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Inflationary household uncertainty shocks

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Abstract

I construct a novel measure of household uncertainty based on survey data for European countries. I show that household uncertainty shocks are not universally like negative demand shocks. Notably, household uncertainty shocks are largely inflationary in Europe. These results lend support to a *pricing bias* mechanism as an important transmission channel. A comparison of results across countries suggest that demographics and factors related to average markups along with monetary policy play a role in the transmission of household uncertainty to inflation. I develop an Overlapping Generations New Keynesian model with age-dependent Deep Habits to rationalize these results.

JEL Codes: D84, E20, E30, E71

Keywords: uncertainty, inflation, deep habits, demographics, household expectations

*Monetary Policy and Research Department, Bank of Finland, Snellmaninaukio, P.O. Box 160, 00101 Helsinki, Finland. Tel: +358 09 183 2465. Email: gene.ambrocio@bof.fi The views expressed in this paper are those of the author and do not necessarily represent the views of the Bank of Finland. This paper subsumes earlier work entitled "Measuring household uncertainty in EU countries." I thank Fabio Canova, Giovanni Caggiano, Joonseuk Oh, Markus Sihvonen, Taka Tsuruga, Fabio Verona, Donghoon Yoo, two anonymous referees to an earlier version of the paper, and seminar participants at the ISER-Osaka University, University of Jyvaskyla, and Bank of Finland for helpful comments and suggestions. All remaining errors are my own.

There is a growing literature studying macro-uncertainty and its effects on the economy.[1] Many measures of macro-uncertainty have been proposed in the literature. These are invariably closely tied to financial markets, professional forecasts, or economic policy. However, an important channel for the transmission of uncertainty shocks is through households' propensity to consume, save, and work.[2] Consequently, empirical analysis focusing on household measures is crucial to forming a comprehensive understanding of the macroeconomic implications of heightened uncertainty. The focus on households is also motivated by the observation that periods of significantly heightened macro-uncertainty occur around large crises in which households played an important role.[3] However, direct measures of household uncertainty useful for macroeconomic analysis are quite scarce.[4] This paper seeks to fill this gap.

In this paper, I construct a measure of household uncertainty for European countries and document its business cycle properties. I then use the proposed measure to study the macroeconomic effects of household uncertainty and compare against the effects of uncertainty arising from other sources such as financial markets and economic policy. Finally, I compare results across countries to gain insight on the factors influencing the transmission of household uncertainty to the macroeconomy and develop a simple model consistent with the observed results.

[1] See e.g. Bloom (2009, 2014); Jurado et al. (2015); Baker et al. (2016); Rossi et al. (2016), and Carriero et al. (2018).

[2] See Sandmo (1970); Barro and King (1984); Pijoan-Mas (2006); Born and Pfeifer (2014); Fernandez-Villaverde et al. (2015); Ravn and Sterk (2017); Basu and Bundick (2017), and Christelis et al. (2020).

[3] See for instance Romer (1990) on the *Great Depression* as well as Mody et al. (2012) and Ravn and Sterk (2017) as recent examples on the *Great Recession*. See also Jorda et al. (2013); Mian and Sufi (2011); Schularick and Taylor (2012); Jorda et al. (2015); Piazzesi and Schneider (2016); Jorda et al. (2016); Mian et al. (2017).

[4] Leduc and Liu (2016) use the *Michigan Consumer Survey* to study the macroeconomic effects of household uncertainty in the US. Measures of household uncertainty not directed towards or especially suitable for macroeconomic analysis include that in Ben-David et al. (2018) for the US, Christelis et al. (2020) for Dutch households, and Guiso et al. (1996) for Italian households.

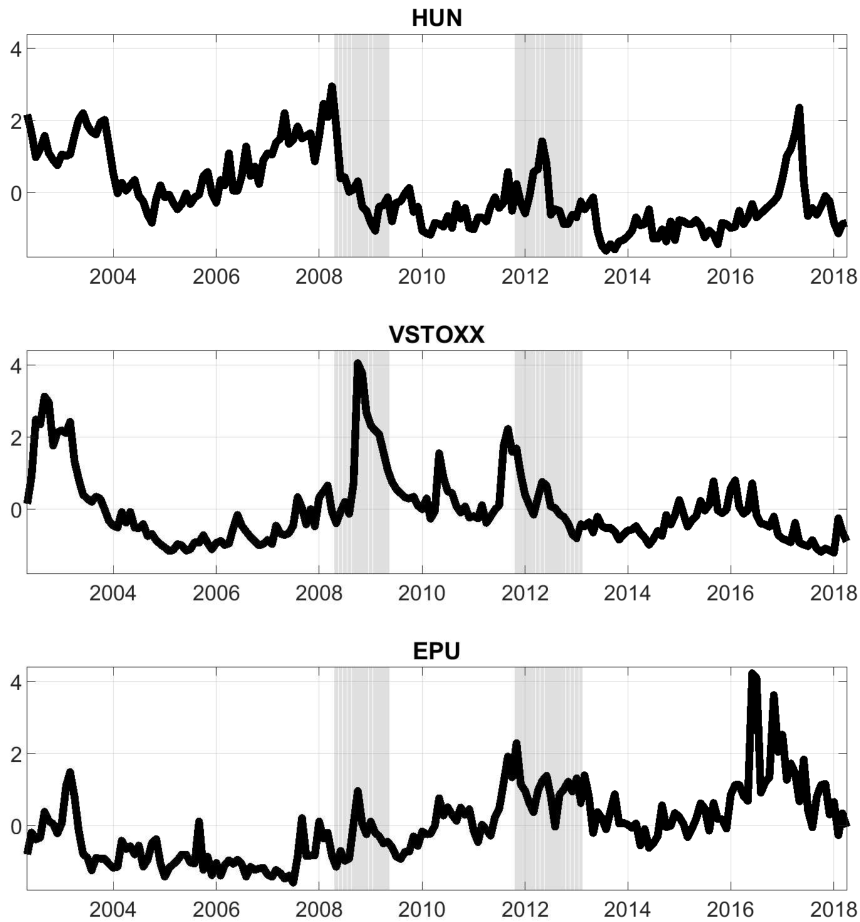
The uncertainty measure is based on the fraction of households who respond with *Don't know* when answering a few questions in the European harmonized consumer survey. Specifically, I use the same forward-looking questions used to construct the European Commission's Consumer Confidence Indicator prior to 2019. A key advantage of the measure is that it is available over a long period of time, at a relatively high frequency, and for a large set of countries. These features make it suitable for studying the macroeconomic consequences of household uncertainty. Further, the harmonized nature of the survey and the large country coverage facilitate cross-country comparisons to help uncover factors that influence the macroeconomic effects of household uncertainty .

Figure 1 illustrates how household uncertainty has evolved over time for the Euro area. For comparison, I also plot alternative Euro area measures of uncertainty namely the implied (from option prices) volatility of the Eurostoxx 50 index (VSTOXX) as a measure of uncertainty in financial markets and the Baker et al. (2016) index for Europe (EPU) as a measure of policy uncertainty .

The Euro area measure of household uncertainty is elevated precisely around events wherein European households would reasonably be more uncertain. Over the period 2002-2018, household uncertainty peaked four times, in June 2003, April 2008, May 2012, and May 2017. These follow closely with the 2003 Iraq invasion in the *War on Terror*, the onset of the Global Financial Crisis, the European Sovereign Debt Crisis, and Brexit respectively.[5] The measures of financial and policy uncertainty also peaked around these events.

[5] Household uncertainty peaked 6 months ahead of the VSTOXX and the EPU during the Global Financial Crisis, just a month prior to ECB President Draghi's *'Whatever it takes'* speech during the European sovereign debt crisis, and following the official invocation of Article 50 of the Treaty on the European Union by the United Kingdom at the end of March 2017.

Figure 1: Measures of uncertainty for Europe



HUN is the Euro area index of household uncertainty. VSTOXX is the option-implied volatility of the Eurostoxx 50 index. EPU is the Baker et al. (2016) measure of economic policy uncertainty for Europe. For ease of comparison, all three measures of uncertainty have been standardized in this figure. Shaded areas are Euro area peak-to-trough periods from the Euro Area Business Cycle Network.

When the measure of household uncertainty is compared with a broad set of indicators, I find that increases in household uncertainty appear to anticipate downturns. Periods of heightened uncertainty tend to be followed by a drop in consumer sentiment, a perceived worsening of household finances, low output, and high unemployment. Further, correlations with reported planned expenditures and views on the timing of large purchases suggest that the measure of household uncertainty may be capturing households' concerns about their ability to support desired consumption. While heightened uncertainty leads to more negative views on whether now is the right time to make large purchases, it is also positively correlated with increases in planned durable expenditures.

I then use a recursively-identified vector-autoregression to uncover the effects of exogenous shocks to household uncertainty and find that they are largely inflationary in Europe and increases unemployment with a significant lag. This is in stark contrast to the results documented by Leduc and Liu (2016) for household uncertainty in the US.[6] They find that positive shocks to household uncertainty raises unemployment and lowers inflation and thus resembles negative demand shocks. The results I document challenge the notion that positive shocks to household uncertainty may universally be interpreted as negative demand shocks.

I conduct several robustness exercises to support this finding. I show that the results are robust to alternative orderings of variables in the recursive identification strategy used in the vector auto-regressions. I also show that fluctuations in household uncertainty do not proxy for sentiment (or shocks to first moments of beliefs). Third, shocks to alternative measures of household uncertainty which focuses on specific questions in the survey or which incorporates the dispersion of household beliefs, also lead to higher inflation. Fourth, the results remain in a vector auto-regression which includes three sources (or measures) of uncertainty associated with financial markets, economic policy, and households. Finally, the results still hold when I exploit information across Euro area countries in both factor and panel-based analyses.

[6] Inflationary macro-uncertainty shocks (measured in the spirit of Jurado et al., 2015) were also obtained in the state-level analysis in Mumtaz et al. (2018) for the US and by Mumtaz and Theodoridis (2015) when studying the impact of US uncertainty shocks on the UK economy. On the other hand, Carriero et al. (2018) find no statistically significant effect of uncertainty shocks on prices using US data.

The inflationary effect of household uncertainty in Europe lends support to the importance of a *pricing bias* mechanism highlighted in Born and Pfeifer (2014) and Fernandez-Villaverde et al. (2015) in the transmission of uncertainty shocks.[7] In monopolistic-competitive markets with nominal rigidities, firms are more inclined to raise prices when faced with higher uncertainty.[8] This is because it is relatively more costly to end up with a lower, as opposed to higher, price than what would be ex-post desirable. When prices turn out to be lower than optimal, firms sell a greater quantity of goods at lower margins. On the other hand, when prices are ex-post higher than optimal, the reduced volume in sales is partially offset by larger margins. Consequently, firms tend to set higher prices when faced with increased uncertainty. In these models, the aggressiveness of a monetary policy rule in taming inflation, the degree of nominal rigidities, and the elasticity of substitution are key factors which can amplify or attenuate the mechanism.[9]

I also document substantial heterogeneity in responses across countries. When compared with a broad set of country characteristics, I find that demographic factors matter. The inflationary effect of household uncertainty is increasing in average markups, population growth, and life expectancy. It is also decreasing in education levels. These findings echo those of Ben-David et al. (2018) and Christelis et al. (2020) who provide micro-level evidence that factors such as age and education are associated with differences in perceived uncertainty across households.[10] These

[7]This is also referred to as a *precautionary pricing* effect in Born and Pfeifer (2019). See also Fernandez-Villaverde and Guerron-Quintana (2020).

[8]In a related strand of the literature, increased uncertainty may also lead to an increase in the likelihood and magnitude of price adjustments (Bachmann et al., 2019). This is because the volatility effect - firms expect to face larger shocks - may dominate the *wait-and-see* effect in firm pricing decisions (Vavra, 2014). See also Baley and Blanco (2019) for similar results in an imperfect information environment.

[9]See also Fasani and Rossi (2018) on how modifications to the monetary policy rule can affect the model-implied response of inflation to uncertainty shocks in Leduc and Liu (2016).

[10]See also Malmendier and Nagel (2016) on age-dependent learning in the formation of inflation expectations, Juselius and Takats (2018) for evidence on the secular links between demographics

cross-country comparisons also reveal a new stylized fact, that average markups in countries that have been members of the Euro area since 2002 are positively correlated with life expectancy and negatively correlated with educational attainment (correlation coefficients of 0.44 and -0.33 respectively). It is also notable and perhaps surprising that only income per capita growth is (negatively) correlated with inflationary uncertainty shocks among a host of additional macroeconomic indicators.

