Regressive Trend Inflation Shocks☆

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Abstract

We identify innovations to trend inflation (rather than to inflation) using a standard trend-cycle model to investigate their aggregate and distributional effects. These innovations generate a persistent and sizable contraction in economic activity and are regressive. They harm poor households through the income and expenditure channels and benefit them through the asset holdings channel, and less so through the revaluation channel. We uncover a new operative channel for regressive trend inflation, the liability channel, which is claimed to be very relevant: rich households raise their liabilities in order to smooth their consumption and reduce their real debt burden in the long run. Finally, we use an IV approach to extract trend inflation shocks driven by: (i) oil supply news; (ii) monetary policy; and (iii)) tax changes. Irrespective of the source, trend inflation shocks turn out to be regressive.

Keywords: heterogeneous effects, trend inflation, trend-cycle decomposition, local projections, IV.

JEL Codes: E31, E32, E43, E52, E58.

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1 Introduction

There is by now ample evidence that unanticipated shocks to inflation have distributional consequences. Several dimensions of household heterogeneity that inflation may impact on have been singled out. Households are heterogeneous as regards their income, wealth, consumption bundles, age, skill level, sector of employment, marginal propensity to consume, or access to finance. However, the evidence on the distributional effects of more persistent changes in inflation is scant. These persistent changes can be obtained by filtering out the noise in inflation data to provide an estimate of the so-called *trend inflation*.

Our paper aims at closing this gap and suggests a novel identification strategy for extracting different trend inflation shocks from the data to analyze their aggregate and distributional consequences. In particular, unanticipated trend inflation shifts are identified by means of a univariate unobserved-components stochastic volatility outlier-adjusted (UCSVO) model that allows for common persistent and transitory factors, time-varying factor loadings, and stochastic volatility as in Stock and Watson (2016). Following Ramey (2016) and Stock and Watson (2018), these shifts are labeled trend inflation *innovations* since, despite being serially uncorrelated and unpredictable, they are related to other structural shocks. In particular, we show that these innovations are correlated with permanent monetary shocks (see, Uribe, 2022); oil price shocks (see, Kanzig, 2021); negative TFP shocks (see, Barsky and Sims, 2012) and tax shocks (see, Romer and Romer, 2010 and Mertens and Ravn, 2019), while their correlation is lower with to transitory monetary policy shocks. Later, we exploit these correlations to use some of the aforementioned shocks as instruments to identify trend inflation *shocks* from the innovations series.

Positive trend inflation innovations induce persistent increases in both headline and core PCE inflation and, consistently with the Fisher equation, they also increase the yields of ten and one-year rates. Importantly, they raise inflation expectations persistently and lead to protracted reductions in output, consumption and investment. In addition, when we use the Consumer Expenditure Survey (CEX) to estimate the response of consumption to the identified shocks on household consumption at different quantiles of the income distribution, the result is that trend inflation innovations are particularly harmful in terms of consumption of those placed at the lower end of the income distribution. Moreover, after checking for age and wealth, we confirm that this dimension of heterogeneity is key to understand the distributional consequences of trend inflation changes.

Specifically, we explore alternative channels through which trend inflation can have distributional effects using: (i) income and liability data from the CEX; (ii) data on income and wealth for the different quantiles of their distributions from Blanchet et al. (2022); and (iii) data on specific inflation rates for different income groups that are constructed using information from CEX data on PCE items and the weights.

The existing literature has identified several channels through which inflation might affect the income distribution. First, regarding income, there is the *earnings composition channel* proposed by Gornemann et al. (2016a) whereby richer households receive a larger share of their income from business and financial (capital) income, which should be less responsive to changes in inflation. Second, in line with the *earnings distribution channel* (see, Heathcote et al., 2010), households differ in terms of where their earnings fall in the overall distribution. Wages and employment prospects of low-income households are typically more sensitive to business cycles and inflation shocks might reduce their real income faster (see Broer et al. (2021) and Amberg et al. (2022) for evidence using German and Swedish administrative data, respectively). Third, unexpected inflation reduces the real value of nominal assets and liabilities and redistributes from creditors to borrowers, leading to the *Fisher or revaluation channel* (see Doepke and Schneider (2006a) and Pallotti (2022)). Fourth, Cravino et al. (2020), Cravino and Levchenko (2017), Kaplan and Schulhofer-Wohl (2017), Jaravel (2021) emphasize the role of the *expenditure channel*, according to which inflation might have heterogeneous effects on consumption because it affects differently the relevant inflation rates for different income groups; for example, Kanzig (2021) shows that carbon policy shocks have a disproportionate effect on poorer households because they have a higher energy expenditure share, and experience a larger fall in their income. Finally, changes in inflation can also affect the real value of household's assets, such as equity holdings, housing and bonds (see, e.g., Del Canto et al., 2023), therefore implying different effects on agents with and without such asset holdings; we will refer to this mechanism as the *asset holdings channel*, through which there is a heterogeneous impact of inflation on households in different income quantiles.

Cardoso et al. (2022), using survey and administrative data from Spain and Del Canto et al. (2023), using US survey data, develop an empirical framework which allows for the incidence of inflation to differ depending on the source of the shock and accounting for changes in all items of the budget constraint. This approach to evaluate the redistributive effects of inflation has been labeled as the "budget set approach".[1] Cardoso et al. (2022) focuses on the inflation hike in 2021 in Spain as a result of the electricity/gas price crisis driven by Ukraine invasion, suggesting that income and wealth are key to explain the redistributive consequences of inflation in this country. As regards the US, Del Canto et al. (2023) find that inflationary oil shocks are regressive, while monetary expansions are progressive, and identify the asset holdings channel as the main mechanism through which inflation redistributes income.

Our main finding is that, in general, trend inflation (positive) innovations benefit high-income households and, therefore are regressive. We document that high-wealth groups experience an increase in their relative real wealth after such an innovation. This results from an increase in their relative labor income and a fall in real house prices after the shock, both in combination with a rise in their real profits that undo the negative effects of the shock in real asset values. The data also suggests that the relative consumption basket of poor households becomes more costly after this type of innovation. Finally,

[1] Yang (2022) revisits the evidence on the these effects of unexpected inflation and studies optimal monetary policy in a HANK model that incorporates the the first three channels mentioned above.

to our knowledge, we uncover a novel empirical result in this literature, namely, that liabilities of the richer households increase relatively more after a trend inflation innovation. This suggests that rich and middle-income agents smooth consumption by increasing their liabilities, while poor households lack this possibility. Moreover, by being able to increase their liabilities in the verge of such innovations, richer households benefit further from the fall in the future value of their real debt. We label this new mechanism the *liability channel* and show that, interestingly, it is operative only for persistent inflation shocks. In response to standard transitory inflation shocks, liabilities do not react significantly to the shock and if anything they move in the opposite direction.

Our estimated trend inflation innovation series also correlates with oil supply news shocks identified by Kanzig (2021). Using an instrumental variable approach, we employ the latter shocks as an instrument in order to identify the component of the trend inflation innovation which is related to oil news shocks. We call that component oil-induced trend inflation shocks, since by construction they are unrelated to other structural shocks. It is shown that such a shock operates as a contractionary supply shock that favors the rich households through the expenditure (similar to Kanzig, 2021), the asset holdings and the liability channels.

Next, Uribe (2022) has initiated a new wave of macroeconomic studies that examines the effects of persistent changes in monetary policy (often labeled as "Neo-Fisherian" shocks). Using quarterly postwar U.S. data, this author estimates an empirical model and a New-Keynesian model, both driven by transitory and permanent monetary and real shocks, showing that a permanent increase in the nominal interest rate causes a fast adjustment of inflation to a permanently higher level, lower real interest rates, and no output loss.[2] As

[2]Earlier work by Ireland (2007), Cogley et al. (2010), and Michelis and Iacoviello (2016) incorporate inflation target shocks within a New-Keynesian model and attribute an important role of movements in the inflation target for inflation dynamics. In addition, Mumtaz and Theodoridis (2023) identify persistent shocks to inflation as shocks that maximize the forecast error variance of inflation at medium term horizons. Lastly, Schmitt-Grohé and Uribe (2022) show that permanent monetary policy shocks are key to understand exchange rate dynamics.

with oil news shocks, our identified innovation to trend inflation is also highly correlated with the monetary shocks identified by Uribe (2022). Hence, a similar IV approach is used to extract the shock component related to permanent changes in the monetary policy stance. The macroeconomic responses to this monetary-induced trend inflation shock differ substantially from the oil-induced shock. In this case, trend inflation shocks are expansionary, rather than contractionary, and increase the consumption - especially of durables - of high and middle income households in the short and medium run.[3] Differently from Del Canto et al. (2023) who argue that these shocks are progressive through the assets holdings channel, we find no significant responses of the real S&P and real house prices -apart from a small increase on impact; in contrast, we find significant increases in real profits for rich households. Monetary-induced policy shocks are also shown to have regressive distributional consequences for non-durable consumption expenditure because they increase the value of the consumption basket of lower income households that hold less liabilities; instead they favor middle and high class households that are shown to increase further their liabilities when facing these trend inflation shocks.

Lastly, we use the LP-IV approach to investigate the effects of trend inflation shocks that are related to the unanticipated tax shocks identified by Romer and Romer (2010).Canova and Pappa (2007) have recognized the importance of fiscal policy in determining inflation dynamics. More recently, Cloyne et al. (2023), using 190 subcomponents of the PCE deflator, show that higher average personal income tax rates lower prices across a broad range of sectors through the demand channel, while the price effects of a rise in corporate tax rate reflect persistent negative supply-side effects. In line with these findings, we show that a mixture of personal income and corporate tax shocks is strong instrument to explain tax-induced trend inflation shocks. These shocks turn out to be even more regressive than monetary-induced trend inflation shocks as they reduce mostly the real wealth of the low

[3]Note that the macroeconomic responses obtained by this shock coincide with those of Uribe (2022) although the identification strategy differs substantially.

income.

Our empirical results speak to the theoretical models that have analyzed the effects of persistent inflation shocks. Doepke and Schneider (2006b) examine the distributional effects of higher expected inflation in a life-cycle model with housing. They find that middle-aged, middle-class households, who currently have the largest mortgage debt burden, benefit the most from such shocks at the expense of wealthy retirees due to the reduction in the real value of their debt (the Fisher channel). Likewise, using a two-agents (homeowners and capital owners) New-Keynesian model augmented with long-term debt, Garriga et al. (2017) and Garriga et al. (2021) also show that the real reduction in the value of debt is key for the transmission of persistent changes in the monetary policy stance, while the real interest rate channel is key for transitory interest rate shocks. Our results complement these findings by showing that rich households are the ones who benefit the most from monetary-induced trend inflation shocks because they can increase their liabilities at a lower real cost of debt. Erosa and Ventura (2002) show that, in a monetary growth model where individuals allocate assets between capital and money and perform transactions using either cash or costly credit, the burden of inflation is substantially higher for the households at the bottom of the income distribution than for those at the top. Our results confirm their intuition, as poor households, not being able to increase their liabilities, suffer the consequences of higher expected inflation. Finally, our results have important policy implications. Central banks should avoid persistent increases in inflation, not only because they affect growth, but also to avoid their negative redistributive effects.

The rest of the paper is organized as follows. Section 2 describes the data and the empirical framework for identifying trend inflation, as well as discusses the nature of the extracted innovations. Section 3 includes the macroeconomic effects of the identified innovations. Section 4 evaluates the effects of our identified innovations across different consumer groups and their distributional effects on consumption, income, and wealth. Section 5 presents results for the identified shocks to trend inflation related to oil supply news, permanent monetary policy shocks, and tax shocks. Finally, Section 6 concludes. An online Appendix gathers additional tables and figures discussed in the main text.

2 Extracting Trend Inflation Innovations

This Section describes the identification of trend inflation. Section 2.1 presents the measure of trend inflation used in the analysis. Section 2.2 derives the series of trend inflation innovations and discusses its links with with main events and structural shocks identified by previous works.

2.1 A Trend-Cycle Model of Inflation

There are different approaches to measure trend inflation. We consider estimates of trend inflation based on the univariate unobserved-components stochastic volatility outlier-adjusted (UCSVO) model applied to PCE inflation by Stock and Watson (2016). According to this model, quarterly PCE annualized inflation is represented as the sum of two components: (i) a permanent stochastic trend component, τ_t, and (ii) a serially uncorrelated transitory component, ϵ_t. The innovations to both components have variances that evolve over time according to independent stochastic volatility processes, while the innovation to the temporary component is allowed to exhibit heavy tails (outliers). A a result, the PCE inflation rate can be represented as:

$$\pi_t = \tau_t + \epsilon_t$$

$$\tau_t = \tau_{t-1} + \sigma_{\Delta_\tau,t}\eta_{\tau,t}$$

$$\epsilon_t = \sigma_{\epsilon_t} s_t \eta_{\epsilon,t}$$

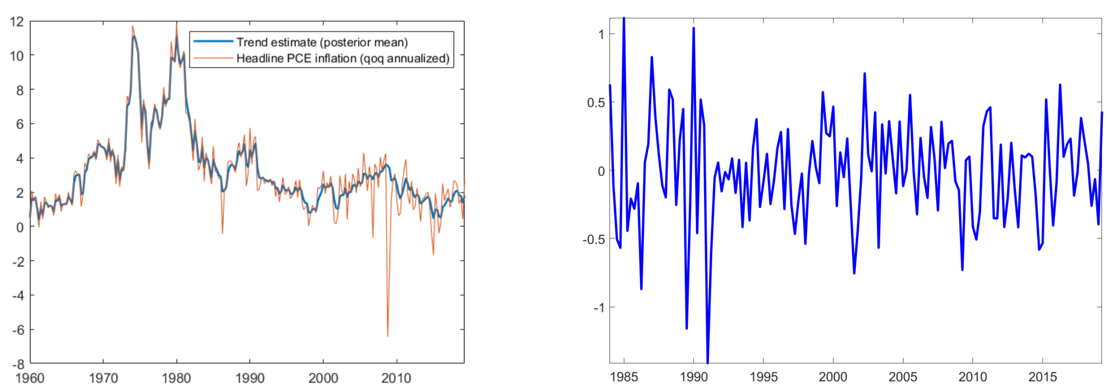
$$\Delta ln(\sigma^2_{\epsilon_t}) = \gamma_\epsilon \nu_{\epsilon,t}$$

$$\Delta ln(\sigma^2_{\Delta_{\tau,t}}) = \gamma_\Delta \nu_{\Delta_{\tau,t}}$$

where $(\eta_\epsilon, \eta_\tau, \nu_\epsilon, \nu_{\Delta_\tau}) \sim \mathcal{N}(0, I_4)$ and i.i.d, while s_t is an i.i.d. random variable that generates outliers in ϵ_t. That is, the model allows for large one-time shifts in the price level—which occur each period with probability p. We use $\sigma_{\Delta_\tau,t}\eta_{\tau,t}$ as the series of shocks to trend inflation.

Trend inflation series are estimated using US data from 1959:Q1 till 2019:Q2, which allows to obtain precise estimates of such unobserved component of inflation. The left panel of Figure 1 depicts annualized headline PCE inflation (in red) together with the trend inflation series extracted using this procedure (continuous blue line). The trend peaks once, in the mid-1970s, at double digit levels and again, at the beginning of the 1980s, though somewhat more moderately; later, it falls back towards about 4% by the mid-1980s and drops even further to around 2% during the Great Moderation and in the later years of the sample. The high volatility of the trend inflation during the Great Inflation period (1965-1982) confirms that inflation expectations were not anchored during this long period until Paul Volcker's disinflation.

Figure 1 Trend Headline PCE Inflation and Trend Inflation Innovations



Note: The left panel depicts Headline PCE inflation (change with respect to the previous quarter, annualized) and the trend inflation series computed using UCSVO model as Stock and Watson (2016). The right panel depicts the series of Trend Inflation innovations estimated for the samples 1984:Q1-2019:Q2. The innovations are identified using the strategy described in Section 2.1. Horizon is in quarters.

2.2 The Series of Trend Inflation Innovations

Considering the availability of CEX data, we restrict our analysis to the sample 1984:Q1 till 2019:Q2 when studying the distributional effects of the shock. In this shorter subsample, the identified series of trend inflation innovations, ε_t^{TI}, does not display systematic serial autocorrelation (see Figure A.1 included in the Appendix). Thus, the series can be considered structural (see Forni and Gambetti, 2014). Table 1 displays the estimated coefficients of the trend inflation innovations on past values of macro financial factors.[4] Second, the series of trend inflation innovations cannot be explained using past macro-financial factors based on the series by McCracken and Ng (2016).

Table 1 Forni and Gambetti (2014) Test on the Trend Inflation Innovations

	Shift in Trend Inflation ($\sigma_{\Delta_{\tau,t}}\eta_{\tau,t}$)
F_{t-1}^1	-0.11
	(0.130)
F_{t-1}^2	-0.12
	(0.236)
F_{t-1}^3	-0.17
	(0.155)
F_{t-1}^4	-0.01
	(0.219)
F_{t-1}^5	0.10
	(0.189)
F_{t-1}^6	0.34
	(0.223)
F_{t-1}^7	-0.07
	(0.251)
F_{t-1}^8	0.04
	(0.246)
N	142
R^2	0.036
F-stat	0.57

*Note: Estimated coefficients of $\sigma_{\Delta_{\tau,t}}\eta_{\tau,t}$ on the first lag of macro financial factors computed by McCracken and Ng (2016) using the sample 1983:Q1-2019:Q2. Robust standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$*

The right panel of Figure 1 depicts the identified series of trend inflation innovations.

