetary policy on regional variables, extra controls

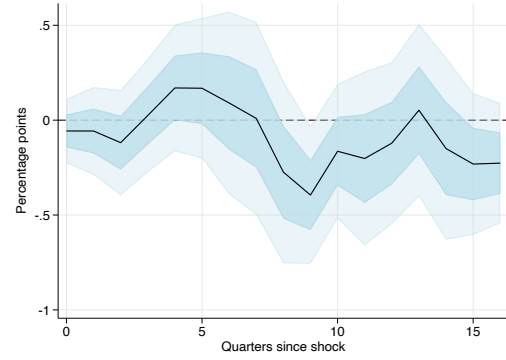A. Real personal income controlling for firms' age

B. Inflation rate controlling for firms' age
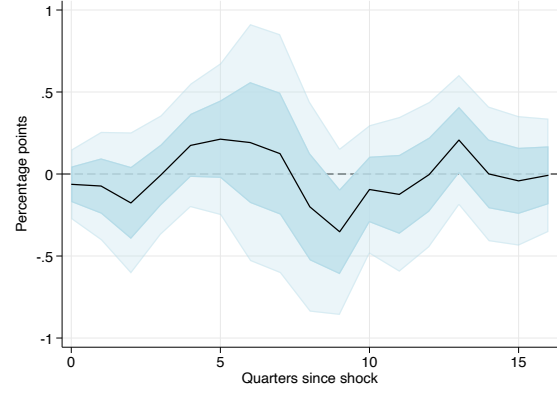
C. Real personal income controlling for establishment births

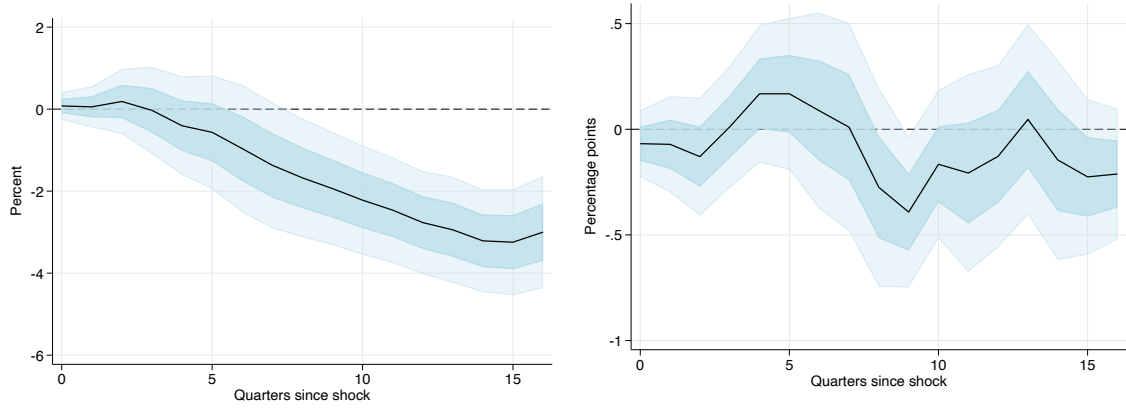D. Inflation rate controlling for establishment births

Notes: Each panel reports the interaction coefficients between the monetary policy shock and the dummy identifying the top 20% of the services/manufacturing production ratio distribution using as dependent variable either the state-level real personal income or the inflation rate. The dark shaded area and the light shaded area represent the 68% and the 95% confidence intervals respectively. The horizontal axis is in quarters.

population aging on monetary policy effectiveness is positive but the relative contribution of each channel is a priori difficult to quantify and, therefore, necessitates further analysis.

Figure 9: Impact of monetary policy on regional variables, extra controls

A. Real personal income controlling for establishment deaths

B. Inflation rate controlling for establishment deaths

C. Real personal income controlling for GDP per capita

D. Inflation rate controlling for GDP per capita
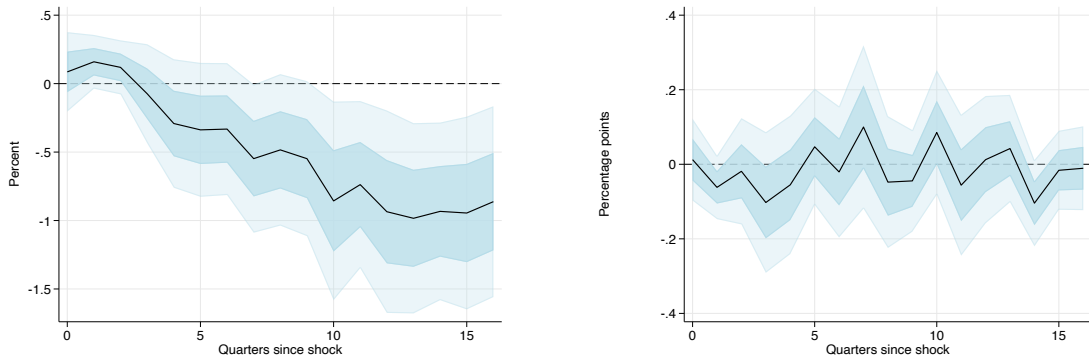
Notes: Each panel reports the interaction coefficients between the monetary policy shock and the dummy identifying the top 20% of the services/manufacturing production ratio distribution using as dependent variable either the state-level real personal income or the inflation rate. The dark shaded area and the light shaded area represent the 68% and the 95% confidence intervals respectively. The horizontal axis is in quarters.

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