Deep habits in consumption as in Ravn et al. (2006) may be the link between demographic factors and inflationary uncertainty shocks. Deep habits at the differentiated goods level critically impact the elasticity of demand that price-setting firms face.[11] In the same way that age influences the propensity to consume and save in the life-cycle hypothesis (Modigliani, 1966), it is quite plausible that habits in consumption take time to ingrain itself into households' consumption decisions and thus intensifies with age. A potential rationalization for this mechanism is that young agents are unsure about the utility value of various consumption baskets while older generations, given repeated experience, have developed tastes for specific baskets and hence exhibit stronger habit persistence.[12] Combined with the *pricing bias* mechanism in New Keynesian models of nominal rigidities, a model with age-dependent deep habits could potentially account for the observed correlations between demographics, average markups, and inflationary uncertainty shocks.

In light of this evidence, I develop an Overlapping Generations New Keyne-

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and inflation, as well as Carvalho et al. (2016); Aksoy et al. (2019) and Leahy and Thapar (2019) on demographics, macroeconomic trends and monetary policy.

[11] For instance, Bronnenberg et al. (2012) use detailed consumption data to show that past (brand-specific) consumption is an important driver of current consumption baskets among US households. See also Carrasco et al. (2005).

[12] See also a related theory on how households learn about their optimal consumption-savings decisions in Allen and Carroll (2001).

sian model with Deep Habits which links demographic factors to the elasticity of substitution across goods and hence average markups. In the model, younger generations have weaker deep habits and contribute to a higher elasticity of substitution across goods. Consequently, an aging population is characterized by lower elasticities and higher average markups. In turn, these lower elasticities amplify the *pricing bias* mechanism and lead to more inflationary uncertainty shocks. When calibrated to demographic and markup patterns observed for European countries, I find that such a channel can generate the observed correlations in the data and can quantitatively account for a fraction of the variation in the inflationary response to uncertainty shocks. Nevertheless, the simulated results suggest that other factors driving differences in average markups as well as in the conduct of monetary policy may be needed to fully account for the observed variation in the inflationary effects of heightened household uncertainty.

These results have important policy implications. The source of uncertainty matters for its macroeconomic effects for the Euro area.[13] Therefore, policies designed to address the negative effects of macro-uncertainty need to take into consideration the underlying source. In addition, the differential effects across countries also indicates that any common policy response in the Euro area is likely to generate heterogeneous effects in the member countries. In particular, aging societies such as Italy and Spain are likely to have more inflationary responses to uncertainty shocks.

The next section describes the data used to construct the proposed measure of household uncertainty and documents its basic properties. Section 2 reports results on the structural analysis of the macroeconomic impact of household uncertainty

[13] See also Bianchi et al. (2018) who show that supply-side uncertainty shocks may have stronger effects on investment and inflation relative to demand-side uncertainty.

shocks in the Euro area and across European countries. Section 3 introduces an Overlapping Generations New Keynesian model with Deep Habits to rationalize the observed relationship between demographic factors, average markups, and inflationary uncertainty shocks. Finally, Section 4 concludes with some remarks.

1. Measuring household uncertainty

Surveys of households provide a rich source of information regarding household beliefs and expectations. Prior literature has shown that survey-based measures of household expectations are not mere reflections of current conditions but also contains exogenous variation that could potentially drive business cycle fluctuations.[14] By and large, the focus on this strand of the literature has been on the level of household expectations.[15]

A few studies exploit the cross-sectional dimension of household surveys to study the microeconomic implications of household uncertainty. Ben-David et al. (2018) use the New York Fed's *Survey of Consumer Expectations* to show that US households' precautionary behavior under uncertainty is reflected in their consumption, investment and borrowing activities. Similarly, Christelis et al. (2020) validate the precautionary savings channel using a panel survey of Dutch households. Giavazzi and McMahon (2012) show that precautionary savings behavior following an increase in political uncertainty manifests as an increase in labor supply among

[14] See e.g. Fuhrer, 1988; Ludvigson, 2004; Barsky and Sims, 2012; Leduc and Sill, 2013; Angeletos and La'O, 2013; Asriyan et al., 2019; Bhandari et al., 2019 and Lagerborg et al., 2019.

[15] Recent examples include Malmendier and Nagel (2016) who show that household inflation expectations are driven by past experiences and influences borrowing behavior. D'Acunto et al. (2019) find evidence that cognitive abilities help determine the accuracy of households' inflation expectations. Vellekoop and Wiederholt (2019) show that higher household inflation expectations lead to less savings in favor of more expenditures in vehicles. Das et al. (2020) relate US household incomes and education levels to households' forecasts of several macroeconomic variables. See also Michelacci and Paciello (2020) who link UK household beliefs to their preferences and wealth.

German households. Guiso et al. (1996) construct a measure of Italian household income uncertainty from the 1989 wave of the household income and wealth survey of the Bank of Italy. They find that high income risk among Italian households induce reduced exposures to equity markets. While very granular and rich in the cross-section, the measures of household uncertainty used in these papers are unsuitable for macroeconomic analysis as they are only available for a few periods in time.[16]

In this paper, I use the European Commission harmonized consumer survey to construct country-level measures of household uncertainty useful for macroeconomic analysis. The survey is carried out monthly at the national level covering all European Union member states as well as candidate member countries. An average of over 40,000 households are surveyed every month across the European Union. The survey is harmonized across countries and is typically conducted in the first two to three weeks of each month.

To construct the measure of household uncertainty, I use households' responses to the same four questions used to construct consumer sentiment indices:

1. How do you expect the general economic situation in this country to develop over the next 12 months?
2. How do you expect the number of people unemployed in this country will change over the next 12 months?
3. How do you expect the financial position of your household to change over the next 12 months?
4. Over the next 12 months, how likely will you be to save any money?

Respondents can choose among five or six options when answering these questions (the middle option (*0*) is omitted for the question on the likelihood of saving).

[16] One recent, although model-based, exception is recent work by Michelacci and Paciello (2020) who extract measures of (Knightian) uncertainty exploiting biases in UK household expectations.

- Much better/more (++)
- Somewhat better/more (+)
- The same (*0*)
- Somewhat worse/less (-)
- Much worse/less (–)
- Don't know (*?*)

I construct an index capturing household uncertainty (HUN) by measuring the frequency (fraction) of *Don't Know* responses. Let $p_{i,j,t}$ denote the fraction of respondents choosing option i for question j at survey date t where $i = 6$ corresponds to *Don't know* responses. The average of the fraction of responses for the sixth option across the four questions is the measure for household uncertainty,

$$HUN_t = \frac{1}{4}\sum_j p_{6,j,t} \tag{1}$$

The measure is constructed for a balanced panel of 20 countries (plus the Euro area average) and for the period May 2002 to April 2018.[17]

To help understand what drives fluctuations in the proposed measure of household uncertainty, I evaluate how it correlates with and responds to other macroeconomic indicators and households' views in other areas. To this end, I construct a consumer sentiment index by quantifying the first five responses into numerical values ranging from -1 to 1, $x_{i,j,t} \in \{1, 0.5, 0, -0.5, -1\}$, and then taking averages of the mean responses across the four questions.

$$CSI_t = \frac{1}{4}\sum_j \sum_{i=1}^{5} x_{i,j,t}\tilde{p}_{i,j,t} = \frac{1}{4}\sum_j \bar{x}_{j,t} \tag{2}$$

[17] Countries were selected based on data availability and includes 14 of the 19 Euro area countries as well as the largest (by GDP) European Union member countries including the United Kingdom. A complete description of the data coverage is provided in the Appendix. Data used in the analysis is available here.

where $\tilde{p}_{i,j,t} = 100 * p_{i,j,t} / \sum_{i=1}^{5} p_{i,j,t}$ re-scales the sum of probabilities for the first five options to sum to 100.

I also include a measure for the dispersion of household beliefs, DIS, defined as the average dispersion of households' views:

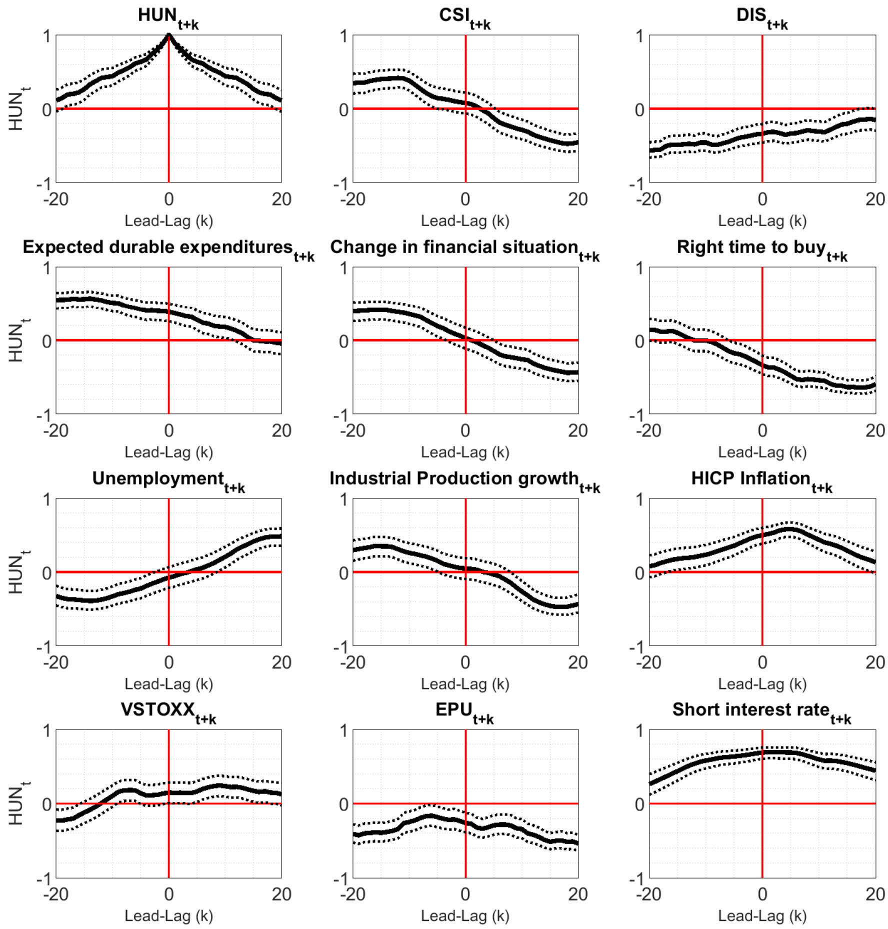
$$DIS_t = \frac{1}{4} \sum_j \sum_{i=1}^{5} (x_{i,j,t} - \bar{x}_{j,t})^2 \tilde{p}_{i,j,t} \quad (3)$$

Finally, I also construct indices of households' views on their expected durable expenditures for the following year, their views on whether it is the right time to make major purchases, and an index of reported changes in their current household financial situations. These measures are calculated in the same way as the consumer sentiment index.

The survey data is augmented with standard monthly macroeconomic variables. I take monthly data on (log) industrial production, consumer (HICP) inflation, the short interest rate (average overnight rate), and the unemployment rate. The industrial production and inflation variables are transformed into year-on-year growth rates while the unemployment rate is in year-on-year differences.

Figure 2 reports lead-lag correlations of household uncertainty with other variables for the Euro area. A near-zero contemporaneous correlation with the consumer sentiment index suggests that the uncertainty measure is not a proxy for sentiment (a first moment of beliefs). It also appears that fluctuations in household uncertainty do not merely reflect poor economic conditions. Instead, the data suggests that periods of high industrial production growth and low unemployment are typically followed by high household uncertainty with near-zero contemporaneous correlations. It is after periods of heightened household uncertainty that we observe higher unemployment and lower industrial production growth. If anything, the measure of household uncertainty anticipates downturns.

Figure 2: Correlations with household uncertainty



The panels report lead-lag cross-correlations of the household uncertainty measure HUN (Euro area average) with several variables. The indices for consumer sentiment (CSI), dispersion of beliefs (DIS), expected durable expenditures, changes in financial situation, and views on the right time to make large purchases are derived from the consumer survey. These variables are Euro area averages. The unemployment rate, industrial production growth and HICP inflation variables are likewise Euro area averages. VSTOXX is the option-implied volatility of the Eurostoxx 50 index. EPU is the Baker et al. (2016) measure of economic policy uncertainty for Europe, and the short interest rate is the daily market rate (EONIA). Dotted lines reflect 95% confidence intervals.