[4] In the Appendix A.2.1 we also plot the histograms of the retrieved shocks. Two results stand out. First, the distribution of shocks is almost symmetric, with negative trend inflation innovations occurring slightly more frequently in the sample.

The spikes in the early 1980s correspond to the Great Inflation period and the volatility of the innovations is reduced substantially at the end of the sample. This series of innovations is generic and may reflect monetary policy decisions as well as other shocks that may also shift trend inflation, like oil or commodity price shocks, to which monetary policy does not react vigorously enough. In order to externally validate our identification procedure, we look into FOMC transcripts for a more detailed description of events (not only related with monetary policy decisions) at the times of the observed spikes.

Table 2 describes the main events in the sample that could help explain inflation dynamics. The recovered shock series fits quite well the narratives described in some of the FOMC meetings. For example, in 1985Q1 the FOMC transcript reflects worries of slack in production and increasing trade deficit that could result in upward pressures on inflation. The course of action for monetary policy is summarized in the meetings as follows: "*..the members did not differ greatly in their views regarding the appropriate operational approach, and all indicated that they could support an approach directed, at least initially, toward maintaining about the current degree of restraint on reserve positions. The members recognized that current uncertainties about the economic outlook and the sensitive conditions in domestic credit and foreign exchange markets weighed against a significant increase in the degree of reserve restraint."* Hence, at this instance monetary policy did not seem to be reacting to growing inflation expectations that according to our estimation resulted into an upward shift in trend inflation. In general, shifts in oil and energy prices together with labor market conditions are key to decipher the identified trend inflation innovations.

Finally, to gain some intuition on the nature of the previous innovations, Figure 2 shows the correlation for four leads and lags of the trend inflation innovations with other shocks identified in the related literature that could lift inflation expectations. As can be observed, our series of trend inflation innovations is correlated with popular monetary policy shock series such as the Gertler and Karadi (2015) and Romer and Romer (2004) series.

If monetary policy is able to anchor inflation expectations, our series can be interpreted

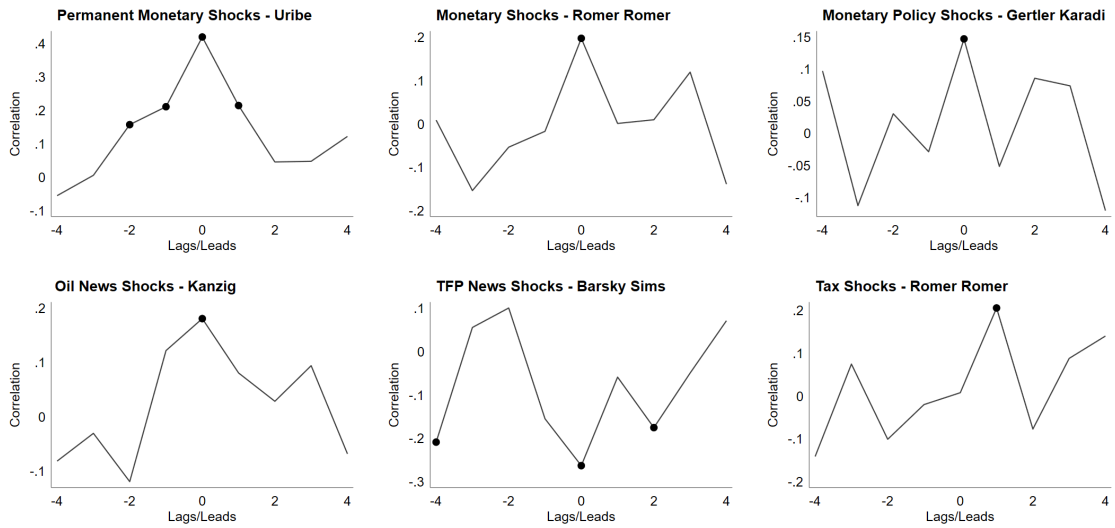
Table 2 Main Shifts in US Trend Inflation Series

Date	Value of the Series	Description
1985:Q1	1.11	*"The information reviewed at this meeting suggests that real GNP is currently expanding at a slower pace than in the fourth quarter, with an increased share of domestic spending apparently being met out of imports." "Broad measures of prices and the index of average hourly earnings appear to be continuing to rise at rates close to those recorded in 1984."* (FOMC Meeting - March 26, 1985)
1987:Q1	0.83	*"Consumer and producer prices rose more rapidly in early 1987, primarily reflecting sizable increases in energy prices. Labor costs increases have remained moderate in recent months."* (FOMC Meeting - March 31, 1987)
1991:Q1	-1.41	*"Energy prices fell substantially further in January and February, but prices of other consumer goods and services rose more rapidly than in preceding months. Wage increases have moderated in recent months."* (FOMC Meeting - March 26, 1991)
2001:Q3	-0.75	*"Expansion in consumer spending appeared to have slowed and business purchases of equipment and software had fallen appreciably, though home building had been well maintained. Energy prices had been relatively flat recently, at a high level, and core price inflation had moderated a little."* (FOMC Meeting - June 26, 2001)
2009:Q2	-0.73	*" The prices of energy and other commodities have risen of late. However, substantial resource slack is likely to dampen cost pressures, and the Committee expects that inflation will remain subdued for some time."* (FOMC Meeting - June 24, 2009)

Note: The Table includes the main events in the series of trend inflation innovations together with a brief description of each event based on FOMC minutes.

either as shocks to the inflation target, or persistent changes in monetary policy. Uribe (2022) and Schmitt-Grohé and Uribe (2022) identify permanent monetary policy shocks in the US and Mumtaz and Theodoridis (2023) identify shocks to the inflation target. While Uribe (2022) exploits long-run restrictions in a co-integrated system, the series of shocks identified by this author as permanent monetary policy shocks are significantly and positively correlated with leads of our series over the common sample. This evidence suggests that the identified trend inflation innovations not only capture shocks to the inflation target or the monetary policy stance, but also include variations in trend inflation

Figure 2 Serial Correlation with Series of Structural Shocks from Previous Works



Note: Serial correlation between the series of Trend Inflation innovations and monetary, oil and TFP shocks identified by previous works. TFP News Shocks Barsky Sims denotes the TFP shocks computed by Barsky and Sims (2011). Permanent Monetary Shock - Uribe denotes the permanent monetary shocks identified by Uribe (2022). Monetary Shock - Romer Romer denotes the monetary policy shocks identified by Romer and Romer (2004). Monetary Policy Shocks - Gertler Karadi denotes the monetary policy surprises computed by Gertler and Karadi (2015). Oil News Shock - Kanzig denotes the series of oil supply news shocks identified by Kanzig (2021). Tax Shocks - Romer Romer denotes the tax shocks identified by Romer and Romer (2010). Continuous black lines represent the estimated correlation for different lags/leads of the corresponding shock series. The point denotes statistical significance $p < 0.05$.

that are unrelated to the monetary policy outlook, such as changes in the fiscal policy stance and supply shocks identified either through news oil shocks or TFP news shocks. On the one hand, trend inflation innovations are negatively correlated (-0.2) contemporaneously and with a lead of the TFP news shocks identified by Barsky and Sims (2012), while they are positively correlated with the oil news shocks identified in Kanzig (2021), pointing to possible anticipated supply factors that contribute to increased trend inflation. On the other hand, the shock correlates positively with the narrative tax shocks series of Romer and Romer (2010), implying again that demand side factors might be contributing to positive inflation trends in the data. Hence, we conclude from this evidence that the identified change in trend inflation is a generic innovation that combines structural shocks to oil prices, demand and supply factors and inflation target shocks that shift inflation expectations in the long run. In section 5 we use an IV approach to disentangle some of those sources of variation in trend inflation.

3 Macroeconomic Effects

In order to estimate the macroeconomic effects of changes in trend inflation we use local projections (LP) (Jordà, 2005). In particular, we estimate the following specification to obtain impulse response functions (IRFs) for 0≤ h ≤ 32 quarters ahead:

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h \epsilon_t^{TI} + \gamma_h X_{t-1} + u_{t+h} \tag{1}$$

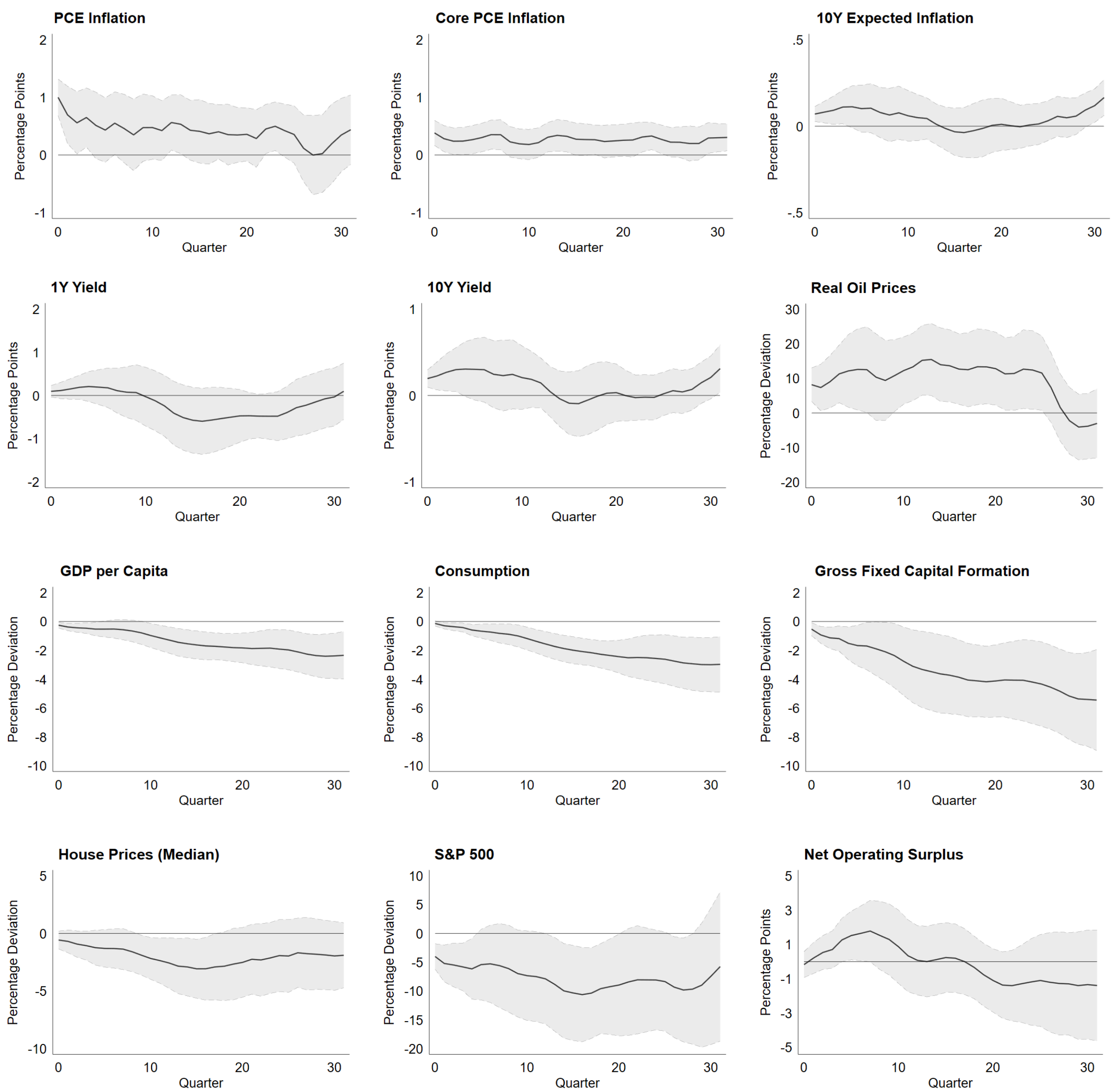
where h denotes the IRF horizon, t is the contemporaneous quarter, y_{t+h} denotes the aggregate variable of interest (GDP, one-year yield, PCE inflation, etc.), and ϵ_t^{TI} is the identified series of trend inflation shocks from Section 2. X_{t-1} includes the cyclical inflation shock (i.e. ϵ_t in Section 2), three lags of the first difference of PCE inflation, real GDP per capita and lags of the dependent variable y_t. Newey-West standard errors are computed to correct for serial correlation of the error term u_{t+h}.

Figure 3 displays the IRFs of the macroeconomic variables to a trend inflation innovation over the sample period 1984:Q1-2019:Q2.[5] The shock induces an immediate and persistent increase in headline and core PCE inflation. This finding is also reflected on the inflation expectations series computed by the Cleveland FED that increase significantly on impact. The same applies to ten-year yields that increase significantly with a lag reflecting the fact that markets are anticipating higher inflation in the future (Fisher effect). The one-year yield is not affected significantly by the shock at any horizon. Likewise, real GDP and demand for both consumption and capital goods decrease persistently. Hence, the

[5] In the Appendix A.2.2 we present the macroeconomic effects of trend inflation innovations for the longer sample 1960:Q1-2019:Q2.

inflationary shock looks like an aggregate supply shock.

Figure 3 IRFs to a Trend Inflation Innovation



Note: IRFs to a trend inflation innovation on aggregate macro variables over the sample 1984Q1-2019Q2 computed using local projections defined in equation 1. IRFs smoothed using 3-quarter backward-looking moving average. Continuous solid lines denote the median IRFs. Shaded areas denote 90% confidence bands based on Newey-West standard errors. Horizon is in quarters.

Finally, we consider the reaction of assets, house and oil prices to fully characterize the effect of the trend inflation innovations and to link it with the responses at the individual household level. The shock induces a significant drop in the real S&P 500, and real house prices with a lag. Oil prices, in agreement with the evidence presented earlier on the correlation of the trend innovation with energy shocks and the supply nature of the shock, increase significantly and persistently following an unexpected trend inflation change. We also plot the responses of the net operating surplus as a proxy for profits which increases over the first 10 quarters to then decrease.[6]

4 Heterogeneous Effects

The previous section established that unexpected trend inflation changes have significant and persistent contractionary effects and tend to shift inflation persistently upward (irrespective of whether this is headline, core PCE, or CPI - that we do not present here for economy of space) . It is well known that inflation affects all economic agents in the economy. However, it is also known that it does not affect everyone in the same way. Differences in the net borrowing position, wealth composition, wages or consumption patterns may result in heterogeneity in the way inflation affects different individuals. In this section we investigate how trend inflation changes affect households, considering their expenditure, wealth and earnings positions.

4.1 Econometric Strategy

In order to estimate the heterogeneous effects of the trend inflation innovations we use again LP (Jordà (2005)). As in the analysis of macro aggregates, we estimate the following specification to obtain impulse response functions (IRFs) for $0 \leq h \leq 32$ quarters:

$$y_{i,t+h} - y_{i,t-1} = \alpha_{i,h} + \beta_{i,h}\epsilon_t^{TI} + \gamma_{i,h}X_{i,t-1} + u_{i,t+h} \tag{2}$$

[6]The net operating surplus is a profits-like measure that shows business income after subtracting the costs of compensation of employees (received), taxes on production and imports less subsidies, and consumption of fixed capital (CFC) from value added, but before subtracting financing costs and business transfer payments. It consists of the net operating surplus of private enterprises and the current surplus of government enterprises.

where t and h denote quarter and IRF horizon, respectively. The index i indicates the different groups of the income distribution, $y_{i,t+h}$ is our variable of interest drawn from the CEX. In our baseline specification we focus on the log of real p.c. consumption by net income group. A more detailed description of the microdata and variables of interest can be found in the next section. ϵ_t^{IT} is the identified series of inflation trend shocks. $X_{i,t-1}$ includes three lags of the first difference of PCE inflation, real GDP and the dependent variable $y_{i,t}$. As in the previous section, we use Newey-West standard errors to control for heteroskedasticity and serial correlation of the error term.

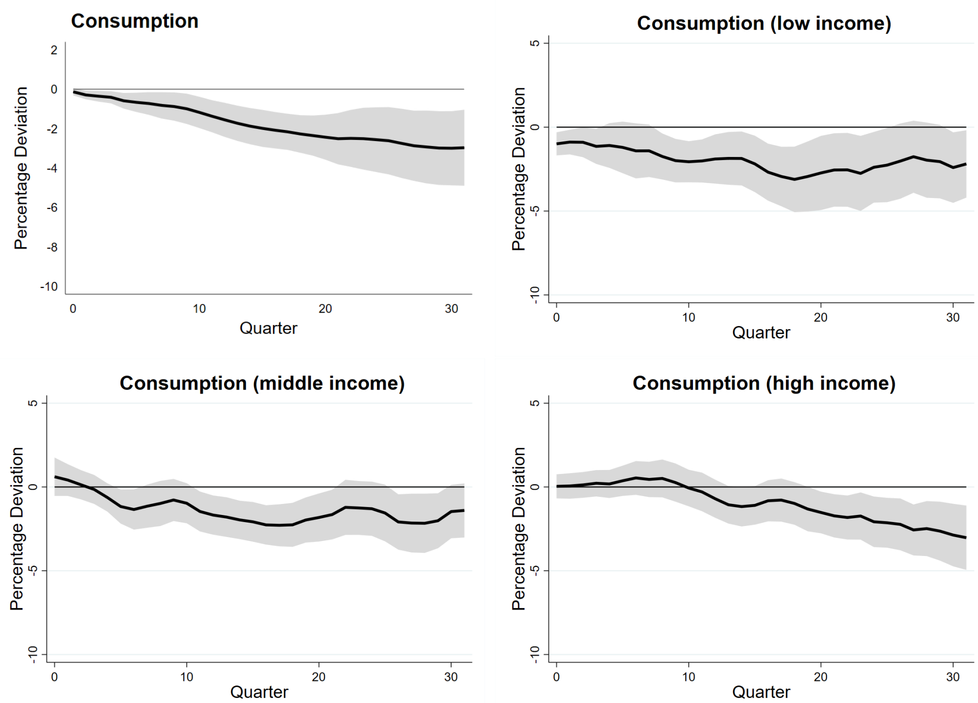
4.2 Micro Dataset

We use data from the CEX interview sample conducted by the Bureau of Labor Statistics, which is a monthly rotating panel where households are selected to be representative of the US population. Our sample goes from 1984:Q1 to 2019:Q2. The CEX contains information about household expenditures on detailed categories, household income, labor supply and a rich set of demographic characteristics. Expenditure categories include durable goods, non-durable goods and services. Following Coibion et al. (2017) our measure of non-durable and service consumption includes food, beverages, clothing, footwear, gasoline and other fuel, personal care, newspapers, tobacco, household operations, utilities, recreation services, financial services, accommodations, telecommunication services and transportation services. Durable consumption in turn includes durable leisure goods, furniture and jewelry. Besides these categories, we also consider households' expenditures for mortgage and rent payments. All series are converted into real-p.c. terms using the CPI and family size, and are then aggregated to quarterly frequency using the reference date of the interview. We then create pseudo cohorts to estimate the heterogeneous effects by household group. More specifically, in our baseline we group households by their net income. Section A.1.2 in the Appendix offers further details on the data and the construction of these variables.

4.3 The Heterogeneous Response of Consumption

In our baseline analysis we estimate the consumption response of households by income group. Figure 4 plots the responses of the level of consumption for the three different income groups to a 1 percentage point rise in trend inflation.[7] The shock decreases private consumption for all income groups in the medium run, though the drop is even more delayed for high income households. In the Appendix we show that the responses of durable consumption are more pronounced than those of non-durable consumption. Yet, we find that both types of consumption drop on impact and persistently for low-income households.

Figure 4 Consumption Response by Income Group



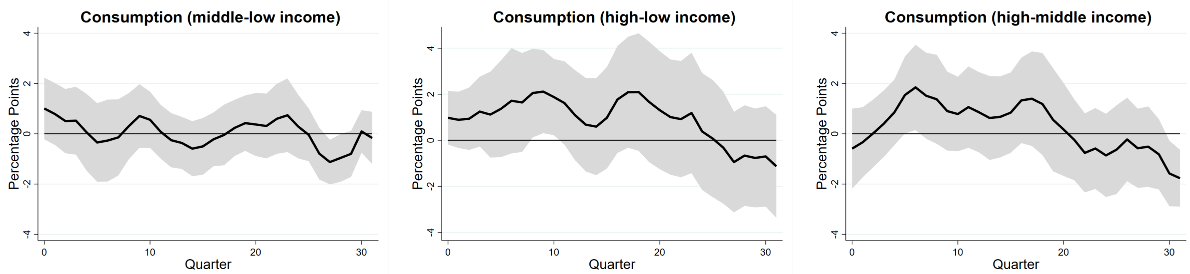
Note: Effects of trend inflation innovation on consumption by net income group over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

To capture better the asymmetric effect of the trend inflation innovation on the consumption of the different income groups, Figure 5 plots the ratio of consumption responses

[7]Due to the trend in underreporting, we re-scale consumption expenditure for each cohort in the survey data by the ratio of the national statistics series to the corresponding series aggregated from the CEX/LCFS, following Cloyne et al. (2020).

between the income groups. Note that, by considering these ratios, we bypass the need to re-scale the consumption expenditure series for each group, allowing us to clearly identify the asymmetric effect of the innovation based on the income distribution. Figure 5 indicates that the high income households suffer the least in terms of consumption losses, and there is little difference in consumption losses between low and middle income households.

Figure 5 Differential Consumption Response by Income Group



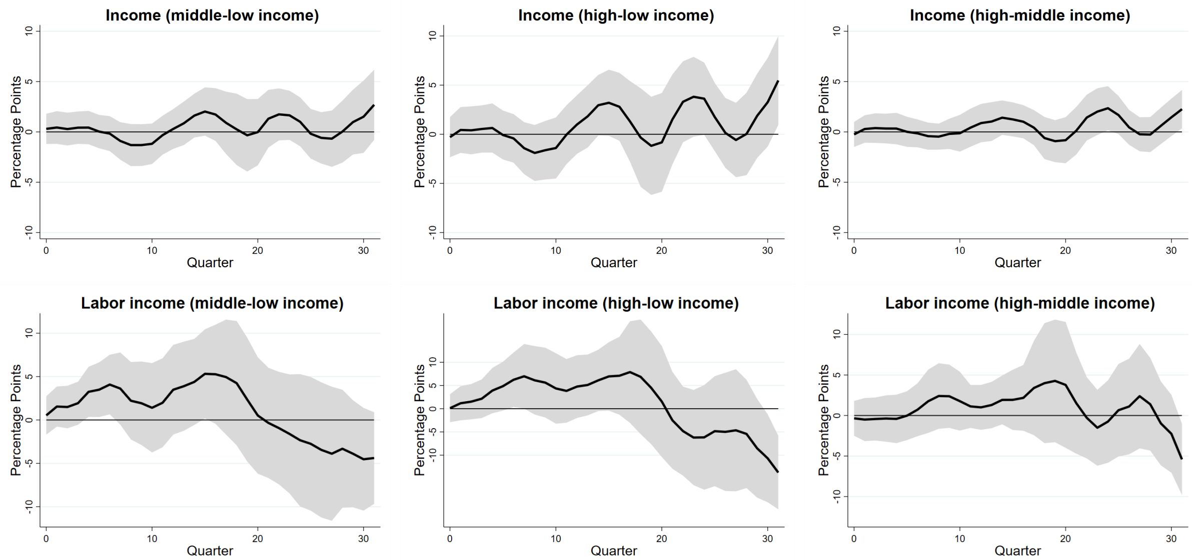
Note: Effects of trend inflation shock on consumption ratio between net income groups over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

4.4 What Explains the Differences?

Earnings Channels

It is well known that households have different earnings growth elasticities to changes in aggregate income (see e.g., Guvenen et al., 2017). To the extent that trend inflation translates into aggregate income growth, households with different income elasticities will be affected differently by inflationary shocks. Also, if poorer households receive less income from capital and real assets, then inflation can affect their real income (see, Gornemann et al., 2016b). The top line of Figure 6 presents the responses of the total net income ratios for the different income groups to a trend inflation innovation. As can be observed, there is weak evidence that changes in total income are able to explain the different consumption responses to a trend inflation innovation.

Figure 6 Differential Total Income (top) and Labor Income (bottom) Response by Income Group



Note: Top line: Effects of trend inflation innovation on income ratio between net income quintiles over sample 1984Q1-2019Q2. Middle line: Effects of trend inflation innovation on labor income ratio between net income quintiles over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

Wages, pensions or unemployment benefits typically adjust slowly to economic fluctuations. As a result, unexpected changes in inflation might affect the real labor income of households and especially of those with higher nominal income. The bottom line of Figure 6 depicts the relative labor income responses to the trend inflation innovation, showing that it decreases significantly the labor income of the households at the lower part of the income distribution. Hence, although total income seems not to be significantly affected, an unexpected change in trend inflation erodes the real labor income of the poor households significantly more than those of the rich or middle class households.

Blanchet et al. (2022) have recently built a new data set that provides estimates of the distribution of income and wealth in the United States at monthly and quarterly frequency (updated daily on `https://realtimeinequality.org`). Borrowing their series for disposable income, defined as pretax income minus all taxes, plus all cash and quasi-cash transfers, we plot in the Appendix (see Figure A.9) the responses of the relative disposable income for the different income groups constructed by these authors. Note, however, that the results of this exercise are not directly comparable with the corresponding results in our previous exercise with CEX data since Blanchet et al. (2022) use different classifications for the income distribution. Our main finding here is that trend inflation innovations increase the relative real disposable income of the very rich, particularly those placed at the top 10, top 1 and top 0.1 of the income distribution. Hence, the responses in both this and the previous exercises suggest that trend inflation innovations affect the labor and disposable income of the different income groups and, hence, can partially explain the differential consumption responses. As a result, we conclude that the earnings channel highlighted in previous studies by Gornemann et al. (2016b), Heathcote et al. (2010), Broer et al. (2021) and Amberg et al. (2022) on the redistributive effects of surprise inflation changes seems to remain operative for more persistent shifts in inflation.

Wealth Channels

We next turn to the data on the wealth distribution of Blanchet et al., 2022 to study whether the trend inflation innovations change the allocation of wealth. The latter includes all financial and non-financial assets owned by households, net of all debts. Assets include all funded pensions. Figure 7 presents the relative responses for the different wealth quantiles to such innovations, where the quantiles now refer to total wealth rather than net income. Taking into consideration that wealth and income are correlated (though such a correlation is not perfect), Figure 7 shows that real wealth drops persistently, and that it appears to fall more for the groups in the lower part of the wealth distribution.[8]

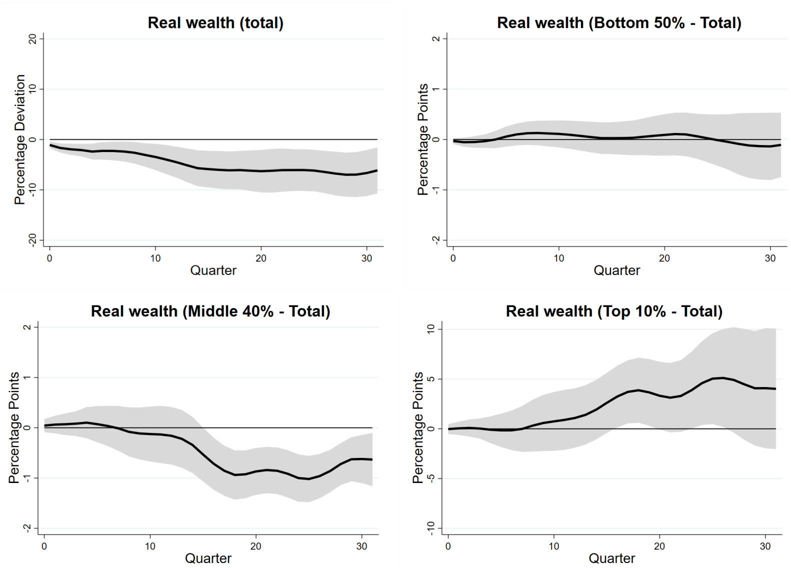
Asset Holdings Channel

According to Kessler and Wolff (1991) and Kennickell and Starr-McCluer (1997), the fraction of households wealth held in liquid assets decreases with income and wealth. Thus, if

[8] Note that the bottom 50% of the wealth distribution has almost no wealth, so the comparison is more pertinent for households in the top 50%.

poor households hold more liquid assets, it is not surprising that they suffer the most from trend inflation shock that erodes the value of those assets. Moreover, if low and middle-income households are more likely to hold a house or a mortgage, the fall in their real wealth can be intuitively explained by the reduction in real house prices documented in Figure 3. In effect, according to historical Survey of Consumer Finances data, the lower the income of households the greater the share of their wealth coming from home ownership, a pattern that seems to have remained invariant over the last three decades. Hence, if the value of houses in real terms drops after a trend inflation innovation, the total wealth of households that mainly hold houses as assets must accordingly fall. Conversely, the relative real wealth of richer households increases significantly 3 years after the innovation. This rise is likely to be due to higher real profits that more than compensate the fall in real house and asset prices depicted in Figure 3.

Figure 7 Wealth Response by Wealth Group (Realtime Inequality Data by Blanchet et al., 2022)



Note: Effects of trend inflation innovation on wealth by wealth group based on Blanchet et al. (2022) data over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

Revaluation Channel

It is important to understand what underlies the changes in wealth of the different groups in the wealth distribution depicted in Figure 7. In addition to changes in the real value of houses and liquid assets, debt and revaluation effects might also explain the heterogeneous effects of trend inflation innovations on wealth. In relation to the wealth channel, Cloyne et al. (2020) show that the expansionary effect of a transitory monetary policy shock on consumption is mainly driven by liquidity constraints. Wong (2021) further shows that mortgage refinancing is very relevant to understand the aggregate dynamics of consumption in response to transitory interest rate shocks.[9] However, persistent changes in inflation may work through alternative channels. For example, using a two-agents (homeowners and capital owners) New-Keynesian model augmented with long-term debt, Garriga et al. (2017) and Garriga et al. (2021) have also found that higher inflation benefits homeowners, due to the reduction in the real value of their mortgage. In particular, Garriga et al. (2021) conclude that previous works have neither estimated these effects nor quantified the role of each transmission channels in response to persistent changes in the stance of monetary policy. Accordingly, we depict in the Appendix (Figure A.10) the responses of real rental and mortgage payments and the 30-year mortgage rate to this type of innovation, finding that neither of them responds significantly, as Garriga et al. (2021) suggest.

In a similar vein, Doepke et al. (2019) analyze the distributional effects of higher expected inflation in a life-cycle model with housing, where it is shown that they induce sizeable and heterogeneous welfare effects. Specifically, they find that middle-aged, middle-class households, who currently have the largest mortgage debt burden, benefit at the expense of wealthy retirees due to a reduction in the real value of debt. Moreover, the responses of winners and losers do not cancel out in the aggregate; instead, their model predicts a

[9] Berger et al. (2021) and Eichenbaum et al. (2021) have also documented that mortgage refinancing is a key channel for the transmission of transitory monetary policy shocks. The transmission of monetary policy through changes in the wealth distribution has been also emphasized by Heterogeneous Agents New-Keynesian (HANK) models (see, e.g. Kaplan et al., 2018).

decline in aggregate consumption, together with an increase in savings and the value of high quality houses. Despite the limitations of the CEX data to examine the debt burden channel directly, we are still able to estimate the effects of trend inflation innovations on consumption for households with different debt, asset positions and age, conditioning on their income and analyze the validity of the predictions of Doepke et al. (2019).

Following Cloyne et al. (2020), we classify households in different income subgroups according to their housing tenure status (renters, mortgagors and outright house owners) and age, (young, middle-age and old).[10] Figure A.7 in the Appendix presents the IRFs of the ratio of consumption of the different age groups and income subgroups. Given that typically older households have accumulated capital and wealth during their lifetime while young households have mostly liquid wealth, old and rich retirees are the ones that gain the most in terms of consumption. Thus, differently from the middle-aged in Doepke et al. (2015)'s study, it is the old rich that benefit the most from persistent inflationary shocks.

We also plot in the Appendix (see Figure A.8) the relative consumption responses for groups with different housing tenure, and for subgroups with different net income within this category. In particular, housing tenure status can be seen as a proxy for wealth where renters are typically households with low wealth. Note that mortgagors and owners have some wealth and that, while it is mainly illiquid for mortgagors, it also liquid for owners. When we ignore the distinction between income groups it appears that owners benefit more than mortgagors from trend inflation innovations. Yet, when we take these groups into account, it becomes apparent that these innovations benefit the consumption of rich house owners more than the consumption of low-income house owners and high-income renters. Therefore, as regards relative consumption responses, income seems to matter more than age and home ownership. The labor income IRFs for different households suggest that trend inflation shifts erode more strongly the real labor income of poor households. Hence, the observed differences must have to do with induced changes in labor and capital

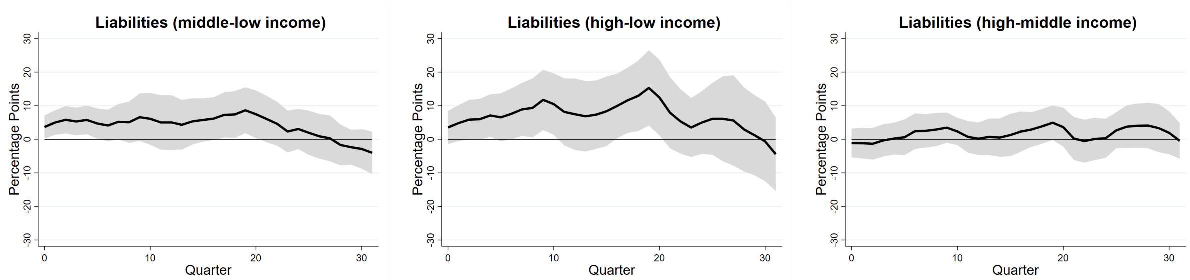
[10]The age brackets are defined by the 33th and 66th percentile of the age distribution in each quarter.

income stemming from trend inflation innovations. Indeed, Figure 3 shows that the real net operating surplus increases significantly, suggesting that firm owners (the rich) benefit from higher real profits, and that such gains overcome the losses they might suffer from the fall in the real value of their stock-market assets.