The observed lead-lag correlations suggest that the household uncertainty measure may be more forward- than backward-looking. A consistent pattern emerges when comparing the lead-lag correlations of the household uncertainty measure with unemployment, industrial production growth, consumer sentiment, and perceived changes in household financial situations. Household uncertainty tends to rise when these other measures were previously indicating *good* times. Contemporaneous correlations with these variables are near-zero and increases in household uncertainty tend to be followed by periods when these indicators indicate *bad* times. These results also indicate that the household uncertainty measure is unlikely to be driven only by fluctuations in disinterest or apathy of respondents.

It should be noted that household uncertainty is positively correlated with both leads and lags of inflation as well as contemporaneously. Thus, identification of uncertainty shocks is crucial to uncovering its effects on inflation. Consequently, the succeeding section includes variations to the recursive identification approach used to identify uncertainty shocks as robustness exercises.

A few more correlations suggest that the measure for household uncertainty may be capturing uncertainty about households' ability to support their desired levels of consumption. Increases in household uncertainty are associated with a growing negative view on whether it is the right time to make large purchases. On the other hand, higher household uncertainty is also preceded by and is positively correlated with expected increases in durable expenditures. This interpretation is also consistent with Christelis et al. (2020) who find that perceived Dutch household consumption risk is correlated with household employment and income risk.

The index also captures households' uncertainty about the economy in general. Two of the four questions used to construct the index refer to general macroeconomic conditions (the general economic situation and the number of unemployed in the country). When calculated individually for each of the questions, I find that the sub-components of household uncertainty are highly correlated with each other. This is consistent with the findings in Ben-David et al. (2018) for US households who show that there is a high degree of correlation between households' uncertainty about their own personal finances and their uncertainty about macro-level variables. Further, as shown earlier, the household uncertainty measure peaks around events that are associated with macroeconomic uncertainty. Finally, the relatively weak correlations with the financial and policy measures of uncertainty indicate that the household uncertainty measure captures a distinct type or source of uncertainty.

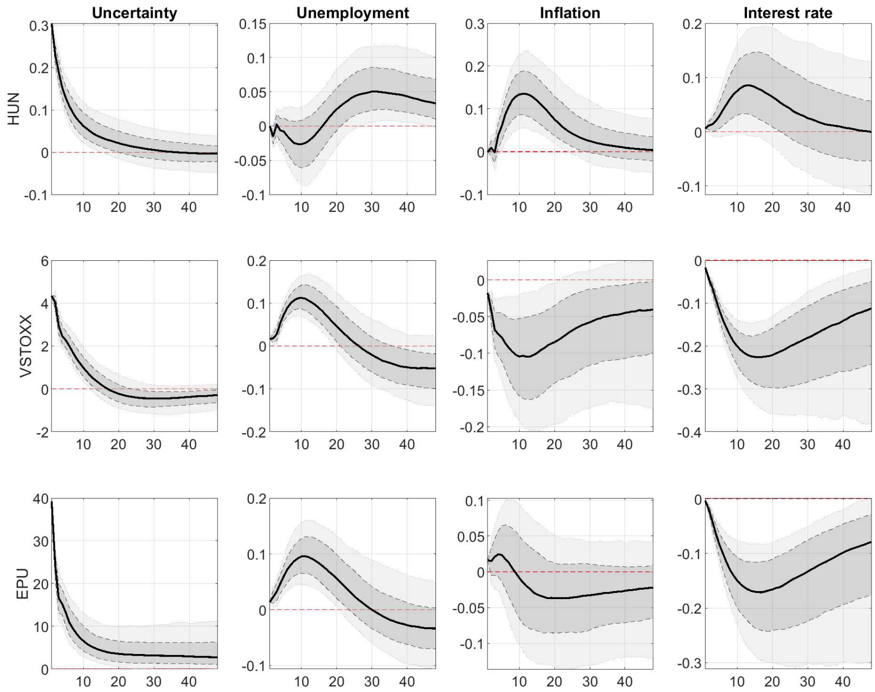
2. Macroeconomic impact of household uncertainty

To flesh out the macroeconomic implications of shocks to household uncertainty in Europe, I emulate the vector auto-regression (VAR) analysis done by Leduc and Liu (2016) for the US. The VAR is comprised of a measure for uncertainty, unemployment, inflation, and interest rates and is estimated with three lags.[18] Shocks are identified recursively with uncertainty ordered first. Figure 3 plots impulse responses using Euro area data to a positive one standard deviation uncertainty shock. Each row uses a different measure of uncertainty. The first row plots the response of several macroeconomic variables (described in the column headers) to a household uncertainty shock. The second and third rows plot responses to financial (VSTOXX) and policy (EPU) uncertainty shocks respectively.

Household uncertainty shocks in the Euro area lead to higher inflation. This is in stark contrast to results based on US data in Leduc and Liu (2016). Further, I find that increases in household uncertainty has a delayed effect on unemployment, raising unemployment only after about 20 months. On the other hand, positive financial uncertainty shocks do look like negative demand shocks as they raise un-

[18] Lag selection is based on information criteria. The VAR is estimated using Bayesian methods with Minnesota priors using the ECB's BEAR toolbox (Dieppe et al., 2016).

Figure 3: Impulse responses to uncertainty shocks

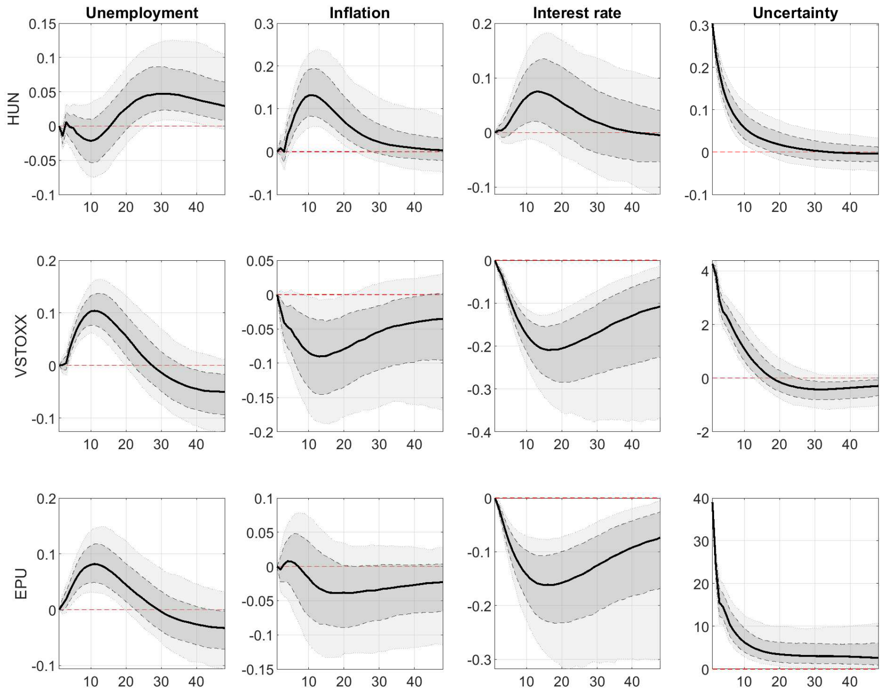


The panels report median impulse responses to one standard deviation shocks to various measures of uncertainty over a 48-month horizon. Each column reports responses for a given variable. The source, or measure, of uncertainty is given by the row labels. HUN is the measure of household uncertainty for the Euro area. VSTOXX is the option-implied volatility of the Eurostoxx 50 index. EPU is the Baker et al. (2016) measure of economic policy uncertainty for Europe. The shaded areas reflect 68% and 90% confidence sets.

employment and lower inflation. The same can be said of impulse responses to shocks arising from the policy uncertainty measure.

The findings on the effects of household uncertainty shocks on inflation and unemployment are robust to an alternative identification strategy which assumes that household uncertainty reacts to all other shocks contemporaneously while household uncertainty shocks only affect other variables with a one month lag. Figure 4 plots impulse responses analogous to the baseline specification but with the uncertainty variable ordered last in the recursive identification strategy. Here we find that impulse responses to household uncertainty shocks have are virtually unchanged relative to the baseline results.

Figure 4: Uncertainty ordered last impulse responses



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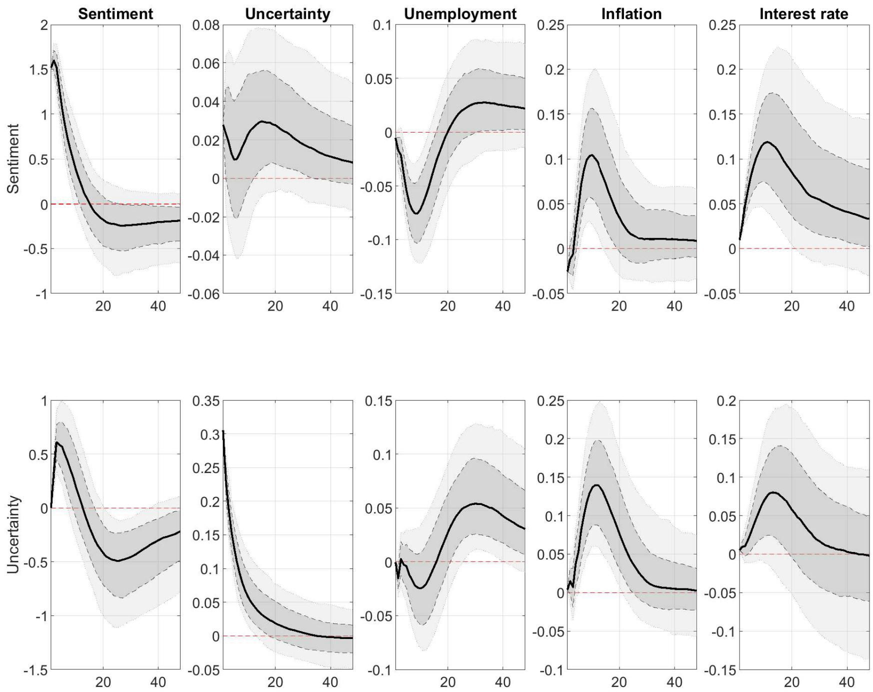
The effects of household uncertainty on unemployment and inflation are not driven by changes in consumer sentiment, a first moment of expectations. The results are robust to the inclusion of consumer sentiment in the VAR. Figure 5 plots impulse responses in a VAR much like in the benchmark analysis but with the following variables: CSI, HUN, Unemployment, Inflation, and Interest rate. Shocks are identified recursively and variables are ordered as indicated in the previous sentence. Here we find that consumer sentiment shocks do act like positive aggregate demand shocks in that it leads to lower unemployment and higher inflation and interest rates. Further, the main result of the paper is still obtained in that household uncertainty shocks (ordered second in the VAR) still feature a delayed response in unemployment and is still inflationary.

Figure 5: Impulse responses in a VAR with CSI



The panels report median impulse responses to one standard deviation shocks to household sentiment and uncertainty. Each column reports responses for a given variable and the household expectations measure used is given by the row labels. The shaded areas reflect 68% and 90% confidence sets.

These findings are also robust to other potential concerns. In the Appendix, I show that the results remain under alternative measures of household uncertainty such as by constructing the measure only from responses to the two questions in the survey concerning household expectations on the general economic situation and unemployment or employing a common factor approach to identifying Euro area household uncertainty. One may also think that the household uncertainty measure imperfectly captures households' uncertainty and that the dispersion of household beliefs may be also contain relevant information regarding households' uncertainty. To this end, I construct indices combining the measure of household uncertainty and dispersion of beliefs and find that positive shocks to these indices also lead to higher inflation and delayed increases in unemployment. The results are also robust to a VAR which includes three measures of uncertainty associated with various sectors (VSTOXX, EPU, and HUN). Here, I still find that uncertainty shocks from the financial measure resemble negative demand shocks while household uncertainty shocks remain inflationary.