Liabilities Channel

According to the "revaluation channel", highlighted in Doepke et al. (2015) and Garriga et al. (2021), borrowers benefit from higher trend inflation since it reduces the real value of their debt. The issue here is that rich and poor households are likely to differ in their access to credit. Thus, to understand the previous heterogeneous consumption dynamics we return to the CEX data and estimate the relative responses of liabilities for the different income quantiles considered above, which are presented in Figure 8. Our main finding here is that consumption dynamics are consistent with the liabilities dynamics. As can be observed, top earners at the income distribution increase their liabilities in response to a trend inflation innovation, while low-income households experience a significant drop (see Figure A.11 in the Appendix). Thus, the evidence suggests that rich households reduce their consumption by less than poorer households because they are able to smooth their consumption by increasing their debt exposure, besides benefiting from the lower real long-term debt. Poor households, instead, cannot increase their debt in the first place.

Figure 8 Differential Liabilities Response by Income Group



Note: Effects of trend inflation innovation on relative liabilities between net income groups over sample 1994Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

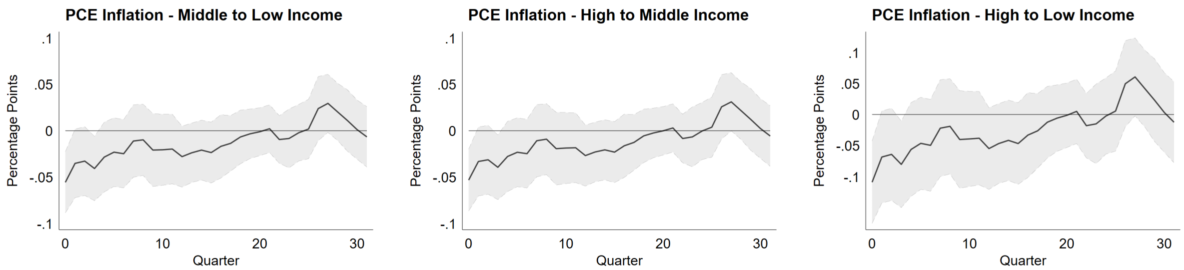
Importantly, the liability channel is only operative for trend inflation innovations. In the Appendix (See Figure A.18) we show that the ratio of liabilities does not change significantly in response to transitory inflation innovations in the cyclical component of inflation, ϵ_t, which are orthogonal to trend innvations (see subsection 2.1). Moreover, if anything, the level of liabilities moves in the opposite direction for households at the low end of the income distribution, while middle income and rich households´ liabilities do not react to the transitory innovation.

Heterogeneous Inflation Rates

The existing literature discussed so far has investigated the distributional consequences of monetary policy that arise from its heterogeneous impact on the value of agents' income or wealth. Recently Cravino et al. (2020), Cravino and Levchenko (2017), Kaplan and Schulhofer-Wohl (2017), Jaravel (2021) and Kanzig (2021) have emphasized that inflationary shocks might have distributional consequences by affecting the relative prices of the goods consumed at different points on the income distribution. For example, Cravino and Levchenko (2017) show that households at the top of the income distribution consume more sticky-priced goods and face substantially lower overall inflation volatility than households in the middle of the income distribution. As a result of prices of goods consumed by the high-income households being less responsive to monetary policy shocks, the overall inflation faced by those households will react less to these shocks. Consequently, monetary shocks will have distributional consequences arising from this channel. It could be argued that the shock we identify is a permanent shock in inflation and differences in the price rigidity of goods consumed by different households should not matter that much. However, it can still be the case that trend inflation innovations affect differently the relative inflation of the different income groups, since those innovations correlate positively with oil price shocks. According to Kanzig (2021), carbon policy shocks harm poorer households because they have a higher energy share, and experience a larger fall in their income.

We exploit the consumption share of the CEX to construct household specific price indices. In particular, we compute the average share of durable, non-durable and services consumption for each group and merge it with the PCE index for each of these categories to derive a household-specific inflation rate. We next investigate how the trend inflation innovations affect relative inflation for the different income groups. The main findings are gathered in Figure 9.

Figure 9 Differential PCE Inflation Response by Income Group



Note: Effects of trend inflation innovation on PCE inflation for different households over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

As can be observed, inflation increases more significantly at the lower end of the income distribution. Hence, another explanation for the heterogeneity of the consumption responses stems from the effects of the trend inflation innovations on the inflation rates faced by the different income groups. Our claim here is that not only short-term changes in the interest rate have distributional consequences as Cravino et al. (2020) highlight, but also that shocks leading to persistent changes in inflation are likely to hit the lower income groups through their unequal effects on the prices of the goods they consume especially in the first year after the trend inflation innovation.

Summing up, the findings in this section suggest that trend inflation innovations are regressive and that all the channels identified in the previous literature about the distributional consequences of unexpected inflation rises remain operative for expected changes in inflation. In particular, trend inflation innovations exhibit larger reductions in the real disposable and labor income and wealth of low earners. In addition, such shocks also erode more the real wealth of poor households by decreasing real house prices and increasing real profits for firms' owners. In contrast, the evidence in favor of the revaluation channel for trend inflation innovations is not strong. Relative to the existing literature, we identify a new channel related to the ability of rich agents to increase their liabilities in response to a trend inflation innovation that helps smooth their consumption. They also benefit from the erosion of the value of their debt due to the higher inflation rate in the future.

Finally, we highlight that our results do not suffer from small sample bias. Herbst and Johannsen (2020) highlight that LP estimates can be biased in small samples and suggest a bias-corrected estimator. Applying this bias-correction yields similar IRFs for the ratios/relative responses (see Figure A.21 in the Appendix). Moreover, these authors point out that Newey-West standard errors are often downward biased in short samples, and recommend to use only heteroscedasticity-robust standard errors. The results using Huber-White standard errors, displayed in Figure A.22 and Figure A.23, turn out to be very similar to our baseline results.

5 Drivers of Trend Inflation

The trend inflation innovation identified in the previous section can be interpreted as a combination of different structural shocks, such as permanent monetary policy changes, news about oil shocks, tax shocks, TFP etc. To draw some more robust conclusions on the policy implications of our findings, we use an LP-IV approach in this section to tell apart the shock component that is related to more permanent variations in the above-mentioned policies. In particular, we use the permanent monetary shocks computed by Uribe (2022), the tax shocks and the oil supply news shocks computed by Kanzig (2021) as instruments in order to extract the components of the trend inflation innovation change that relates to each of these shocks.

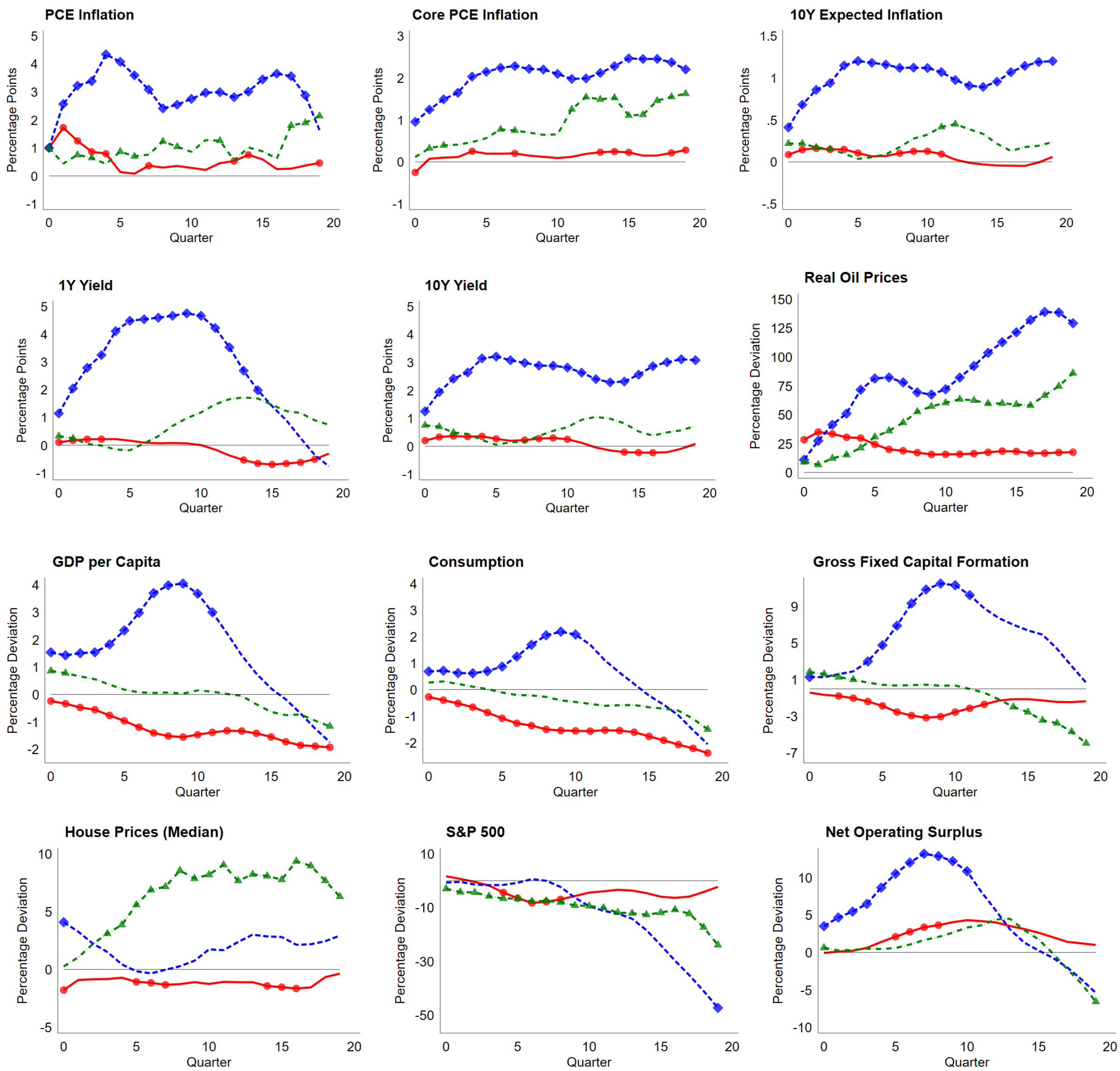
The choice of the permanent monetary policy shocks is driven by policy considerations, the availability of the shock series and the high correlation of the trend inflation innovation with the shock identified by Uribe (2022). Not surprisingly, when we instrument the trend inflation innovation with the latter shock, the F statistic equals 21.2, implying that it is very relevant for explaining fluctuations in the trend innovation series. Given that both series are shock series, the exogeneity assumption is clearly satisfied. As regards the other sources of the shock, we also analyze the responses of the economy to the component of trend inflation innovations that correlates with the tax shocks series of Romer and Romer (2010) and news about oil prices, identified by Kanzig (2021). As with monetary policy permanent shocks, both are relevant for explaining fluctuations in our trend inflation innovation series. The F statistic for the those two shocks equal, 8 and 11, respectively, and the R2, representing the percentage of variation in trend inflation explained by variation in the three shocks is 13% for the permanent monetary shock, 5% for the tax shock and 7% for the oil news shock.

5.1 Aggregate Effects

Figure 10 presents the IRFs to a trend inflation shock in a LP-IV regression where the trend inflation innovation is instrumented with: (i) the Uribe (2022) monetary policy shock (blue dashed lines with diamonds); (ii) the tax shocks of Romer and Romer (2010) (green dashed-dotted lines with triangles), and (iii) the oil news shocks of Kanzig (2021) (red continuous lines with dots). In all cases the chosen symbols represent statistically significant responses at the 90% confidence level. In the Appendix A.2.5, responses for each shock and 90 percent confidence bands are displayed separately (see Figures A.12, A.13 and A.14).

All shocks increase headline and core PCE inflation persistently and they also raise real oil prices. Importantly, they all lead to persistent and significant increases in ten-year expected inflation. Similar results hold for ten-year yields and one-year yields increase significantly for all shocks in the short-run. What clearly distinguishes the policy-induced

Figure 10 IRFs to a Trend Inflation Shock driven by Oil Supply and Monetary Policy



Note: IRFs to a trend inflation shock on aggregate macro variables over the sample 1984Q1-2019Q2 computed using a LP-IV approach. IRFs are smoothed using 3-quarter backward-looking moving average. Horizon is in quarters. Blue dash lines present responses when the trend innovation is instrumented with the permanent monetary shock series of Uribe (2022), red continuous lines the case in which the innovation is instrumented with the oil news supply shock of Kanzig (2021), and green dotted lines the case in which the innovation is instrumented with that tax shock of Romer and Romer (2010). Blue diamonds, red circles, and green crosses denote statistical significance at 90%. Newey-West standard errors.

trend inflation shocks from those related to oil news shocks is the output response. The component of trend inflation shocks due to either monetary policy or tax changes induces a rise in demand (reflected also in the IRFs of consumption and investment) that drifts inflation. Real house prices also increase in response to policy-driven trend shocks (more persistently for tax cuts), while only tax-driven trend shocks affect real stock prices S&P500. These findings confirm the results of Mumtaz and Theodoridis (2020) who show that, after 1980, tax cuts lead to reductions in real stock prices. By contrast, contrary to Kanzig (2021)' results that oil supply expansions lead to substantial increases in equity prices, our identified news shocks to oil prices that induce persistent changes in inflation do not affect real stock prices and, in agreement with Kanzig (2021), they do not affect real house prices either. To complete the picture, only the trend shocks induced by permanent monetary policy changes and oil shocks seem to affect firms´profits significantly in the medium run.

Compared to the IRFs to the trend inflation innovation, the responses and R2 of the identified shock components presented in Figure 10, suggest that most of the variation in the trend innovation is driven by supply factors: the responses for the oil shock resemble more closely the responses for the innovation presented in Figure 3. Before closing this section, it is important to remark that the shocks analyzed in this section differ from the original shocks series identified by Uribe (2022), Romer and Romer (2010) and Kanzig (2021). To this end, in the Appendix, we compare the PCE inflation IRFs to the original shock series identified by these authors with the responses obtained with the LP-IV approach for the trend shocks in Figure A.19. By definition, only the responses of the shock identified by Uribe (2022) exhibit a permanent effect on PCE inflation, unlike those to the raw shocks series of Romer and Romer (2010) and Kanzig (2021), implying that our approach is able to pick only those shocks from the series that affect trend inflation significantly.[11]

5.2 Heterogeneous Effects

Moving to the analysis of the heterogeneous effects of these different trend inflation shocks, we follow the approach used in Section 4 to investigate the individual-level data responses to the three identified shocks. The first row in Figure 11 presents the consumption responses

[11] Figure A.19 displays this comparison.

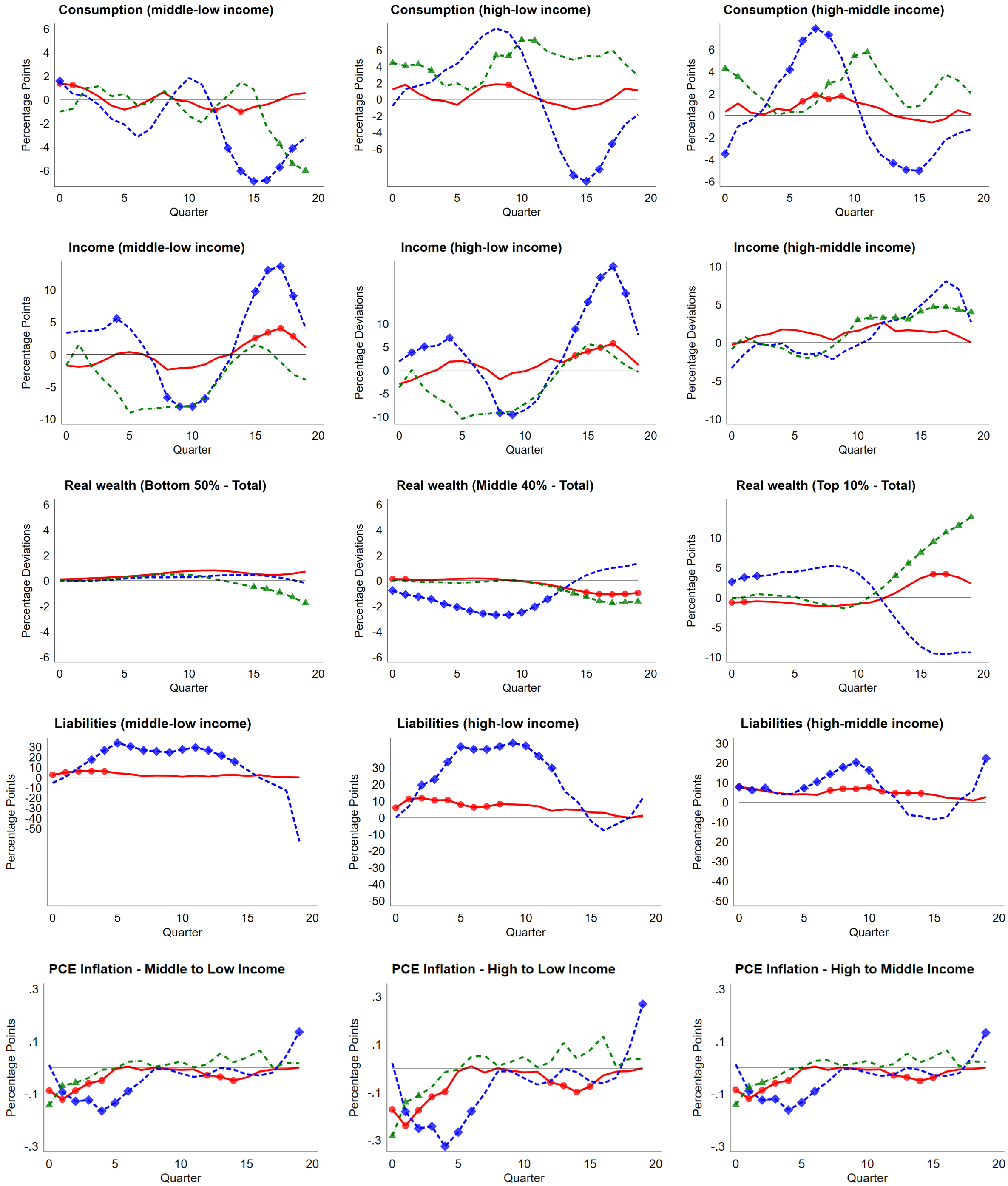
for the three aforementioned income groups to the three shocks. As in Figure 10, we depict responses to the different shocks using marks to represent statistical significance at the 90 percent confidence level. As can be seen, trend inflation shocks induced by tax changes or oil prices are regressive by benefiting the relative consumption of the rich households. By contrast, trend inflation shocks induced by permanent monetary policy changes seem to benefit low and middle income households in the long run. Hence, in principle, one could characterize them as progressive (confirming the results of Del Canto et al. (2023)). Yet, presenting total consumption responses is misleading. In the Appendix (see Figures A.24 and A.25) we show that, while this conclusion is correct for non-durable consumption, it does not hold in the case of durable consumption of low-income households, which decrease substantially, while that of high-income households is increased both in absolute terms and relative to the other two groups in the short and medium run.