In addition, I verify that the results are not driven by assumed priors in the Bayesian VAR estimation. I obtain the same results from a VAR estimated by Ordinary Least Squares. Finally, I also exploit country-level information from the five largest member countries of the Euro area in a panel-VAR setting to obtain averaged Euro area impulse responses. In particular, I take country-level data for household uncertainty, unemployment, inflation, and interest rates for Germany, France, Italy, Spain, and the Netherlands and use the mean-group estimator for dynamic panel data proposed by Pesaran and Smith (1995) to generate the cross-sectional averaged impulse responses. In addition, I also use stochastic pooling of impulse responses from VARs estimated for each of the countries following Canova and Pappa (2007).[19] In both of these panel VAR exercises, I also find that household uncertainty shocks are inflationary.

A *pricing bias* mechanism highlighted in Born and Pfeifer (2014) and Fernandez-Villaverde et al. (2015) may be a plausible explanation for inflationary uncertainty shocks. Given nominal rigidities and asymmetries in profit functions, firms are more inclined to raise prices when faced with higher uncertainty. Why then would uncertainty shocks be deflationary for financial and policy uncertainty in the Euro Area and generally in the US? The analysis in Fernandez-Villaverde et al. (2015) gives us some guidance. They show that the *pricing bias* mechanism can be reconciled with

[19] For the stochastic pooling of impulse responses, the interest rate is assumed exogenous in the country-level VARs as was done in Canova and Pappa (2007).

deflationary uncertainty shocks if monetary policy is characterized by augmenting an otherwise standard Taylor-type rule with a term that responds to uncertainty. In addition, Fasani and Rossi (2018) show that the model-implied responses of inflation to uncertainty shocks in the model developed in Leduc and Liu (2016) to explain the empirical evidence using US data can be sensitive to variations in the monetary policy rule.[20] Thus, a plausible explanation may be that monetary policy in the Euro area responds to financial and policy uncertainty shocks but not to household uncertainty shocks. In practice, this need not be an explicit component to the monetary policy rule or process. It is more likely that measures of financial and policy uncertainty feed into the inputs used to formulate the monetary policy stance and hence leads to a monetary policy rule which implicitly responds to financial and policy uncertainty shocks.

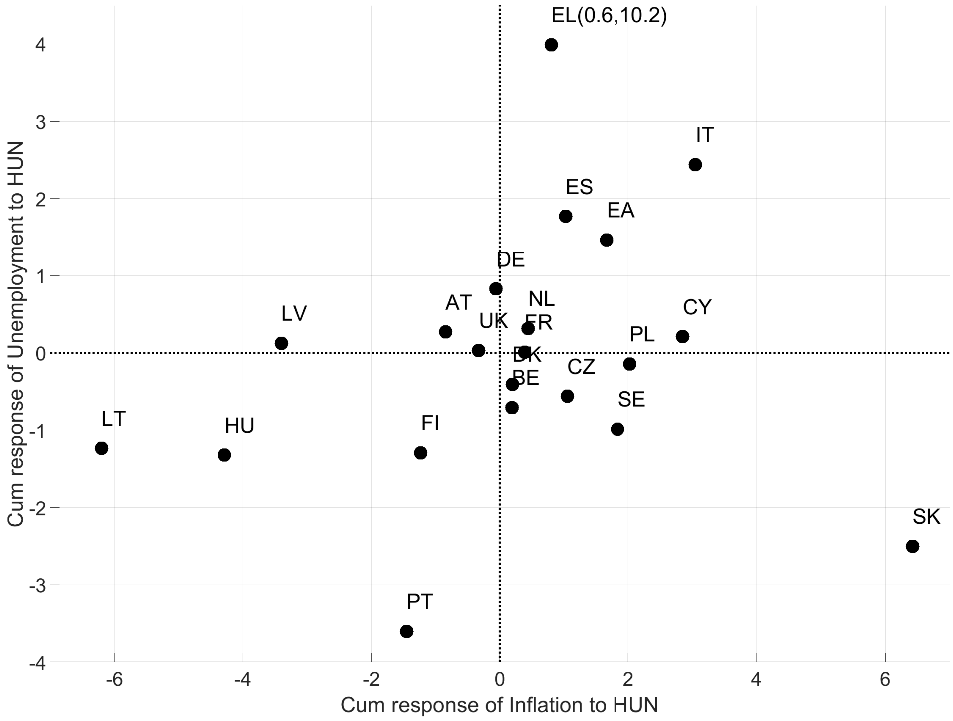
These results mask significant heterogeneity across European countries. I repeat the VAR exercise for each of the 20 individual countries in the sample and find that household uncertainty shocks are inflationary for many countries. Figure 6 plots cumulated median impulse responses, over a 48 month horizon, of unemployment (vertical axis) and inflation (horizontal axis) to household uncertainty shocks for each of the 20 countries in the sample and the Euro Area.[21] To help control for country differences and secular trends, the VAR is augmented with month-specific constant terms as well as linear time trends as additional (exogenous) control vari-

[20] The link between inflation and the monetary policy response to uncertainty is further supported by evidence in Mumtaz et al. (2018) who find that the state-level impact of aggregate uncertainty shocks in the US are also inflationary. Mumtaz and Theodoridis (2015) find that US uncertainty shocks may be inflationary for the UK economy. See also Annicchiarico and Rossi (2015).

[21] Dots on the upper left quadrant would resemble negative demand shocks. Dots on the upper right quadrant would be consistent with negative supply shocks. Dots in the bottom quadrants indicate expansionary uncertainty shocks. Basu and Bundick (2017) note that this may occur in an economy without nominal rigidities whereby the precautionary savings effect of heightened uncertainty on labor supply leads to higher output consistent with micro-evidence presented in Giavazzi and McMahon (2012). See also the discussion in Fernandez-Villaverde and Guerron-Quintana (2020).

ables.

Figure 6: Cumulated impulse responses to household uncertainty by country



The dots represent cumulated median impulse responses, over a 48-month horizon, from one standard deviation shocks to household uncertainty for 20 European countries and the Euro area. The cumulated response of unemployment is on the vertical axis and the cumulated response of inflation is on the horizontal axis. The impulse responses are taken from a recursively-identified VAR estimated with three lags and includes linear time trends and month-specific constant terms. Country codes are official European Union designations. The cumulated response of unemployment to household uncertainty shocks for Greece (EL) is truncated to 4% in the plot from 10.2% for presentation purposes. The mapping between country codes and country names are given in Table A.1.

For Austria and Latvia, household uncertainty shocks raise unemployment and lower inflation. However, for many countries such as Italy, Spain, and Greece, household uncertainty shocks raise unemployment and inflation.

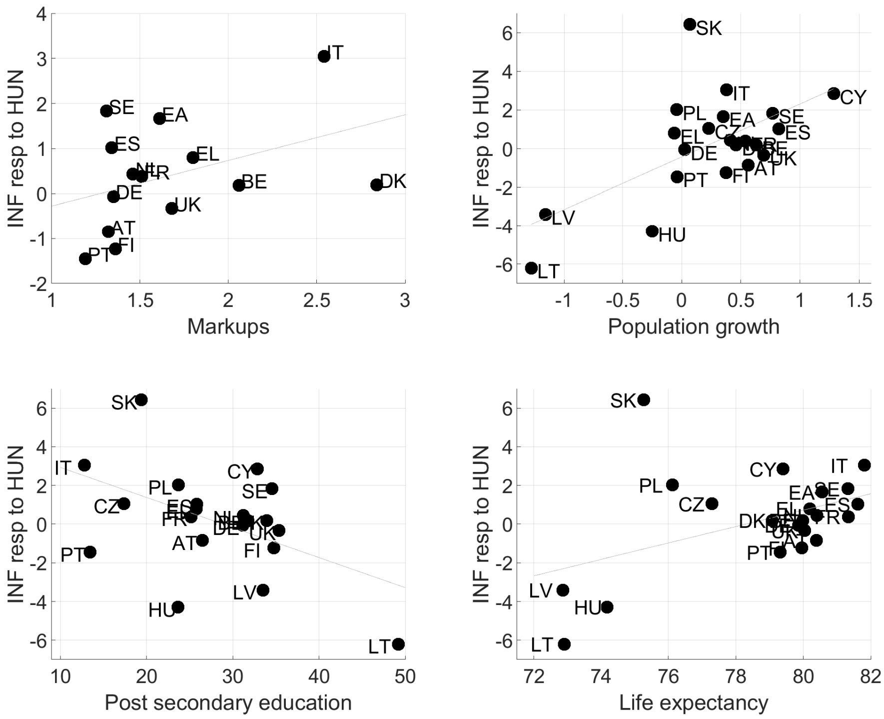
What can account for these differences? Here, the analysis in Born and Pfeifer (2014) provide some directions on where to look. In their analysis of the transmission mechanism of uncertainty shocks, several factors attenuate or amplify the response of inflation to uncertainty shocks. First, as in Fernandez-Villaverde et al. (2015) and Fasani and Rossi (2018), the conduct of monetary policy plays a role. While a plausible explanation to account for differences between US and European results, since there is a common monetary policy for several countries in our sample, this is unlikely to be the leading explanation for differences across all European countries. Second, Born and Pfeifer (2014) also show that a higher degree of nominal rigidities tend to increase the response of inflation to uncertainty shocks. Finally, the elasticity of substitution between intermediate goods, crucial to the determination of markups in the New Keynesian framework, is another factor.

The theoretical link between markups and the response of inflation to uncertainty shocks is borne out in the data. I use estimated average markups for 13 countries in the sample and the Euro area from De Loecker and Eeckhout (2020) and find a positive correlation between average markups and inflationary responses to household uncertainty.[22] The upper left panel of Figure 7 plots the cumulated response, over a 48-month period, of inflation to household uncertainty shocks on the vertical axis and average markups on the horizontal axis. I also collect a broad set of country average characteristics over the period 2002-2017 from the World Bank World Development Indicators database. These characteristics cover a broad range of economic and social areas and includes measures similar to variables documented in Mumtaz et al. (2018) as important for heterogeneity in state-level impulse responses to uncertainty shocks in the US.

Demographics also seem to matter for the effect of household uncertainty on inflation. The upper right and bottom panels of Figure 7 compare the response of inflation to household uncertainty shocks against country averages of population growth, post secondary education, and life expectancy. Regression analysis reveal that population growth and life expectancy at birth correlate positively with

[22] Markups are averages for 2016. Data taken from Table 1 of De Loecker and Eeckhout (2020). Markups for Europe are paired with impulse responses for the Euro area. See also the appendix for alternative markup estimates.

Figure 7: Inflation impulse responses to household uncertainty by country variables



Each dot represents results for each country in the sample and the Euro area. The vertical axes indicate the cumulated median impulse response, over a 48-month horizon, of inflation to shocks to household uncertainty for 20 European countries and the Euro area. The impulse responses are taken from a recursively-identified VAR estimated with three lags and includes linear time trends and month-specific constant terms. Markups are over the period 2016 and taken from De Loecker and Eeckhout (2020). Other country variables are indicated on the horizontal axes labels and are averages over the period 2002-2017. Country codes are official European Union designations. The mapping between country codes and country names are given in Table A.1.

inflationary responses. In addition, countries with a larger share of the adult population with post secondary education tend to also have less inflationary responses to household uncertainty shocks. It is also surprising that, among a large set of macroeconomic indicators, only income per capita growth correlate (negatively) with the differential effects of uncertainty on inflation.[23]

Table 1 reports regression results of the cumulated response of inflation to household uncertainty shocks on markup estimates and demographic factors. I include specifications which allow for differences in coefficients for Euro area member

[23] Additional regression results are provided in Table A.4 of the Appendix.

countries (since 2002) as well as controlling for income per capita growth which is one other variable with a significant and negative correlation with the cumulated impulse responses. The regression results in the first three columns of Table 1 indicate that the positive relationship between markups and inflation impulse responses is driven by countries which have been members of the Euro area since 2002.[24] On the other hand, the regression results in columns 4 to 12 of Table 1 indicate that the relationship between the demographic factors and inflation impulse responses is shared across all European countries in the sample with no significant difference between estimated coefficients for Euro area member and non-member countries in the sample.

[24]These results are robust to alternative markup estimates for European countries. See the relevant section in the appendix, in particular Table A.8, for additional regression results using alternative sources for markup estimates.