Next, the second row of Figure 11 presents the responses of relative net income for the three income groups to the three identified shocks. High income households experience a rise in their relative income in response to tax-induced trend shocks in the medium and long run and to oil-induced trend shocks in the long run. Monetary policy induced trend shocks favor the income of high and middle-income families in the long run and affect positively the relative income of low-income households in the medium run. Hence, relative to the first row of Figure 11, changes in net income do not seem to be behind the heterogeneous consumption responses. It seems that the medium run changes in the relative income of low-income households could drive some of the non-durable consumption responses presented in Figure A.24. By contrast, the pattern of relative real wealth responses cannot explain the differential consumption responses (See the third row of Figure 11). [12]

The forth row of Figure 11, presents responses of liabilities only to permanent monetary policy and oil news trend shocks. The tax-induced trend inflation shock is excluded from

[12]Note again that, for wealth, the comparison is with respect to total wealth and not by income distribution.

Figure 11 Heterogeneous Responses to Trend Inflation Shock driven by Oil Supply and Monetary Policy



Note: Effects of supply-driven (red), monetary (blue) and demand-driven (green) trend inflation shock over sample 1984Q1-2019Q2 (1994Q1-2019Q2 for liabilities). IRFs smoothed using 3-quarter backward looking moving average. Blue diamonds, red circles, and green crosses denote statistical significance at 90%. Newey-West standard errors.

this exercise due to the short sample for the tax shocks (ending in 2006) and the limited sample availability for the liabilities series. In the Appendix we show that, while poor households reduce their liabilities, rich households increase them significantly (for some quarters) for oil driven trend shocks (see Figure A.16). Hence, the differential response of liabilities to the oil shocks could explain their regressive effects. The significant in the ratio of liability responses should explain the regressive nature of permanent monetary policy shocks regarding durable consumption but could definitely not explain the pattern of relative total or non-durable consumption responses. Del Canto et al. (2023) find monetary expansions to be progressive because interest rate cuts raise the price of equities, housing and bonds in the short run. We also find such an effect on real house prices (on impact), but we find no significant response of assets prices in Figure 10. Moreover, real profits increase significantly and persistently in response to a monetary-induced trend inflation shock, benefiting firm owners rather than low-income households. Therefore, the progressivity of permanent monetary policy shocks for non-durable consumption can only be explained by the relative income responses shown in Figure 11.

Finally, the last row of Figure 11 presents relative inflation responses for the different income groups. All trend shocks are regressive and the expenditure channel is operative for all shocks in the short and medium-run.

6 Conclusions

Inflation effects are not the same for everyone. Our paper reveals that households' experiences with trend inflation depend on how much they earn, how they spend, how wealthy they are, and what type of assets they hold. On the one hand, trend inflation innovations are regressive since they reduce the real labor income of poor households and increase the real value of their consumption expenditure relative to rich households. On the other hand, they could be progressive since they decrease the value of real assets and houses.

We show that the revaluation channel does not seem to be operative for trend inflation. Overall, we argue that trend inflation innovations are regressive by uncovering a new channel through which they benefit rich households in a disproportionate way, namely, through their capacity to increase liabilities when expected inflation raises. Foremost, we show that the *liability channel* is only operative for trend inflation changes and not for standard unexpected changes in inflation.

We use a LP-IV approach to distinguish between different components of trend inflation shocks. We show that the propagation of trend inflation shocks induced by demand factors, such as monetary policy or tax changes, has different characteristics compared to trend shocks induced by supply factors, such as oil news shocks. Trend inflation shocks induced by tax changes or oil prices are regressive and they operate mainly through the asset holdings, expenditure and liability channels. By contrast, permanent monetary policy shocks induce shifts in inflation that harm the relative consumption of durables by low-income households in the short and medium run, whilst they favor their relative consumption of non-durables in the long term.

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A Appendix

The Online Appendix presents the data description and additional empirical analysis such as robustness checks that we have left out of the main draft of the paper for economy of space.

A.1 Data Appendix

A.1.1 Macroeconomic Variables

These are the variables included in the specification of the baseline VAR:

- Underlying inflation: the trend of headline PCE inflation. The trend is extracted using a Beveridge-Nelson decomposition following Mertens (2016). We update the original series from Mertens until June 2019 using the original codes available from the author. The monthly trend series is aggregated to quarterly frequency by taking quarterly averages.

- Real per capita GDP growth: Annualized quarterly growth rate of Seasonally Adjusted US real gross domestic product per capita. Source: FRED. Series: A939RX0Q048SBEA.

- PCE Inflation: Annualized quarterly growth rate of Seasonally Adjusted Personal Consumption Expenditures: Chain-Type Price Index. Source: FRED. Series: PCEPI.

- 1-Year Rate: 1-Year Treasury Constant Maturity Rate. Source: FRED. Code: DGS1.

- 10-Year Rate: 10-Year Treasury Constant Maturity Rate. Source: FRED. Code: DGS10.

We also employ the following variables in the additional exercises:

- Private Consumption: Private Final Consumption Expenditure in the United States divided by total population, annualized percentage change relative to previous quarter, seasonally adjusted. SOurce: FRED. Code: USAPFCEQDSMEI

- Investment: Real gross private domestic investment divided by total population, annualized percentage change relative to previous quarter, seasonally adjusted. Source: FRED. Code: GPDIC1.
- Fiscal Deficit: US fiscal deficit as computed by Hagedorn et al. (2018).
- Current Account/GDP: Balance on Current Account as a % of GDP, NIPA's, Quarterly, Seasonally Adjusted Annual Rate. Source: FRED. Code: NETFI divided by GDP.
- US-UK exchange rate: U.S. / U.K. Foreign Exchange Rate in the United Kingdom, U.S. Dollars to One British Pound, Quarterly. Source: FRED. Code: USUKFXUKM.
- House Prices: Median sales price of houses sold in the United States deflated by PCE, annualized % change with respect to previous quarter. Source: FRED. Code: MSPUS.

A.1.2 Consumer Expenditure Survey

We use the Consumer Expenditure Survey (interview section) from 1984-2019.[13] The files from 1984-1995 are obtained from the Inter-university Consortium for Political and Social Research (ICPSR) at the University of Michigan, and the files starting from 1996 from the website of the Bureau of Labor Statistics (BLS).

The CEX is a monthly rotating panel, where households are selected to be representative of the US population. Each household is interviewed once per quarter, for at most five consecutive quarters, although the first interview is used for pre-sampling purposes and is not available for analysis. While expenditure is reported at the household level, demographics are reported for individuals. These include age, income, labor supply, family size, and year of birth of the head of household.

[13] It is possible to find CEX data back to 1980 Q1 but there are several changes in methodology in the first years and issues regarding data quality

In each interview, the reference period for expenditures covers the three months prior to the interview month. Income and most labor supply questions are only asked during the second and fifth interview and the reference period covers the twelve months prior to the interview month.

Our data preparation procedure broadly follows Coibion et al. (2017). All expenditure data is aggregated up from the disaggregated MTAB files and income and demographic data is derived from the MEMB and FMLY files. Starting from the raw data files the following steps are carried out:

1. All expenditure data is aggregated up from the disaggregated MTAB files. We aggregate the monthly UCC expenditures by household and generate expenditure aggregates for the different categories such as food following the BLS documentation.

2. We correct for breaks in the expenditure variables. In particular, between 1982 and 1987 food at home is adjusted following Aguiar and Bils (2015).

3. We deflate all series using the Consumer Price Index (CPI).

4. Then, we convert the expenditure data into a quarterly time series using the reference date of the interview. We merge the expenditure data with the income and demographic data from the MEMB and FMLY files by household and interview date.

5. We define consumption and income variables following Coibion et al. (2017):

    - Non-durable goods and services: food, alcohol, tobacco, clothing and footwear, household utilities, fuel, personal care, public transport, household services and nondurable household goods, leisure services and goods (e.g. entertainment services, reading)
    - Durable goods: durable leisure goods (e.g. entertainment equipment) and durable household goods (e.g. furniture and electrical appliances).[14]

[14]This definition of durable consumption does not include large purchases such as car or house purchases.

- Labor-related earnings and total disposable income: Labor-related earnings only include wages and salaries, income from farm and non-farm business, self-employment. Social security benefits and pensions are not part of earnings but are together with income from investments included in non-labor income. Then, total disposable income consists of labor and non-labor income and net (disposable) income is calculated as gross income - (taxes - rebates/refunds). Following Coibion et al. (2017) tax is computed using the NBER TAXSIM calculator.

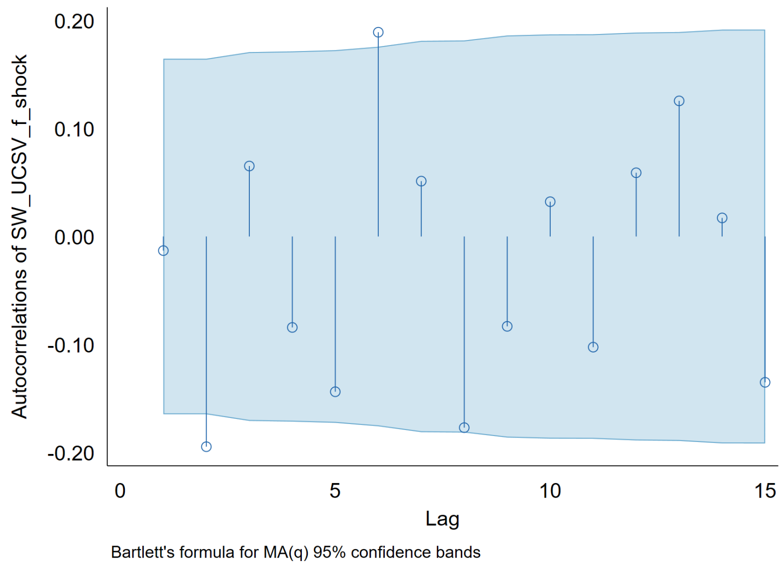
- mortgage and rental payments: mortgage payments are defined as interest and capital repayments for mortgages on the main house (the house currently lived in) and rental payments are equal to the rent paid and do not include any services.

6. Household variables are transformed into real-per capita values using family size

7. We use the household weights provided within the survey and normalize these so that they sum up to 1 within each housing tenure group and quarter. Then, we apply these normalized weights to the household level variables to construct cohort-level series.

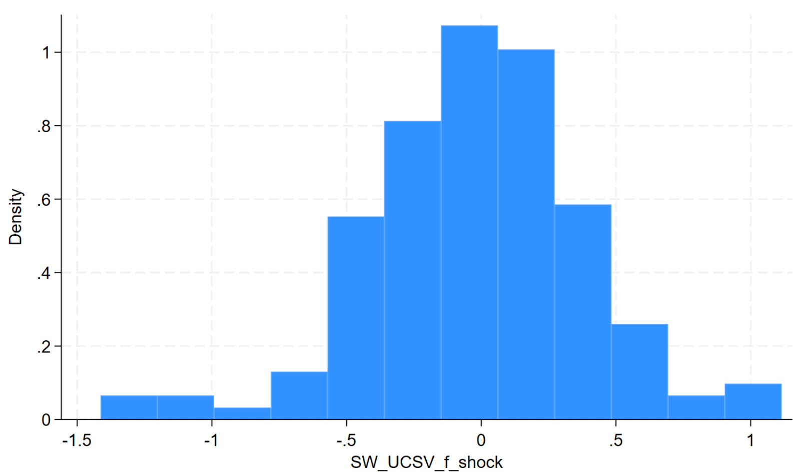
8. In order to deal with under-reporting trends over time and following Cloyne et al. (2020), the cohort-level series for non-durable and durable expenditures are adjusted each quarter using the ratio of aggregate national accounts to aggregated household data (NIPA/CEX). The same ratio is used to adjust the three cohort series (mortgagors, owners and renters).

Figure A.1 Trend Inflation Innovation Series - Autocorrelogram



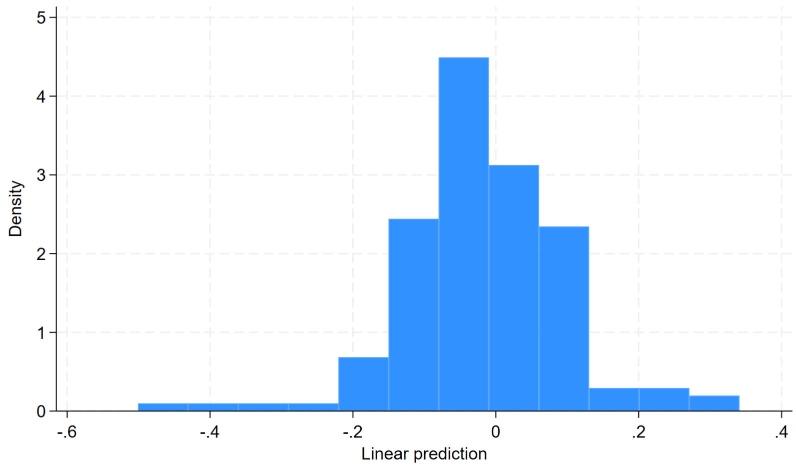
Note: Autocorrelogram of the Trend Inflation Innovation series.

Figure A.2 Trend Inflation Innovation Series - Histogram



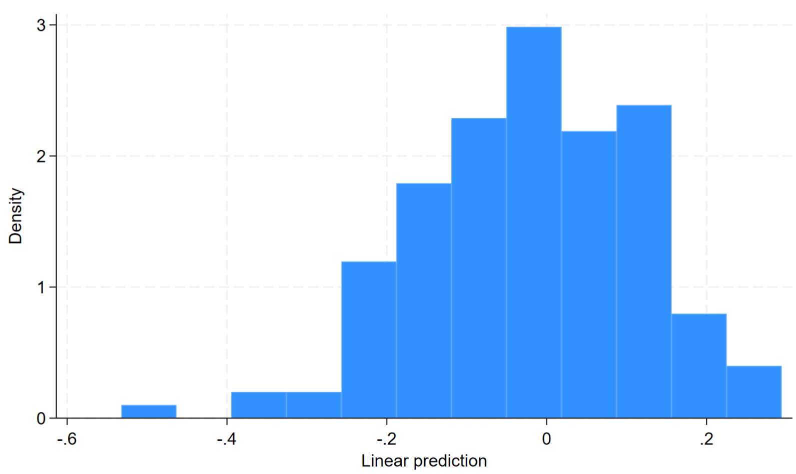
Note: Histogram of the Identified Trend Inflation Innovation series.