Table 1: Regression of cumulated impulse responses of inflation to household uncertainty shocks on country variables

Dep. var.: Cum Inflation IRF	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Constant	-1.433	1.939	1.883	-0.475	-0.223	-2.428	-32.576	-49.028	-27.172	4.490	6.905	7.663
	(1.131)	(1.661)	(2.037)	(0.530)	(0.728)	(2.831)	(15.949)	(20.877)	(42.614)	(1.918)	(2.766)	(2.608)
Markup	1.040	-0.707	-0.706									
	(0.648)	(0.810)	(0.860)									
Pop growth				2.713	3.093	4.747						
				(0.829)	(0.938)	(2.260)						
Life exp							0.416	0.638	0.371			
							(0.203)	(0.271)	(0.529)			
Secondary Educ										-0.155	-0.227	-0.182
										(0.065)	(0.087)	(0.085)
Dum EA		-5.609	-5.641		0.122	1.988		-50.647	-61.324		-5.086	-6.259
		(2.043)	(2.243)		(1.382)	(2.703)		(83.213)	(86.846)		(4.068)	(3.840)
Markup x Dum EA		3.154	3.194									
		(1.087)	(1.369)									
Pop growth x Dum EA					-2.184	-3.880						
					(2.712)	(3.455)						
Life exp x Dum EA								0.603	0.734			
								(1.037)	(1.081)			
Secondary Educ x Dum EA											0.165	0.151
											(0.142)	(0.132)
Income per cap growth			0.044			0.704			-0.455			-0.714
			(0.803)			(0.872)			(0.768)			(0.384)
R-squared	0.189	0.581	0.581	0.373	0.409	0.433	0.189	0.307	0.323	0.239	0.307	0.437
Obs	13	13	13	20	20	20	20	20	20	20	20	20

The dependent variable is the cumulated median impulse response (over a 48-month horizon) of inflation to household uncertainty shocks. Average markups are for the year 2016 and taken from De Loecker and Eeckhout (2020). Other country variables are 2002-2017 averages for 20 European countries obtained from the World Bank World Development Indicators database. Dum EA is a dummy variable for Euro area member countries since 2002.

These results indicate that demographic factors may play an important role in the transmission of household uncertainty to the macroeconomy. These are also consistent with micro-level studies. Christelis et al. (2020) document a negative relationship between age and perceived consumption risk among Dutch households. Ben-David et al. (2018), on the other hand, find a U-shaped life-cycle pattern in US households' uncertainty. Ben-David et al. (2018) also find that lower education levels are associated with higher uncertainty. Furthermore, these results point to a link between demographic factors and markups, at least for Euro area member countries. Indeed, while cross-country markup estimates are uncorrelated with demographic factors for the full sample, I find that the markup estimates are positively correlated with life expectancy (with a correlation coefficient of 0.44) for Euro area member countries (since 2002).[25] In the next section, I develop a simple model of age-specific deep habits in an overlapping generations New Keynesian framework and which links life expectancy with average markups. I then evaluate to what extent the calibrated versions of the model can reproduce the empirical evidence presented in this section.

3. Demographics, deep habits, and uncertainty

This section presents an Overlapping Generations New Keynesian model with Deep Habits which links demographic factors to firm pricing behavior and thus the response of inflation to uncertainty shocks. The model draws on a key insight of deep habits that consumption habit persistence at the goods level effectively makes demand for differentiated goods less elastic (Ravn et al., 2006). It also brings expectations of changes in future demand elasticity into the current pricing problem of firms (Lubik and Teo, 2014). Together with the pricing bias mechanism described in the main text, variations in the degree of deep habits can amplify or attenuate the inflationary effects of heightened uncertainty.

The objective of this section is to quantitatively assess the extent to which the proposed link between demographics, markups, and inflationary uncertainty shocks through age-dependent deep habits can explain the observed variation in the data. As such, I expand on a parsimonious version of New Keynesian models with deep habits (Ravn et al., 2010; Lubik and Teo, 2014; Zubairy, 2014; Leith et al., 2015) by incorporating Blanchard-Yaari overlapping generations and where younger generations have weaker habits than the old. For instance, in the model, agents who

[25] Correlation coefficients are reported in Table A.6 of the appendix.

enter the economy for the first time do not have a reference consumption basket to form habits around. The Blanchard-Yaari overlapping generations framework provides a simple characterization of demographics in terms of life expectancy and population growth. Similarly, the assumption that deep habits intensify with age provides an intuitive and straightforward mechanism which links demographics, average markups, and inflationary uncertainty shocks.[26]

3.1. Households

Time is discrete and denote with N_t the mass of households in the economy for period t where $N_0 = 1$. At the beginning of every period a fraction g^b of the mass of households in the previous period are born. At the end of each period a fraction g^d of all household exit the economy such that the mass of households grow at the rate $g^b - g^d$ every period.

$$N_t = (1 + g^b - g^d)^t N_0 \tag{4}$$

Henceforth, all quantities will be expressed in per capita terms. Define $g \equiv g^b/(1 + g^b - g^d)$, a summary statistic for the age distribution. Then the time-invariant age distribution $f(j)$ of households who have lived for j periods is given by,

$$f(j) = g(1-g)^j \tag{5}$$

where $j \in [0, \infty]$. Households derive utility from consumption, provide labor services, and save in a risk-free asset to maximize the discounted sum of utility from consumption of a basket of goods indexed by i and labor yielding the following

[26]One alternative with similar implications is that the time (opportunity) cost of search when forming consumption baskets as well as attention costs to evaluating relative prices in the spirit of Aguiar and Hurst (2007) and Carroll et al. (2020) may be age-dependent. Thus, demographics may also affect the price elasticity of demand through an information frictions channel.

program for a household born j periods from today,

$$\begin{aligned}
max \qquad & \mathbb{E}_t \sum_{s=0}^{\infty} (1-g^d)^s \beta^s U(\{c_{i,j,t+s}\}, h_{j,t+s}) && (6) \\
\text{subject to:} & \\
U &= \frac{x_{j,t}^{1-\sigma}}{1-\sigma} - \frac{h_{j,t}^{1+\kappa}}{1+\kappa} && (7) \\
x_{j,t} &= \left[\int_0^1 (c_{i,j,t} - \theta_j c_{i,t-1})^{\frac{\eta-1}{\eta}} di \right]^{\frac{\eta}{\eta-1}} && (8) \\
\int_0^1 P_{i,t} c_{i,j,t} di + B_{j,t} &= R_{t-1} B_{j,t-1} + W_t h_{j,t} + \Phi_t \quad \forall t && (9)
\end{aligned}$$

where $\Phi_t = \int \Phi_{i,t} di$ are firm profits treated as exogenous by households, β is the discount factor, σ is the coefficient of relative risk aversion, κ is the inverse Frisch elasticity of labor supply, η is the elasticity of demand for differentiated goods, and θ_j is the age-specific deep habits parameter which is assumed to be increasing in age j. In particular, I assume

$$\theta_j = (1 - exp(-\nu j))\theta \tag{10}$$

where ν is a shape parameter. For example $\theta_0 = 0$ while $\lim_{j \to \infty} \theta_j = \theta$. The households' problem yield the following optimality conditions,

$$\begin{aligned}
c_{i,j,t} &= x_{j,t} \left[\frac{P_{i,t}}{P_t} \right]^{-\eta} + \theta_j c_{i,t-1} && (11) \\
h_{j,t}^{\kappa} &= x_{j,t}^{-\sigma} W_t / P_t && (12) \\
\text{where} & \\
P_t &= \left[\int_0^1 P_{i,t}^{1-\eta} di \right]^{\frac{1}{1-\eta}} && (13) \\
c_{i,t} &= \int_0^{\infty} c_{i,j,t} f(j) dj && (14)
\end{aligned}$$

I assume that savings decisions are relegated to a representative household and there is zero net supply of the risk-free asset such that in equilibrium $B_{j,t} = B_t = 0$ for all households and periods.[27] A symmetric equilibrium for households within the same age group yield the Euler equation,

$$x_{j,t}^{-\sigma} = (1-g^d)\beta R_t \mathbb{E}_t[x_{j,t+1}^{-\sigma} P_t/P_{t+1}] \tag{15}$$

and aggregating across households yields the aggregate Euler and demand equations,

$$x_t^{-\sigma} = (1-g^d)\beta R_t \mathbb{E}_t[x_{t+1}^{-\sigma} P_t/P_{t+1}] \tag{16}$$

$$c_{i,t} = x_t \left[\frac{P_{i,t}}{P_t}\right]^{-\eta} + \tilde{\theta} c_{i,t-1} \tag{17}$$

where

$$x_t \equiv \int_0^\infty x_{j,t} f(j) dj \tag{18}$$

$$\tilde{\theta} \equiv \int_0^\infty \theta_j f(j) dj$$

$$= \theta(exp(\nu)-1)(1-g)\left[exp(\nu)-1+g\right]^{-1} \tag{19}$$

Note here that the age distribution is crucial to average deep habits ($\tilde{\theta}$). A young and dynamic population with high entry and exit of households (large g) exhibits lower habit persistence than an aging population with low entry and exit (small g). For instance, at the extreme where agents live for one period ($g = 1$), there are no deep habits and $\tilde{\theta}$ is zero while when agents are infinitely-lived with no entry and exit ($g = 0$) then habit persistence is maximized and $\tilde{\theta} = \theta$.

[27] One interpretation of this assumption is the presence of a well-functioning social security system.

3.2. Firms

Infinitely-lived firms produce differentiated goods in monopolistically competitive markets and maximize the sum of profits discounted by households' average stochastic discount factor (q_t) by choosing labor demand and goods prices subject to Rotemberg price adjustment costs.[28] A firm producing good i solves the following problem,

$$max \qquad \mathbb{E}_t \sum_{s=0}^{\infty} q_{t+s} \Phi_{i,t+s} \tag{20}$$

subject to:

$$q_{t+s} = (1-g^d)^s \beta^s x_{t+s}^{-\sigma} P_{t+s}^{-1} \tag{21}$$

$$\Phi_{i,t} = P_{i,t} c_{i,t} - W_t h_{i,t} - \frac{\delta}{2} P_t c_t \left(\frac{P_{i,t}}{P_{i,t-1}} - \pi^* \right)^2 \tag{22}$$

$$c_{i,t} = x_t \left[\frac{P_{i,t}}{P_t} \right]^{-\eta} - \tilde{\theta} c_{i,t-1} \tag{23}$$

$$c_{i,t} \leq y_{i,t} = A_t h_{i,t} \tag{24}$$

where π^* is the steady-state inflation rate, δ is the price adjustment cost parameter and $c_t \equiv \int c_{i,t} di$. The productivity of labor inputs A_t is the same across firms and follows an auto-regressive process with time-varying volatility,

$$log(A_t) = (1-\rho_a) log(\bar{A}) + \rho_a log(A_{t-1}) + \sigma_{A,t} \varepsilon_{a,t} \tag{25}$$

$$log(\sigma_{A,t}) = \rho_v log(\sigma_{A,t-1}) + \varepsilon_{v,t} \tag{26}$$

[28] The assumption of Rotemberg adjustment costs relative to a Calvo mechanism may not be completely innocuous as Oh (2020) finds that Rotemberg adjustment costs tend to lead to disinflationary uncertainty shocks relative to Calvo-type nominal rigidities. This suggests that uncertainty shocks may be even more inflationary in a similarly-calibrated model with Calvo rigidities. See also Ascari and Rossi (2012) for differences between Rotemberg and Calvo mechanisms especially when trend inflation is not zero.

where $\bar{A}$ is steady-state productivity, ρ_a and ρ_v are persistence parameters for the level of productivity and its variance, $\varepsilon_{a,t}$ are productivity shocks with $\varepsilon_{a,t} \sim i.i.d.N(0, \sigma_a)$, and $\varepsilon_{v,t}$ are uncertainty shocks with $\varepsilon_{v,t} \sim i.i.d.N(0, \sigma_v)$. One might be concerned that the volatility shocks in the model, which is also referred to as *risk* shocks in the literature is compatible with the household uncertainty index presented earlier in the paper which can also be interpreted as a measure of *Knightian* uncertainty or ambiguity. While a valid concern, a plausible link between the model-based uncertainty shocks and the survey-based measure for household uncertainty in the data is that households may opt to respond with *Don't know* in a survey when expected forecast errors (which depend on volatility shocks) are too large. This link is explored in further detail in the Appendix.