Figure A.3 Trend Inflation Shock Series due to Oil Shocks - Histogram



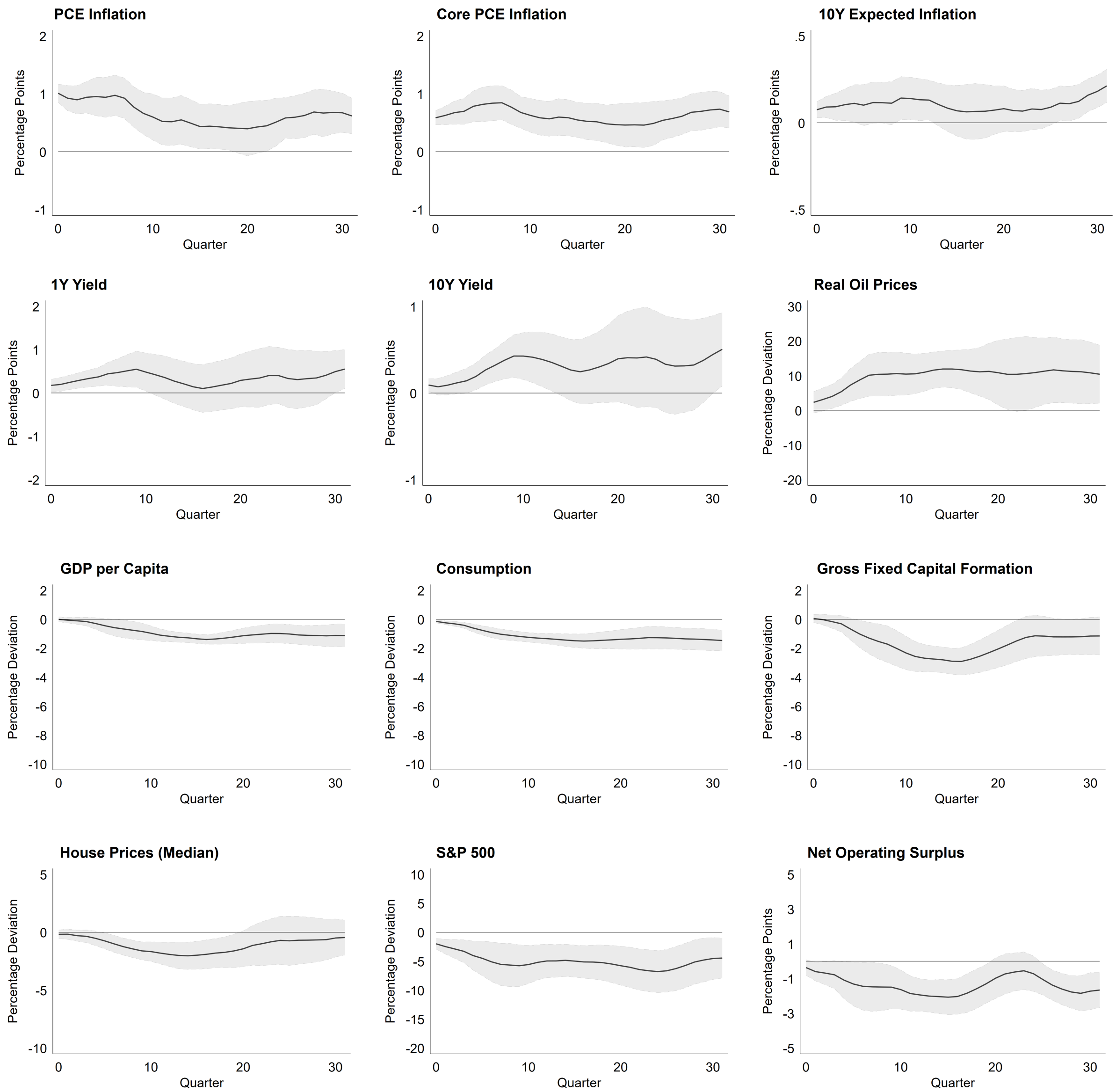
Note: Histogram of the Identified Trend Inflation Shock series explained by the oil shocks. This shock is identified as the Trend Inflation shock that is explained by the oil supply news shock computed by Kanzig (2021).

Figure A.4 Trend Inflation Shock Series due to Monetary Policy - Histogram



Note: Histogram of the Identified Trend Inflation Shock series. This shock is identified as the Trend Inflation shock that is explained by the permanent monetary shock computed by Uribe (2022).

Figure A.5 IRFs to a Trend Inflation Innovation - Long Sample



Note: IRFs to a trend inflation innovation on aggregate macro variables over sample 1960Q1-2019Q2 computed using local projections defined in equation 1. IRFs smoothed using 3-quarter backward-looking moving average. Continuous solid lines denote the median IRFs. Shaded areas denote 90% confidence bands based on Newey-West standard errors. Horizon is in quarters.

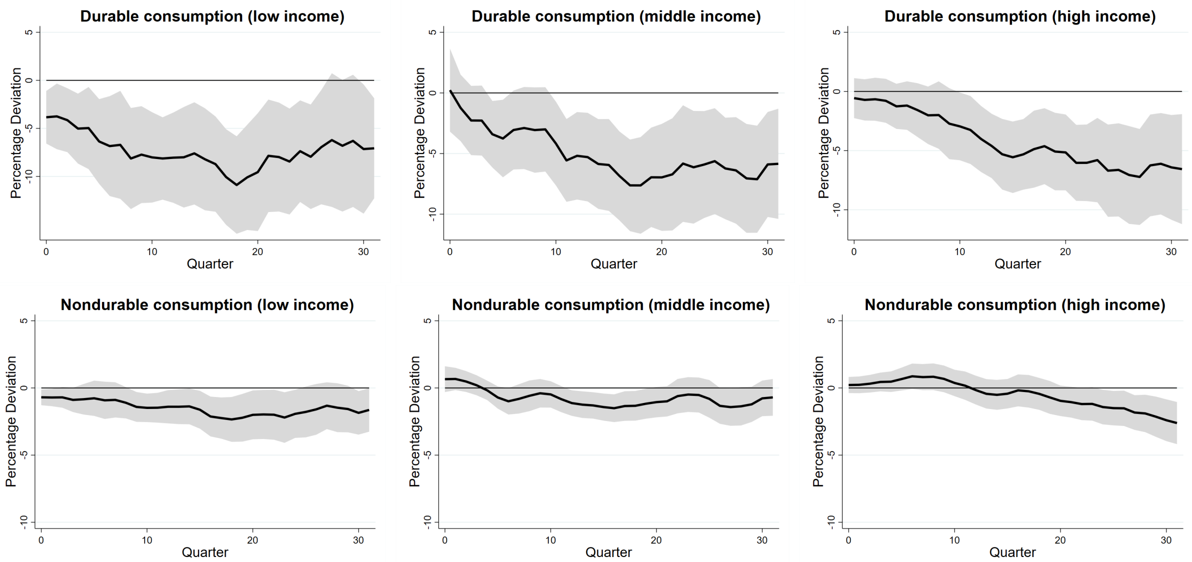
A.2 Additional Empirical Results

A.2.1 Identified Trend Inflation Innovations

A.2.2 Macro Effects

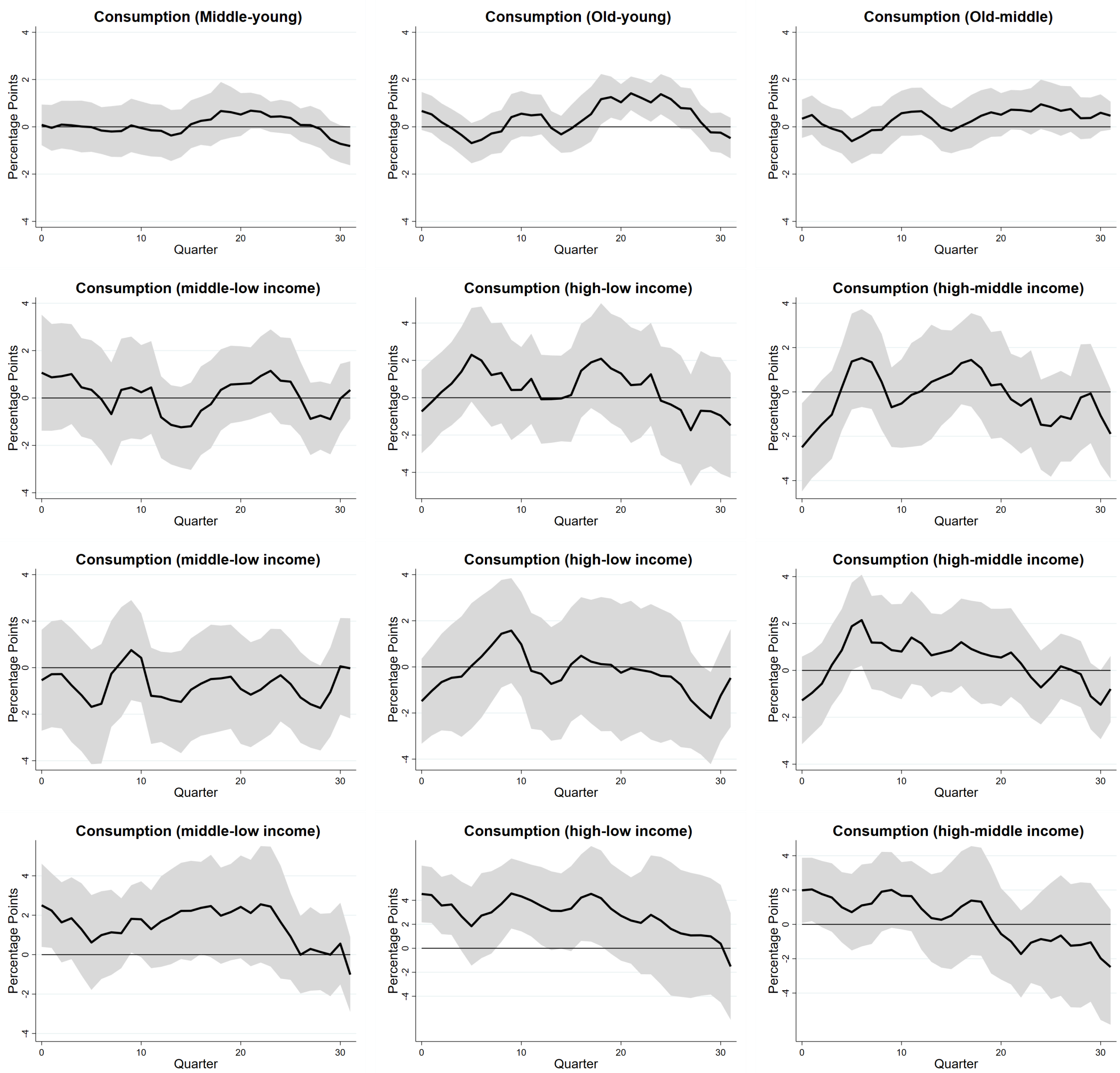
A.2.3 Consumption Responses

Figure A.6 Consumption response by income group (durables vs nondurables)



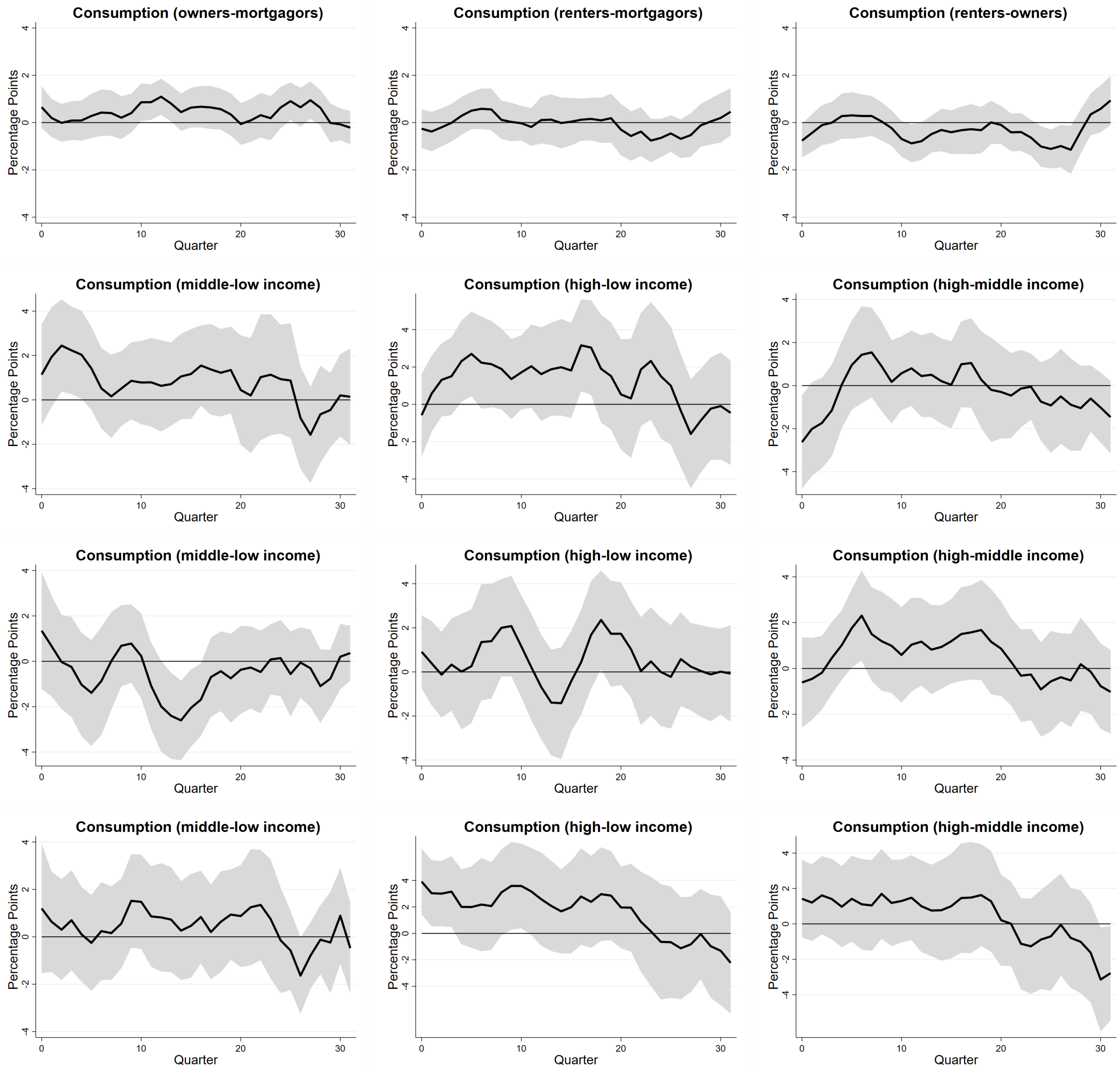
Note: Effects of trend inflation innovation on durable (top) and nondurable and services (bottom) consumption by net income group over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

Figure A.7 Heterogeneity by age and subgroups: young (2nd row), middle-aged (3rd row) and old (bottom row)



Note: Effects of trend inflation innovation on consumption by net income group over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

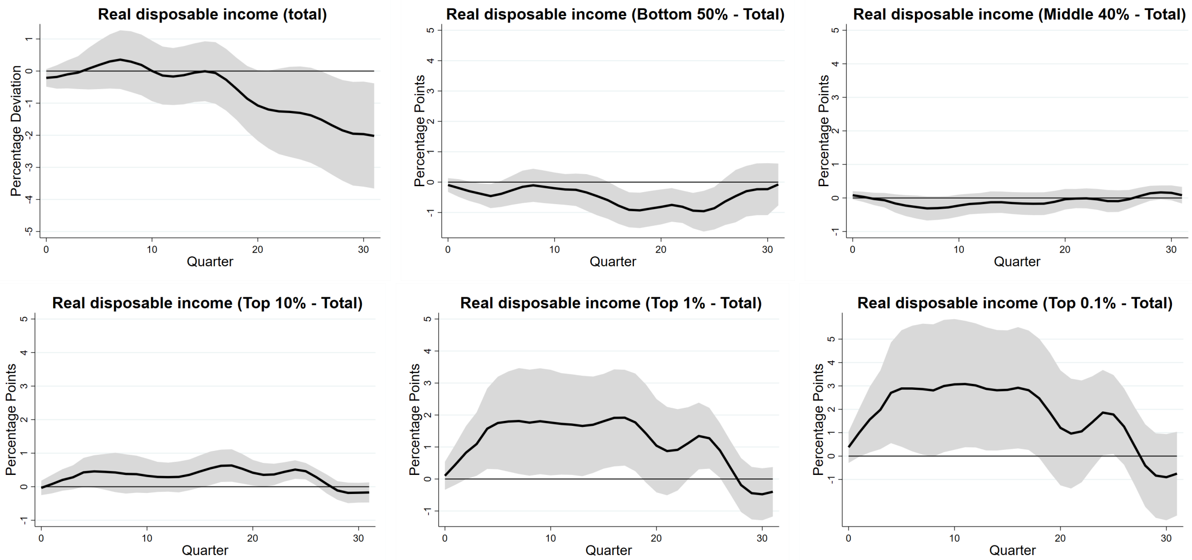
Figure A.8 Heterogeneity by housing tenure and subgroups: renter (2nd row), mortgagor (3rd row) and owner (bottom row)



Note: Effects of trend inflation innovation on consumption by net income group over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

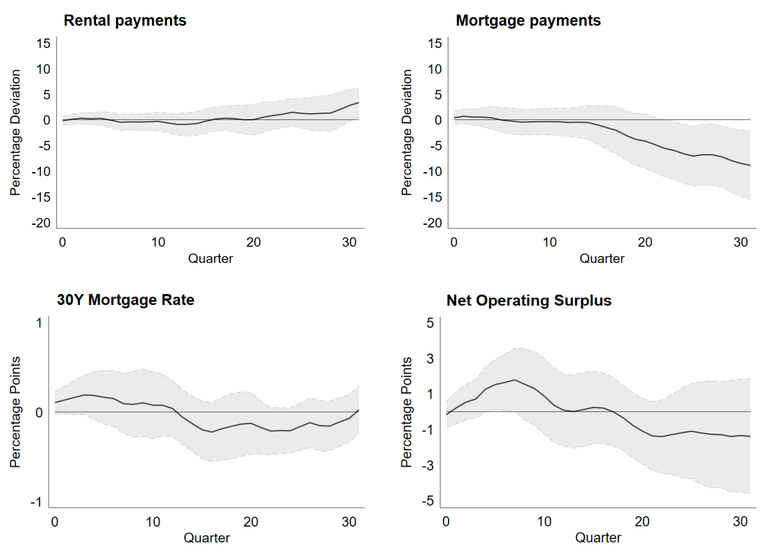
A.2.4 Other variables

Figure A.9 Income response by income group (Realtime Inequality data by Blanchet et al. (2022))



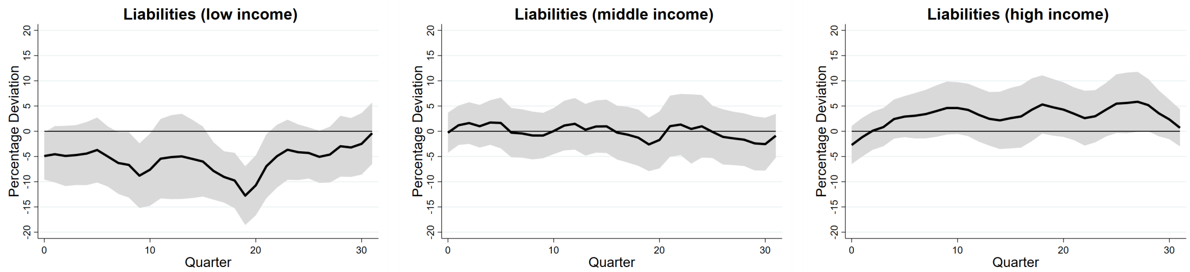
Note: Effects of trend inflation innovation on income by income group based on Blanchet et al. (2022) data over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

Figure A.10 Mortgages, Rental Payments and Interest Rates response to a Trend Inflation Innovation



Note: Effects of trend inflation innovation on housing payments over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

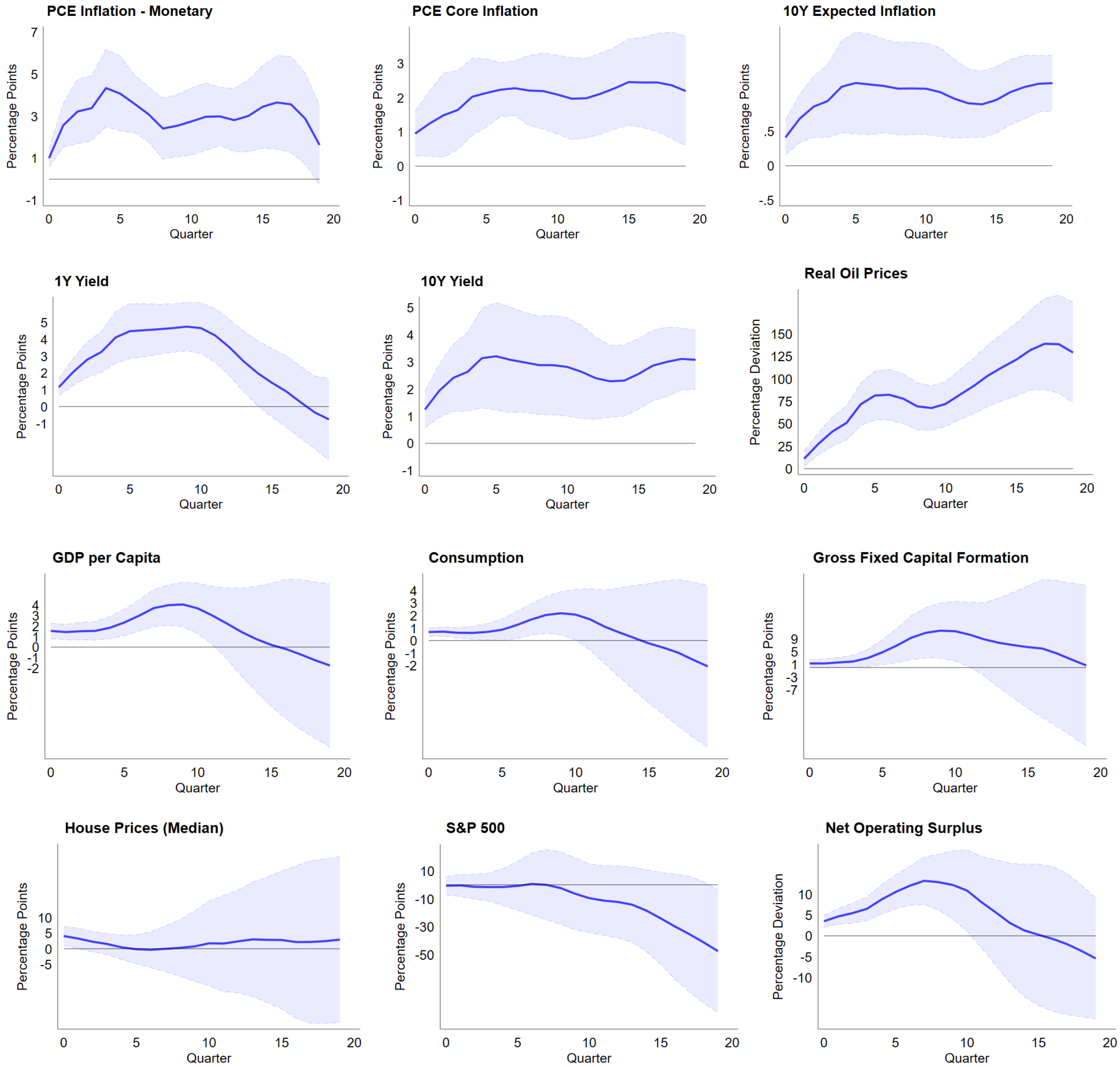
Figure A.11 Liabilities response by income group



Note: Effects of trend inflation innovation on liabilities by net income groups over sample 1994Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

A.2.5 Effects of Different Trend Inflation Shocks

Figure A.12 IRFs to a Trend Inflation Shock driven by Permanent Monetary Policy Shocks



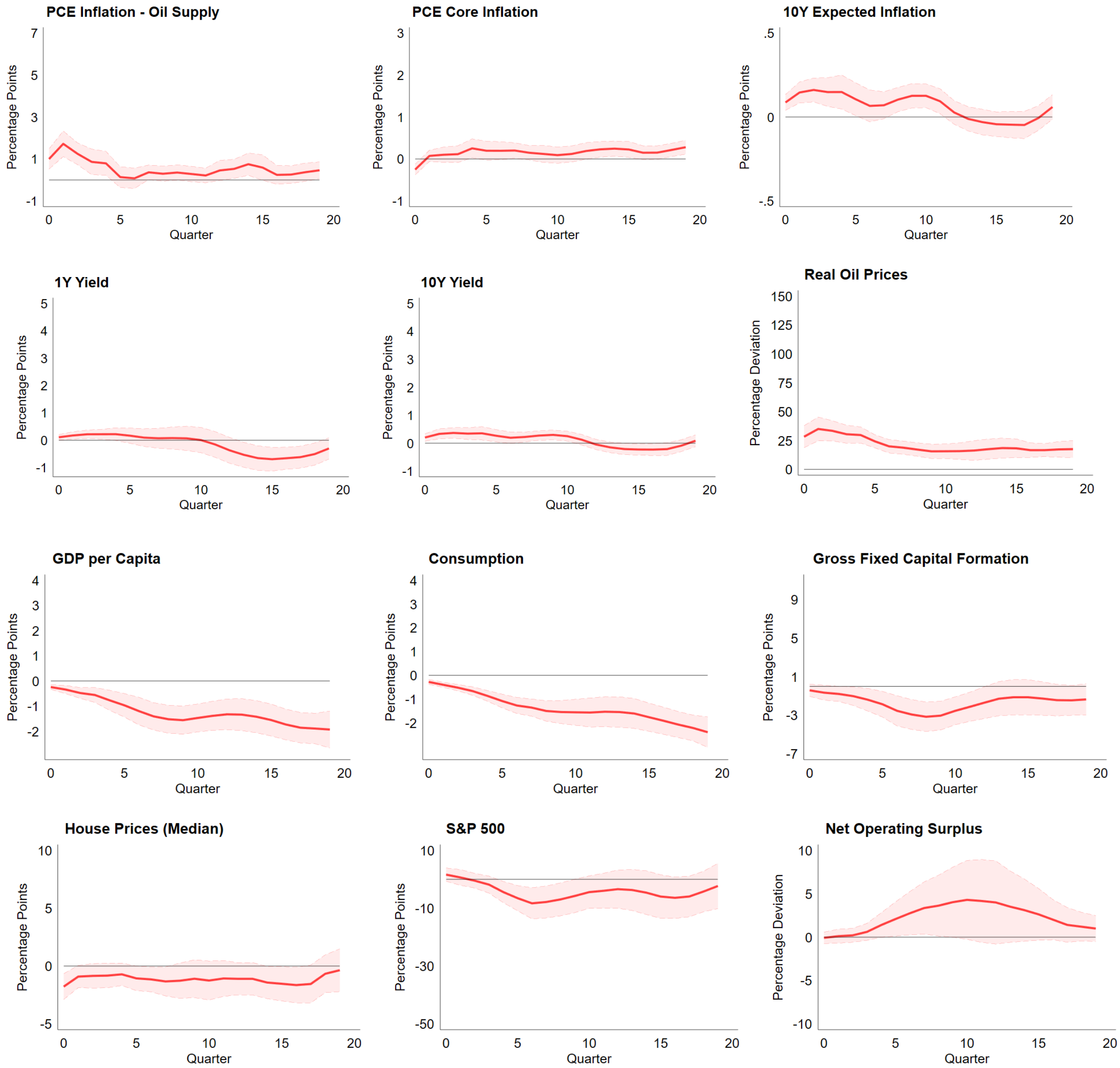
Note. IRFs to a trend inflation shock driven by permanent monetary shocks on aggregate macro variables over sample 1984Q1-2019Q2 computed using a LP-IV approach. IRFs are smoothed using 3-quarter backward-looking moving average. Horizon is in quarters. Shaded areas denote statistical significance at 90%. Newey-West standard errors.

Trend Inflation Shocks Driven by Permanent Monetary Policy Shocks

Trend Inflation Shocks Driven by Oil Supply News Shocks

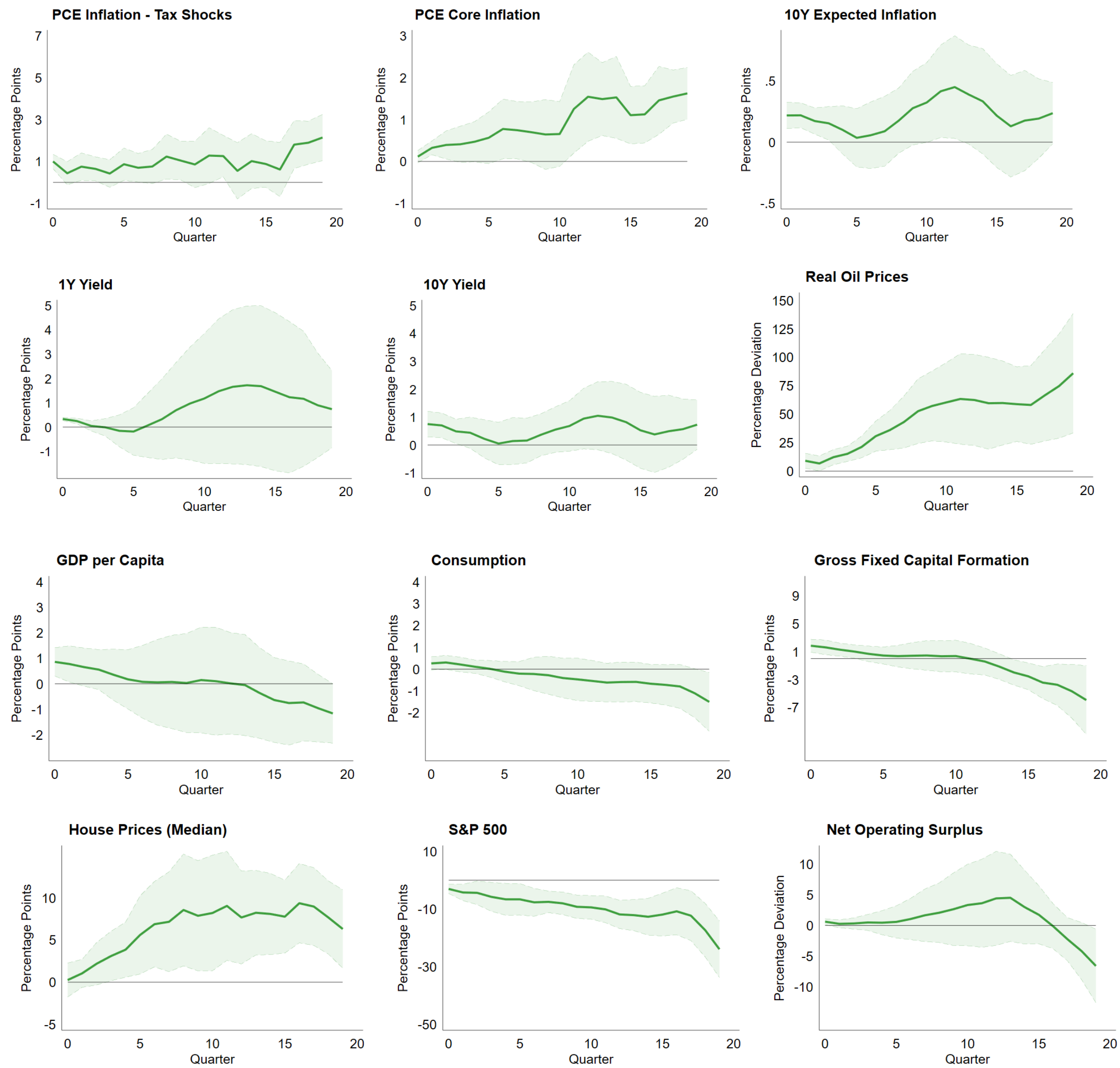
Trend Inflation Shocks Driven by Tax Shocks

Figure A.13 IRFs to a Trend Inflation Shock driven by Oil Supply News Shocks



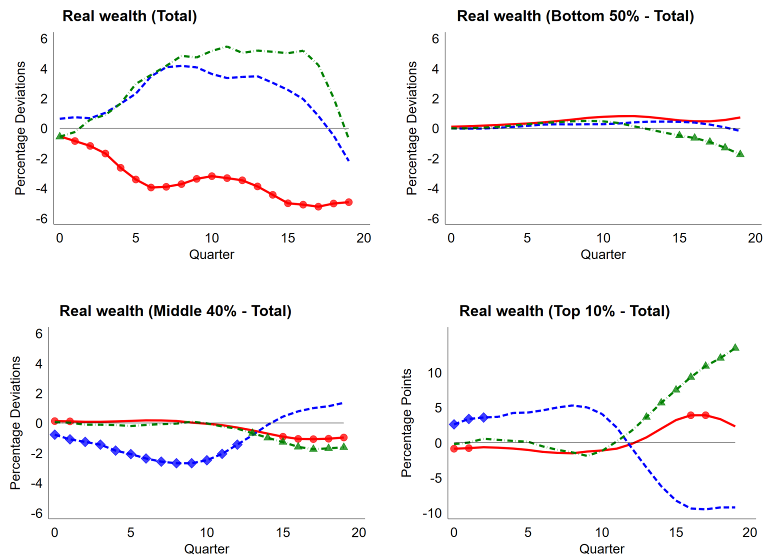
Note. IRFs to a trend inflation shock driven by oil supply news shocks on aggregate macro variables over sample 1984Q1-2019Q2 computed using a LP-IV approach. IRFs are smoothed using 3-quarter backward-looking moving average. Horizon is in quarters. Shaded areas denote statistical significance at 90%. Newey-West standard errors.

Figure A.14 IRFs to a Trend Inflation Shock driven by Tax Shocks



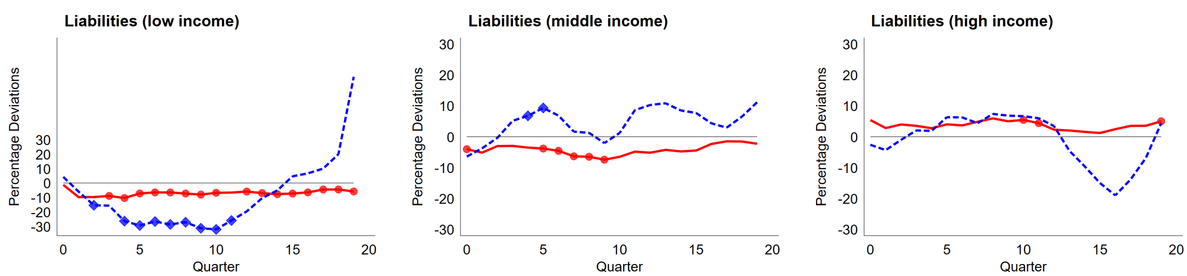
Note. IRFs to a trend inflation shock driven by oil supply news shocks on aggregate macro variables over sample 1984Q1-2019Q2 computed using a LP-IV approach. IRFs are smoothed using 3-quarter backward-looking moving average. Horizon is in quarters. Shaded areas denote statistical significance at 90%. Newey-West standard errors.