The solution to the firms' problem yield the following optimality conditions,

$$
\begin{aligned}
W_t/P_t &= \lambda_{y,t} A_t && (27)\\
P_t\lambda_{c,t} + P_t\lambda_{y,t} &= P_{i,t} + \tilde{\theta}\mathbb{E}_t \frac{q_{t+1}}{q_t} P_{t+1}\lambda_{c,t+1} && (28)\\
\eta\lambda_{c,t}\frac{P_t}{P_{i,t}}(c_{i,t} - \tilde{\theta}c_{i,t-1}) - c_{i,t} &= \mathbb{E}_t \frac{q_{t+1}}{q_t}\delta c_{t+1}\frac{P_{t+1}}{P_{i,t}}\frac{P_{i,t+1}}{P_{i,t}}\left(\frac{P_{i,t+1}}{P_{i,t}} - \pi^*\right)\\
&\quad -\delta c_t \frac{P_t}{P_{i,t-1}}\left(\frac{P_{i,t}}{P_{i,t-1}} - \pi^*\right) && (29)
\end{aligned}
$$

where $\lambda_{y,t}$ is the multiplier on production (marginal cost, equation 24) and $\lambda_{c,t}$ is the multiplier on demand (equation 23).

3.3. *Monetary policy and aggregation*

I close the model with a description of monetary policy which follows a Taylor-type rule.

$$\frac{R_t}{R^*} = \left[\frac{R_{t-1}}{R^*}\right]^{\rho_r} \left[\frac{\pi_t}{\pi^*}\right]^{\alpha_\pi(1-\rho_r)} \left[\frac{y_t}{y^*}\right]^{\alpha_y(1-\rho_r)} \left[\frac{\sigma_{v,t}}{\sigma_v^*}\right]^{\alpha_v(1-\rho_r)} \tag{30}$$

where $\pi_t = P_t/P_{t-1}$ is the gross inflation rate, R^*,π^*, and y^* are the steady-state nominal rate, inflation, and output respectively. The last term in brackets allows for a monetary policy response to uncertainty shocks $\sigma_{v,t}$ whenever $\alpha_v > 0$. This follows from Fernandez-Villaverde et al. (2015) who show that such an augmented monetary policy rule can generate deflationary uncertainty shocks.

Aggregation, a symmetric equilibrium and market-clearing conditions yield the following equations which characterize the model.

$$x_t = c_t - \tilde{\theta} c_{t-1} \tag{31}$$

$$h_t^\kappa = x_t^{-\sigma} w_t \tag{32}$$

$$x_t^{-\sigma} = \tilde{\beta} R_t \mathbb{E}_t x_{t+1}^{-\sigma} \pi_{t+1}^{-1} \tag{33}$$

$$c_t = y_t - \frac{\delta}{2}(\pi_t - \pi^*)^2 \tag{34}$$

$$w_t = A_t \lambda_{y,t} \tag{35}$$

$$\lambda_{y,t} + \lambda_{c,t} = 1 + \tilde{\theta}\tilde{\beta}\mathbb{E}_t \left[\frac{x_{t+1}}{x_t}\right]^{-\sigma} \lambda_{c,t+1} \tag{36}$$

$$\eta \lambda_{c,t} x_t - c_t = \delta \tilde{\beta} \mathbb{E}_t \left[\frac{x_{t+1}}{x_t}\right]^{-\sigma} c_{t+1}\pi_{t+1}(\pi_{t+1} - \pi^*) - \delta c_t \pi_t (\pi_t - \pi^*) \tag{37}$$

$$\frac{R_t}{R^*} = \left[\frac{R_{t-1}}{R^*}\right]^{\rho_r} \left[\frac{\pi_t}{\pi^*}\right]^{\alpha_\pi(1-\rho_r)} \left[\frac{y_t}{y^*}\right]^{\alpha_y(1-\rho_r)} \left[\frac{\sigma_{v,t}}{\sigma_v^*}\right]^{\alpha_v(1-\rho_r)} \tag{38}$$

$$y_t = A_t h_t \tag{39}$$

where $w_t = W_t/P_t$, $h_t = \int h_{i,t} di = \int h_{j,t} f(j) dj$, $y_t = \int y_{i,t} di$, and $\tilde{\beta} = (1-g^d)\beta$. The above equations along with the laws of motion for productivity and the variance of shocks to productivity in equations 25-26, complete the description of equilibrium.

Note that equations 31 to 39 are isomorphic to a New Keynesian model with deep habits and infinitely-lived agents. The age structure of the economy only enter through two parameters, $\tilde{\beta}$ and $\tilde{\theta}$.

The (deterministic) steady state markup μ is given by,

$$\mu = \frac{\eta}{(\eta - 1) - \frac{\tilde{\theta}}{(1-\tilde{\theta})}(1 - (1 - g^d)\beta)} \tag{40}$$

which is increasing in the degree of habit persistence.[29] Further, aging or less demographically dynamic economies (low g) feature higher average deep habits (see equation 19) and thus higher markups. The model predicts that aging societies are characterized by larger average markups.

3.4. *Dynamic implications and responses to uncertainty shocks*

The model is calibrated to match the demographic patterns for 10 European countries which have been part of the Euro area since 2002 and the Euro area as a whole. One set of parameters (g^b and g^d) are set to match the range of values of life expectancy and population growth. Specifically, g^d is set to match data on life expectancy (in quarters after the age of 21) while the entry rate g^b is then set to match the model implied population growth rate ($g^b - g^d$). Given values for the demographic parameters, the parameters relating to deep habits and markups (θ, ν, and η) are then set to best match the cross-country demographic and average markup

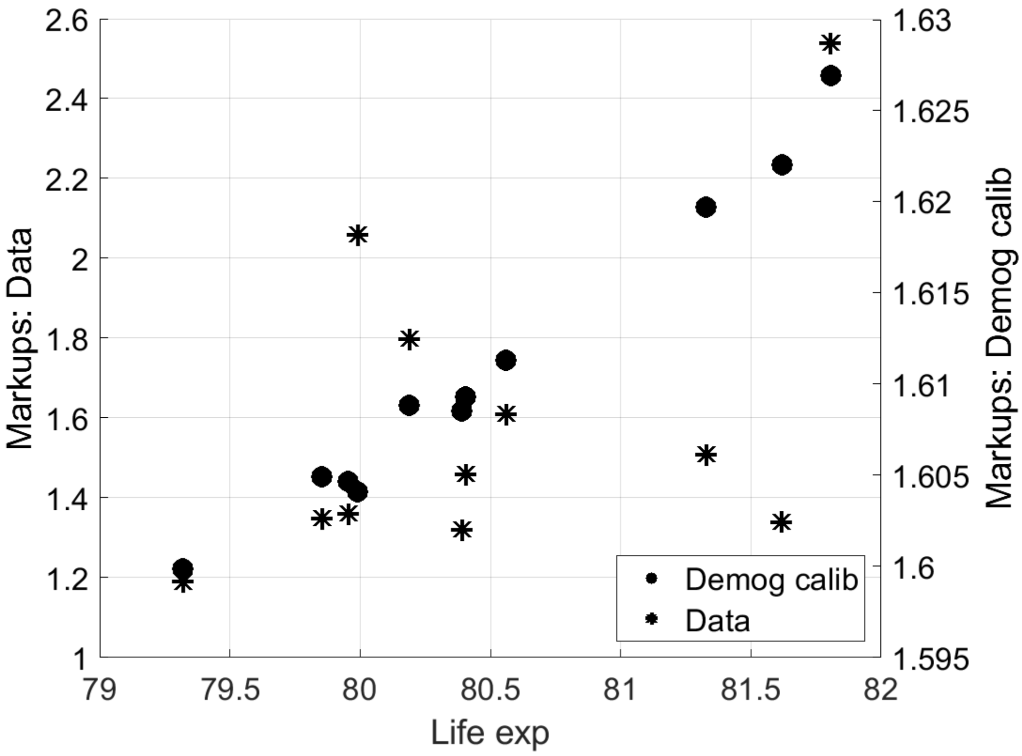
[29] In particular, $\frac{\partial \mu}{\partial \tilde{\theta}} = \mu^2 \frac{1-(1-g^d)\beta}{\eta(1-\tilde{\theta})^2}$. On the other hand, the effect of aging on steady state markups through the discount factor is negative. That is $\left.\frac{\partial \mu}{\partial g^d}\right|_{\tilde{\theta}} = \mu \frac{\tilde{\theta}\beta}{(\eta-1)-\tilde{\theta}(\eta-(1-g^d)\beta)}$.

patterns. The parameter η is set such that the calibrated steady state markup for the Euro area demographics calibration is closest to the data. The parameters θ and ν are then set to match the rest of the range of observed markups. This set of parameters are assumed to be the same across countries in the first set of calibrations such that all cross-country variation is due to differences in demographics parameters. Figure 8 reports the implied average markups generated by the calibration (right axis) against the data (left axis) with life expectancy on the horizontal axis. While the calibrated values generate the same positive relationship between markups and life expectancy as in the data, the variation in steady state markups only ranges from 1.60 to 1.63 whereas we observe a range of values from 1.19 to 2.54 in the data. The variation in deep habits cannot sufficiently cover the range of variation in markups observed in the data because the impact of deep habits on markups depends heavily on the discount factor (see equation 40). If the discount factor is very close to one, then variations in the deep habits parameter imply only small changes to the steady state markup. This is the case unless the deep habits parameter takes implausibly large values. That is, small variations of the deep habits parameter lead to large changes in steady state markups if and when it is already very close to one. Alternatively, if the discount factor were assumed to be lower, then the range of implied markups from the demographics calibration can also yield wider ranges.

Consequently, I consider a second set of calibrations in which the parameter η is also calibrated to match average markups in the data.

The rest of the parameters are calibrated based on the literature and are reported in Table A.9 of the Appendix. I then solve the model using third order perturbation methods (Andreasen et al., 2018) and simulate how the economy reacts to a shock to the volatility of productivity, an uncertainty shock. The size of the uncertainty shock is calibrated such that the cumulated response of inflation over a four-year

Figure 8: Demographics and markups calibration



Data (star symbols) and implied values (filled circles) from calibrated demographic parameters (g^b and g^d) with common values for θ, ν, and η.

period for the calibration of demographics and markups corresponding to the Euro area is the same as in the data.[30] When calculating such responses, I follow Basu and Bundick (2017) and all shock responses are initialized at the stochastic steady state.

Figure 9 plots the cumulated response of inflation over a 4-year period of various calibrations of the model matched to demographic and markup patterns in European countries.[31] While variations in demographics and hence the degree of deep habits can generate a positive correlation between the cumulated response of inflation to uncertainty shocks and demographics as observed in the data, it is not sufficient to match the range of responses of inflation across countries. The range of cumulated inflation responses produced by alternative demographic calibrations represent only 18 percent of the variation observed in the data (filled circles relative to stars in the figure). On the other hand, the model is able to replicate the full range of inflation responses to uncertain shocks once we fully allow for markups to match the data (hollow circles).[32] Consistent with the patterns documented in the empirical section of the paper, the model generates inflationary response to uncertainty shocks which are increasing in average markups, population growth and life expectancy.

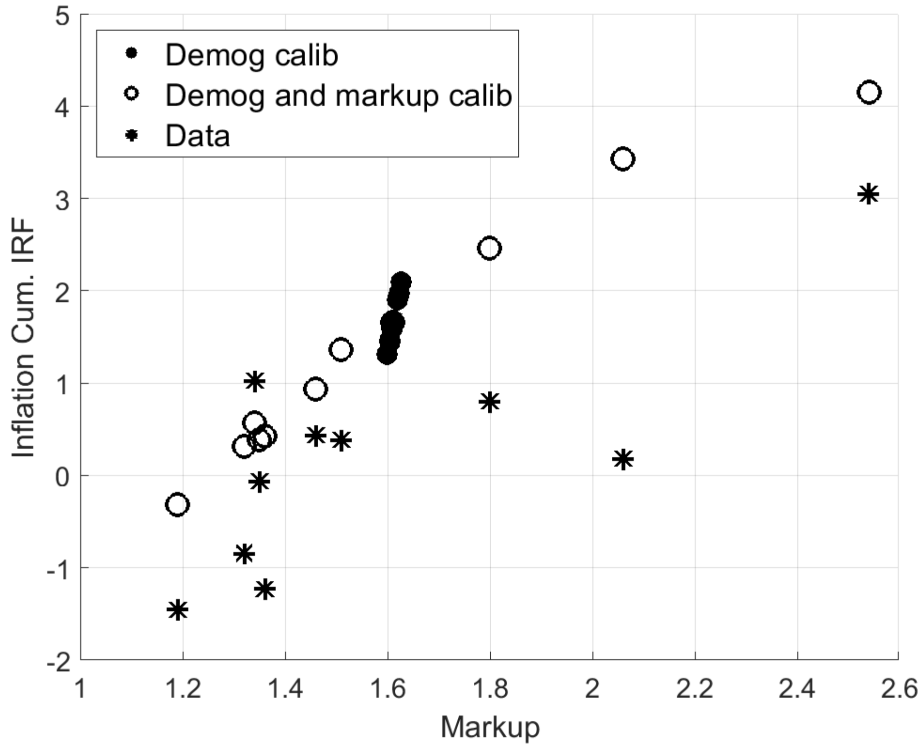
In sum, the simulation results tell us that (1) variations in the degree of the pricing bias mechanism as captured by differences in average markups can generate the observed variation in the responses of inflation to uncertainty shocks, and (2) demographics and age-specific deep habits alone cannot account for all of the observed variation in average markups across countries in Europe. While the age-dependent

[30] The volatility shock is assumed to have a persistence of 0.5 ($\rho_v = 0.5$) and steady state volatility is one ($\sigma_v^* = 1$).

[31] See Figure A.8 in the Appendix for a comparison of model-implied impulse responses relative to the VAR-evidence documented in Section 2.

[32] The level difference in model-implied cumulative responses relative to the data is mainly driven by forcing the calibration to exactly match the Euro area observation.

Figure 9: Cumulated inflation to response uncertainty across calibrations



Each dot represents simulations from a particular calibration of the model. The cumulated response of inflation over a 4-year horizon is on the vertical axes. The horizontal axes report the implied values of demographic characteristics (panel a) and markups (panel b) for each calibration. The size of the uncertainty shock is calibrated such that the cumulated response of inflation for the calibration of demographics and markups corresponding to the Euro area is the same as in the data.

deep habits mechanism can generate a positive relationship between demographics and inflation responses to uncertainty shocks, this mechanism by itself cannot generate sufficient variation in average markups to match the range of impulse responses observed in the data. That is, the results point to the need for other factors which generate differences in average markups. It should be noted that this is not inconsistent with the aims of the model as it is not meant to be an accurate depiction of (differences in) all aspects of economies in Europe. Clearly, other country characteristics play a role and may differ significantly across European countries. The model is purposely stylized and simplified to emphasize the link between demographics, markups, and inflation. What could help and complement the model mechanisms in matching the empirical observations?

The literature provides several other leading factors which generate differences in average markups across countries as well as the inflationary effects of uncertainty shocks. For instance, the model abstracts from labor market rigidities which have been shown to be one channel through which uncertainty shocks transmit to unemployment and inflation.[33] More generally, differences in the degree of nominal price and wage rigidities may play important roles in the differential responses of inflation to uncertainty. Another candidate is differences in the degree of competition among firms and the *superstar* firm phenomenon.[34]

Furthermore, the conduct of monetary policy, especially its systematic response to uncertainty shocks may also be crucial to the inflationary effects of uncertainty arising from various sources (Fernandez-Villaverde et al., 2015; Fasani and Rossi, 2018). Indeed, and consistent with the literature, in the Appendix I show that a modified monetary policy rule with a stronger response to output or one which directly responds to uncertainty shocks can lead to deflationary uncertainty shocks in the model. These results suggest that demographics combined with monetary policy, and potentially other factors that affect average markups are needed to quantitatively match the varying responses of inflation to uncertainty shocks observed across European countries.

4. Conclusion

In this paper, I construct a measure of household uncertainty which is available at a monthly frequency for many European countries and the Euro area as a whole.

[33] See e.g. Leduc and Liu (2016); Cacciatore and Ravenna (2020); den Haan et al. (2020) and Freund and Rendahl (2020) for models which focus on a search-and-matching friction.

[34] See for instance recent work by Covarrubias et al. (2019); Autor et al. (2020); De Loecker et al. (2020) and De Loecker and Eeckhout (2020).

I show that the macroeconomic effects of household uncertainty shocks in Europe differ from the effects of shocks to uncertainty arising from financial markets and policy. For the Euro area and many European countries, shocks to household uncertainty do not act like negative demand shocks. Instead, household uncertainty shocks are inflationary in Europe and have a delayed impact on unemployment. One explanation may be a *pricing bias* transmission mechanism coupled with monetary policy in the Euro area which does not or only weakly responds to household uncertainty shocks. A comparison across countries indicate a link between demographics, average markups, and inflationary uncertainty shocks. In turn, this suggests that demographics may be related to factors underlying the *pricing bias* mechanism such as the degree of nominal rigidities and elasticities of substitution (firm market power) crucial to the determination of markups.

This paper proposes one hypothesis relating demographics to average markups through deep habits to rationalize these observations. I find that while differences in demographics can explain part of the results, other channels and mechanisms would be needed to fully account for the observed differences across countries. The results presented in this paper points to the need for additional channels and alternatives. For instance, the model abstracts from potential links between demographics, the propensity to supply labor, and labor market rigidities. It also does not feature a rich enough asset market to fully explore how the precautionary behavior of households could affect the supply of savings and the demand for assets of varying riskiness. Exploring these complementary alternatives is left for future work. It should also be noted that the underlying source of differences in demographic patterns (e.g. by immigration) are left unexplored.

These results also have important policy implications. Uncertainty shocks which raise unemployment and inflation imply that a trade-off is present when considering the appropriate (monetary) policy response. Further, demographic conditions may amplify or attenuate this policy trade-off. Consequently, differences in demographic conditions in the Euro area imply that a common policy reaction to uncertainty shocks would have heterogeneous effects across member countries.

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Appendix

Data sources.

Survey data is taken from the European harmonized consumer survey and augmented with macroeconomic variables taken from the European Statistical Data Warehouse. In addition the economic policy uncertainty measure by Baker et al. (2016) is obtained from their website while the option-implied volatility measure of uncertainty is taken from *Stoxx Ltd*.[35] Average markups are taken from Table 1 of De Loecker and Eeckhout (2020) and available for 13 of the 20 countries in the sample. Their estimates for Europe are used in place of estimates for the Euro area. These estimated markups are for the year 2016 and are sales-weighted averages from firm-level estimates. Finally, additional country characteristics are obtained from the World Bank's World Development Indicators database.

The calculation for the various survey-based indices are detailed in the main text.[36] The countries and regions covered in the analysis along with variable descriptions are provided in Table A.1.

[35] https://www.policyuncertainty.com/ and https://www.stoxx.com/index-details?symbol=V2TX.
[36] Data available here.

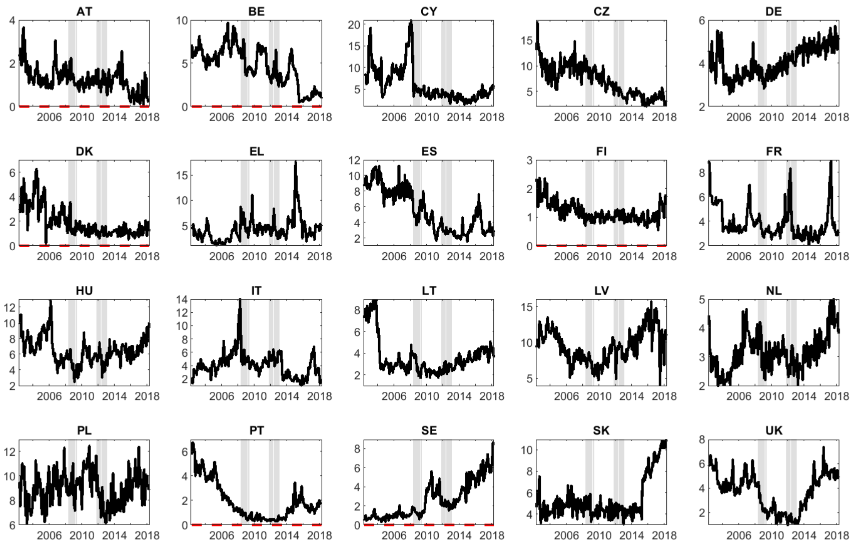
Table A.1: Data coverage

Region		Variable		
Name	Symbol	Variable name	Description	Source
Austria	AT	HUN	Index of household uncertainty	Consumer survey
Belgium	BE	CSI	Consumer sentiment index	Consumer survey
Cyprus	CY	DIS	Index of household belief dispersion	Consumer survey
Czechia	CZ	VSTOXX	Option-implied volatility of Eurostoxx 50	Stoxx Ltd.
Germany	DE	EPU	Baker et al. (2016) European policy uncertainty index	https://www.policyuncertainty.com
Denmark	DK	Industrial production growth	Y-o-y change in log industrial production	Statistical Data Warehouse
Greece	EL	HICP inflation	Y-o-y change in log HICP	Statistical Data Warehouse
Spain	ES	Short interest rate	Daily market rate (EONIA for EA countries)	Statistical Data Warehouse
Finland	FI	Unemployment	Y-o-y difference in unemployment rate	Statistical Data Warehouse
France	FR	Term spread	10-year sovereign bond yields less short rate	Statistical Data Warehouse
Hungary	HU	Expected durable expenditures	Index of household planned durable expenditures	Consumer survey
Italy	IT	Right time to buy	Index of household views on right time	Consumer survey
Lithuania	LT		to make large purchases	
Latvia	LV	Change in financial situation	Index of change in household financial situation	Consumer survey
Netherlands	NL	Markups	Values for 2016 in Table 1	De Loecker and Eeckhout (2020)
Poland	PL	Income per capita growth	Adjusted net national income per capita annual growth	World Bank WDI
Portugal	PT	GDP	Constant 2010 USD	World Bank WDI
Sweden	SE	GDP per capita growth	Annual growth	World Bank WDI
Slovakia	SK	Investment to GDP	Gross fixed capital formation to GDP	World Bank WDI
United Kingdom	UK	Savings to GDP	Gross domestic savings to GDP	World Bank WDI
Euro Area	EA	Current Account to GDP	Current account balance to GDP	World Bank WDI
		Trade to GDP	Total trade to GDP	World Bank WDI
		Share industry	Industry value added to GDP	World Bank WDI
		Share services	Services value added to GDP	World Bank WDI
		Credit to GDP	Domestic financial sector credit to GDP	World Bank WDI
		Employment to population	Employment to population ratio (15+)	World Bank WDI
		Labor force participation rate	Labor force to population ratio (15+)	World Bank WDI
		Share self-employed	Self-employed to total employment	World Bank WDI
		Share vulnerable employment	ILO estimated share to total employment	World Bank WDI
		GINI Index	World Bank estimate	World Bank WDI
		Income share top 10%	Income share held by first decile	World Bank WDI
		Share tertiary educ. (+25)	Share of population (+25) with at least Bachelor's or equivalent	World Bank WDI
		Share secondary educ. (+25)	Share of population (+25) with at least post-secondary	World Bank WDI
		Literacy rate	Share of population (+15)	World Bank WDI
		Life expectancy	Life expectancy at birth in years	World Bank WDI
		Population growth	Annual percent	World Bank WDI
		Share female	Percent of total population	World Bank WDI
		Share rural population	Percent of total population	World Bank WDI
		Legal rights index	Strength of legal rights (0=weak to 12=strong)	World Bank WDI

World Bank data are averages over the period 2002-2017. Average markups are estimated 1981-2004 averages. All other data are monthly over the period May 2002-April 2018. The VSTOXX and EPU are treated as Euro area variables.

Figure A.1 plots the time-series evolution of the household uncertainty measure for each of the 20 European countries.

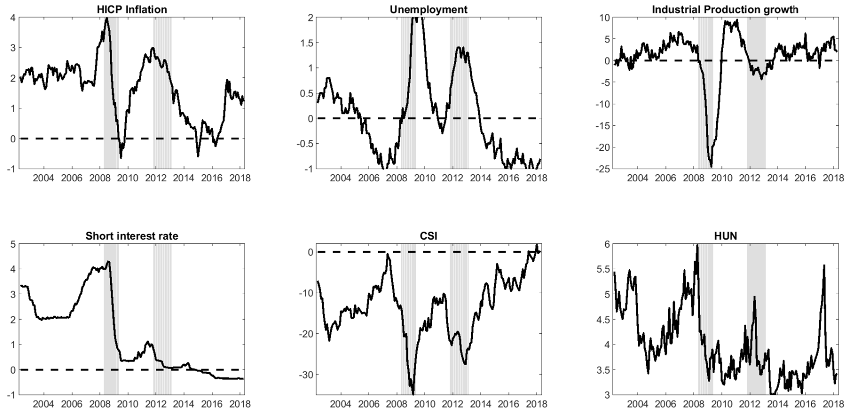
Figure A.1: Household uncertainty across Europe



The panels plot the household uncertainty measure, HUN, for the 20 European countries in the sample. Shaded areas are Euro area peak-to-trough periods.