Figure A.15 Real wealth response to different shocks



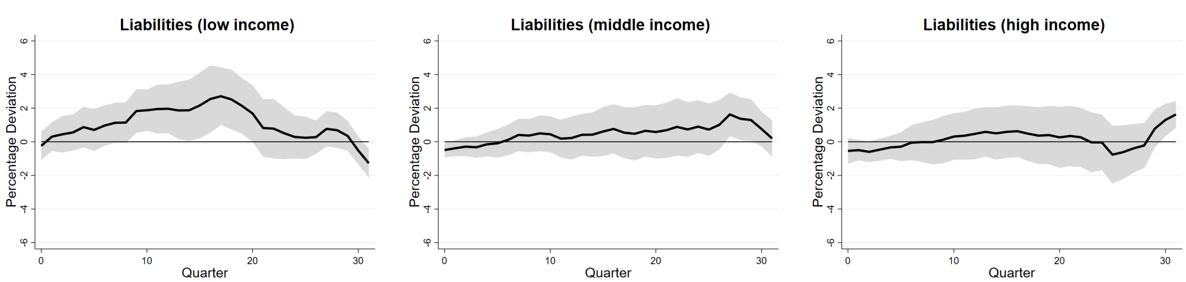
Note: Effects of supply-driven (red), monetary (blue) and demand-driven (green) trend inflation shock on consumption by income group over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

Figure A.16 Liabilities response to different shocks



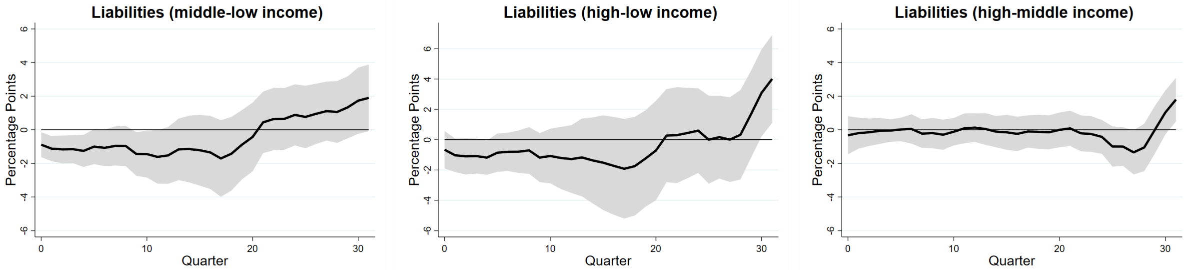
Note: Effects of supply-driven (red), monetary (blue) and demand-driven (green) trend inflation shock on liabilities by net income groups over sample 1994Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

Figure A.17 Liabilities response by income group to cyclical shock



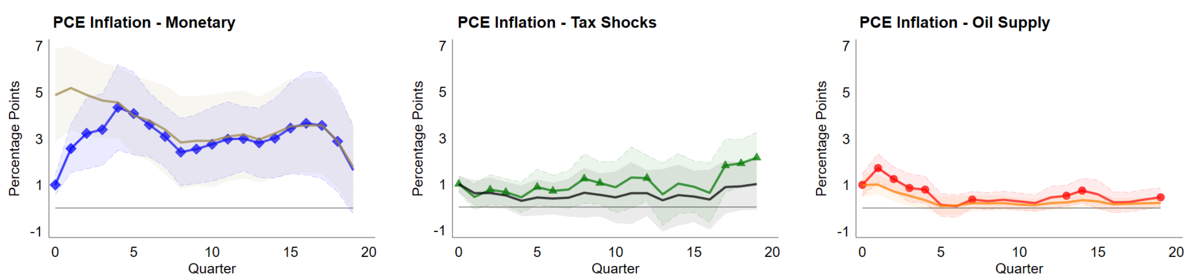
Note: Effects of cyclical inflation shock on liabilities by net income groups over sample 1994Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

Figure A.18 Differential liabilities response by income group to cyclical innovation



Note: Effects of cyclical inflation innovation on relative liabilities by net income groups over sample 1994Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

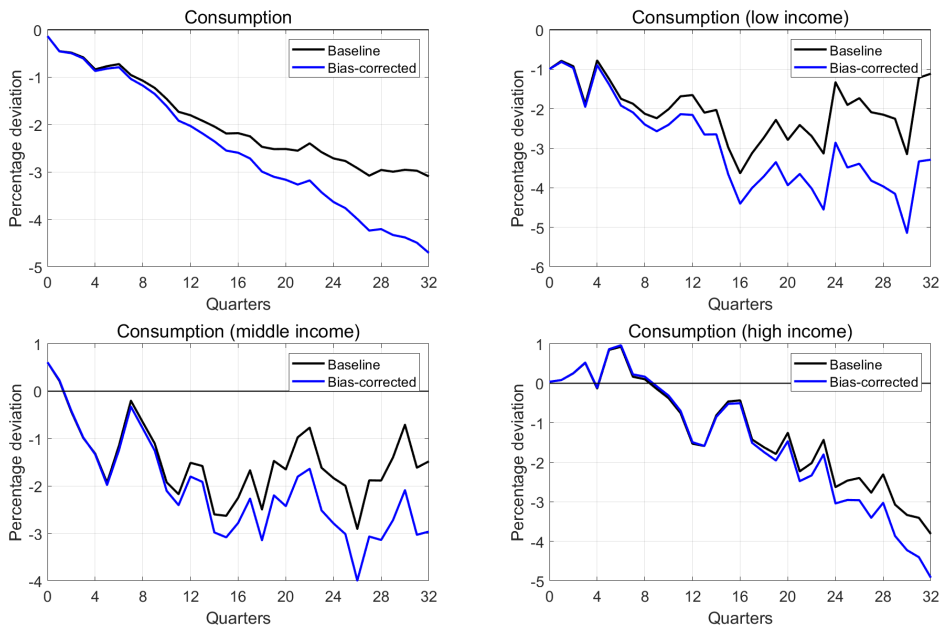
Figure A.19 Comparing PCE responses of original shock series vs. LP-IV responses of trend inflation shock



Note: Impulse responses to a trend inflation shock instrumented and with the original series of shocks (computed using local projections). Left panel: PCE responses to the Uribe (2022) shock (brown continuous lines) vs. LP-IV responses to the component of trend inflation shocks explained by permanent monetary shocks Uribe (2022) (blue lines with diamonds). Middle panel: PCE responses to the Romer and Romer (2010) shock (grey continuous lines) vs. LP-IV responses to trend inflation shocks explained by tax changes when using the Romer and Romer (2010) shock as an IV (green lines with triangles). Right panel: PCE responses to the Kanzig (2021) shock (orange continuous lines) vs. LP-IV responses to the component of trend inflation shocks explained by tax shocks when using the Kanzig (2021) shock as an IV (red lines with circles). IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Newey-West standard errors.

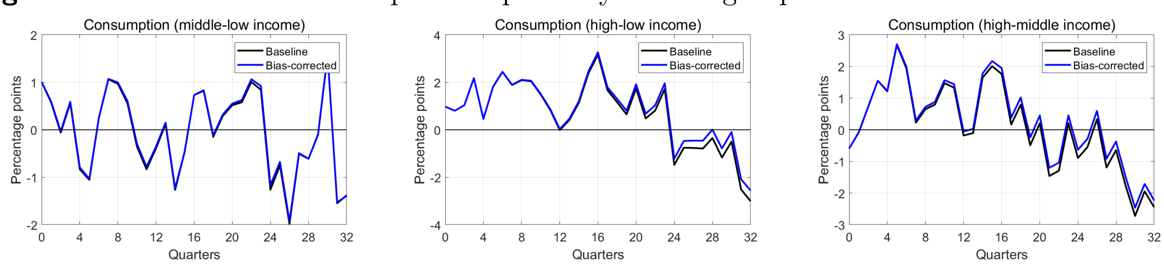
A.3 Robustness to bias-correction and Huber-White std errors

Figure A.20 Consumption response by income group



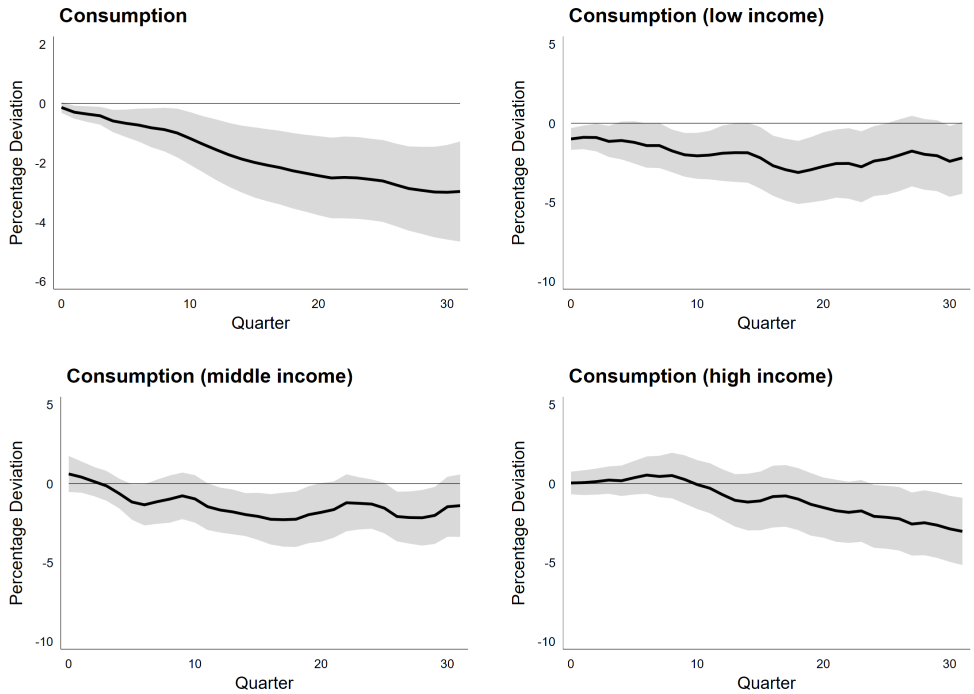
Note: Effects of trend inflation innovation on consumption by net income group over sample 1984Q1-2019Q2. Bias-correction based on Herbst and Johannsen (2020). IRFs are not smoothed.

Figure A.21 Differential consumption response by income group



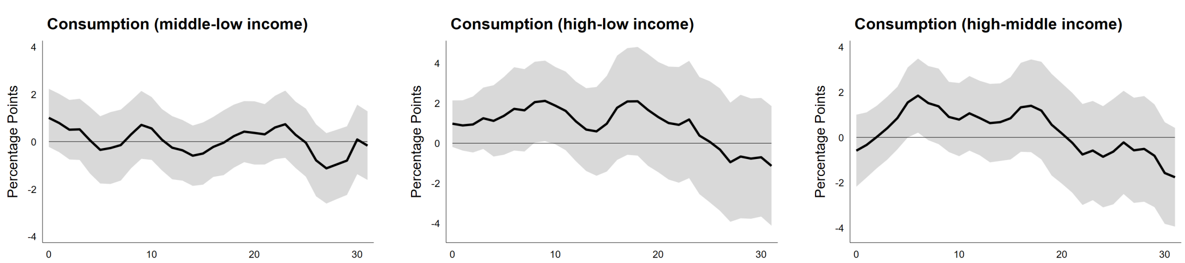
Note: Effects of trend inflation innovation on consumption ratios by net income group over sample 1984Q1-2019Q2. Bias-correction based on Herbst and Johannsen (2020). IRFs are not smoothed.

Figure A.22 Consumption response by income group



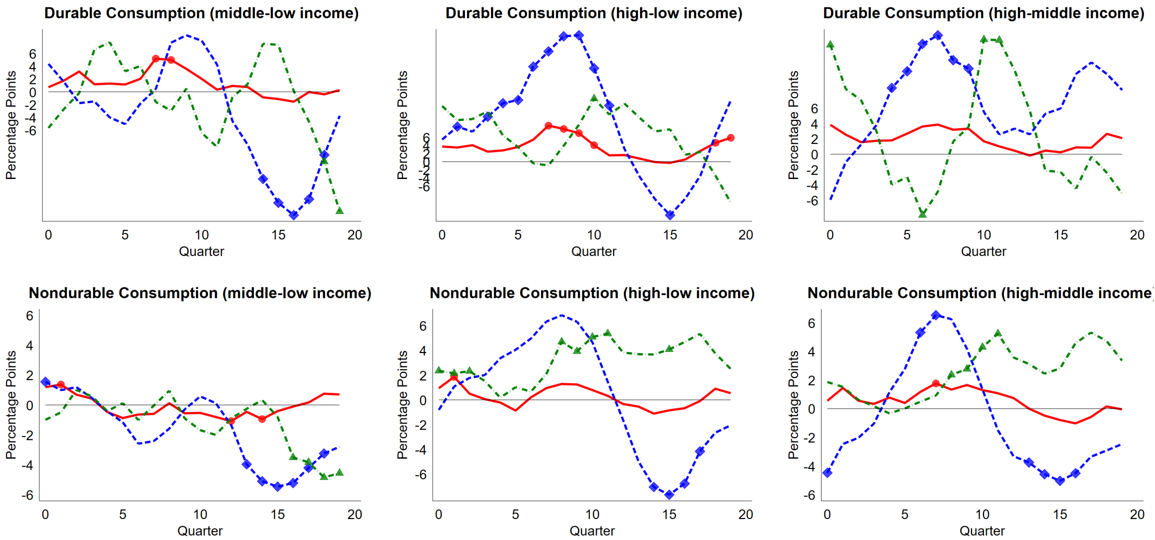
Note: Effects of trend inflation innovation on consumption by net income group over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Huber-White standard errors.

Figure A.23 Differential consumption response by income group



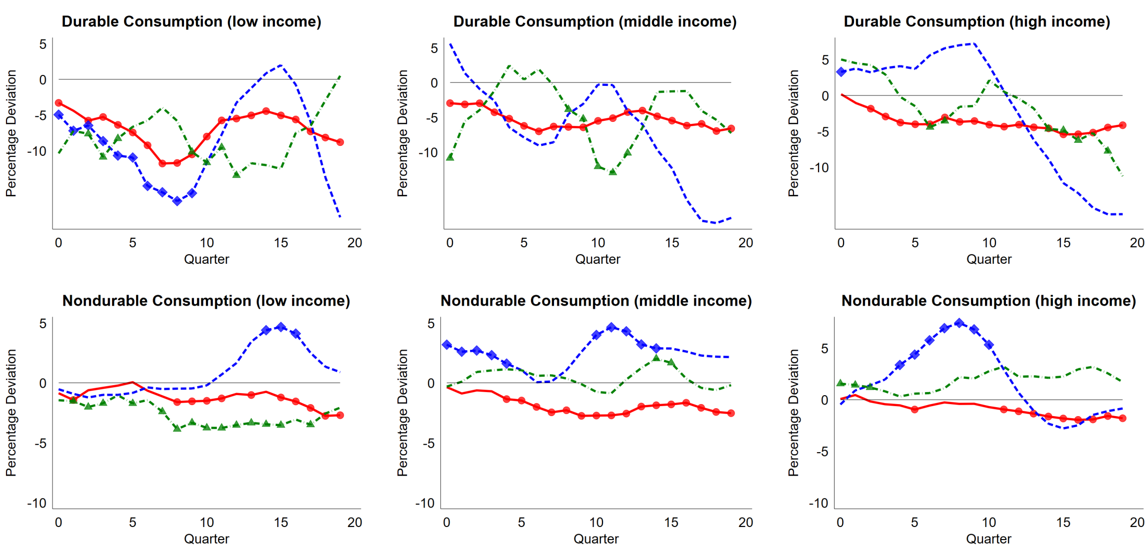
Note: Effects of trend inflation innovation on consumption ratio between net income groups over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Shaded areas denote 90% confidence bands based on Huber-White standard errors.

Figure A.24 Heterogeneous consumption ratio responses to different shocks



Note: Effects of supply-driven (red), monetary (blue) and demand-driven (green) trend inflation shock on durable and nondurable consumption ratios over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Blue diamonds, red circles, and green crosses denote statistical significance at 90%. Newey-West standard errors.

Figure A.25 Heterogeneous consumption responses to different shocks



Note: Effects of supply-driven (red), monetary (blue) and demand-driven (green) trend inflation shock on durable and nondurable consumption over sample 1984Q1-2019Q2. IRFs smoothed using 3-quarter backward looking moving average. Blue diamonds, red circles, and green crosses denote statistical significance at 90%. Newey-West standard errors.