Figure A.2 plots the evolution of several key variables used in the analysis for the Euro area.

Figure A.2: Euro area household expectations and macro variables

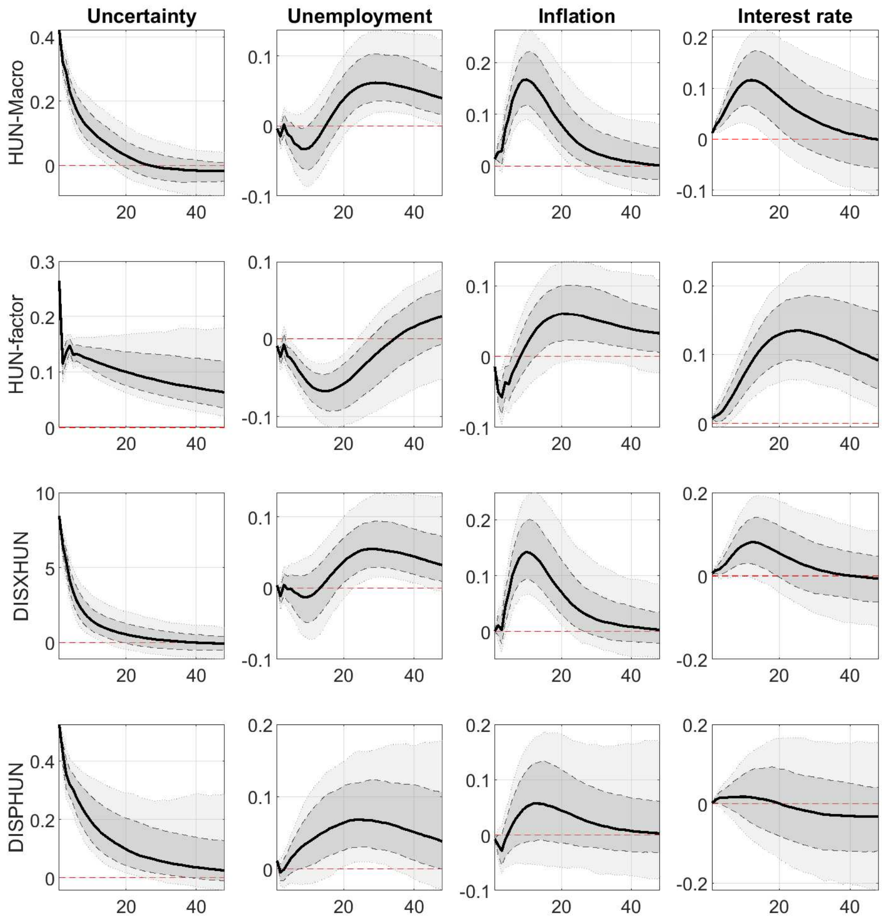


HICP inflation and Industrial Production growth are year-on-year growth rates of of the consumer price index and industrial production respectively. Unemployment is the year-on-year difference in unemployment rates. Short interest rate and Term spread are daily money market rates and the term spread (10-year rates less daily market rates) respectively. CSI, DIS, and HUN are indices of consumer sentiment, dispersion of beliefs, and household uncertainty respectively. All series are Euro area averages. Shaded areas are Euro area peak-to-trough periods.

Robustness of the effects of uncertainty on inflation and unemployment.

The results for the Euro area are also robust to alternative measurements of Euro area uncertainty. First, the result remains when the household uncertainty index is constructed solely from the two questions pertaining to households' expectations about future general economic activity and unemployment ($HUN-Macro$). Second, uncertainty shocks are still inflationary in the Euro area when the Euro area measure of household uncertainty is the common factor from the country-level measures of household uncertainty for 10 countries in the sample which are in the Eurozone ($HUN-Factor$). The countries included in the factor analysis are those which have been part of the Euro area for the full sample period. The list of countries are reported in Table A.2. The top two rows of Figure A.3 plots impulse responses to shocks based on these alteranative measures of Euro area household uncertainty. An interesting outcome is that shocks to the common factor measure of Euro area household uncertainty also appear to lower unemployment. Note however that the loadings of the country-level household uncertainty measures for the 10 Euro area countries on the common factor do not all have the same sign. Table A.2 reports these factor loadings. Further, as the factor extraction process does not take into account the relative sizes of the economies, as would have been the case with simple aggregated measures, it is not clear whether the common factor approach to deriving a Euro area measure of household uncertainty would be appropriate.

Figure A.3: impulse responses from alternative Euro area household uncertainty measures



The panels report median impulse responses to one standard deviation shocks to alternative measures of Euro area household uncertainty. Each column reports responses for a given variable. The source, or measure, of uncertainty is given by the row labels. HUN-Macro is the measure of household uncertainty for the Euro area using only survey responses to expected future economic activity and unemployment. HUN-factor is the common factor in each of the household uncertainty indices of 10 Euro area countries in the sample. DISXHUN is the product of the HUN and DIS variables and DISPHUN is the sum of the standardized DIS and HUN variables. The shaded areas reflect 68% and 90% confidence sets.

Table A.2: Factor loadings of household uncertainty indices on Euro area common factor

Austria	Belgium	Germany	Greece	Spain
0.451	0.592	-0.399	-0.373	0.904
Finland	France	Italy	Netherlands	Portugal
0.639	0.372	0.139	-0.271	0.749

Contemporaneous correlations of the various Euro area measures of uncertainty are reported in Table A.3

Table A.3: Correlations of Euro area measures of uncertainty

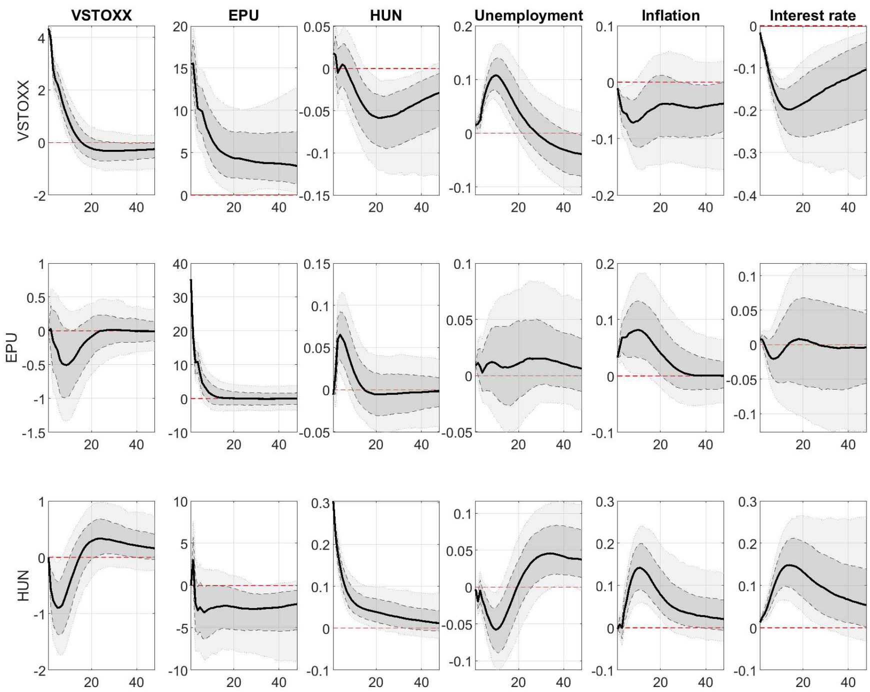
	CSI	DIS	HUN	HUN-Macro	HUN-Factor	VSTOXX	EPU
CSI	1						
DIS	-0.45726***	1					
HUN	0.07683	-0.33877***	1				
HUN-Macro	0.26442***	-0.38619***	0.95587***	1			
HUN-Factor	-0.06086	-0.48619***	0.66152***	0.62465***	1		
VSTOXX	-0.50458***	0.18973***	0.14878**	0.031185	0.16315**	1	
EPU	0.00038295	0.25806***	-0.26164***	-0.2335***	-0.52725***	0.21968***	1

*,**,*** *represent statistical significance at the 10, 5, and 1% respectively.*

We also observe similar results when the measure of uncertainty is some combination of DIS and HUN where DISXHUN is the product of the two variables and DISPHUN is the sum of the standardized DIS and HUN variables. The bottom two rows of Figure A.3 plots impulse responses of unemployment, inflation, and interest rates to shocks to a combination of DIS and HUN.

The inflationary effects of household uncertainty shocks remain even if we account for uncertainty arising from multiple sources. Figure A.4 plots impulse responses in a VAR much like in the benchmark analysis but with three measures for uncertainty: VSTOXX, EPU, HUN, Unemployment, Inflation, and Interest rate. Shocks are identified recursively and variables are ordered as indicated in the previous sentence. Here we find that uncertainty shocks from the financial measure, ordered first, do act like negative aggregate demand shocks in that it leads to higher unemployment and lower inflation and interest rates. More importantly, the main result of the paper is still obtained in that household uncertainty shocks (ordered third in the VAR) still feature a delayed increase in unemployment and is still inflationary.

Figure A.4: Impulse responses in a VAR with multiple uncertainty measures

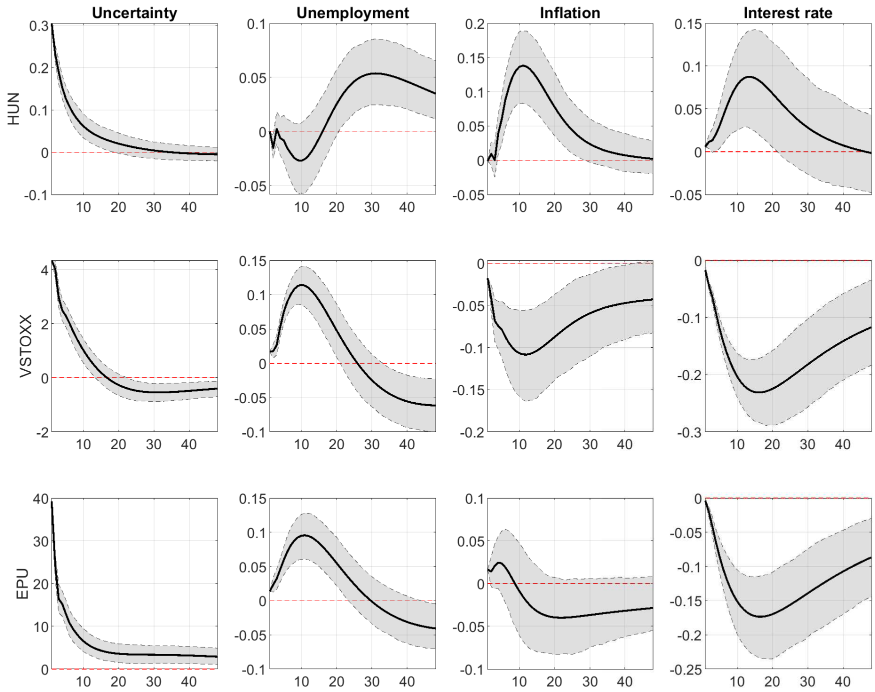


The panels report median impulse responses to one standard deviation shocks to uncertainty from various sources. Each column reports responses for a given variable. The source, or measure, of uncertainty is given by the row labels. HUN is the measure of household uncertainty for the Euro area. VSTOXX is the option-implied volatility of the Eurostoxx 50 index. EPU is the Baker et al. (2016) measure of economic policy uncertainty for Europe. The shaded areas reflect 68% and 90% confidence sets.

The results are also not driven by the assumed priors in the Bayesian VAR. Figure A.5 reports impulse responses from a of recursively-identified shocks in a VAR estimated by Ordinary Least Squares.

I also verify if the results remain in a panel-VAR setting for Euro area countries. In particular I estimate panel VARs for the five largest Euro area economies in the sample (Germany, France, Italy, Spain, and the Netherlands). First, I use the mean-group panel VAR proposed by Pesaran and Smith (1995) as a simple

Figure A.5: Impulse responses from an OLS-VAR

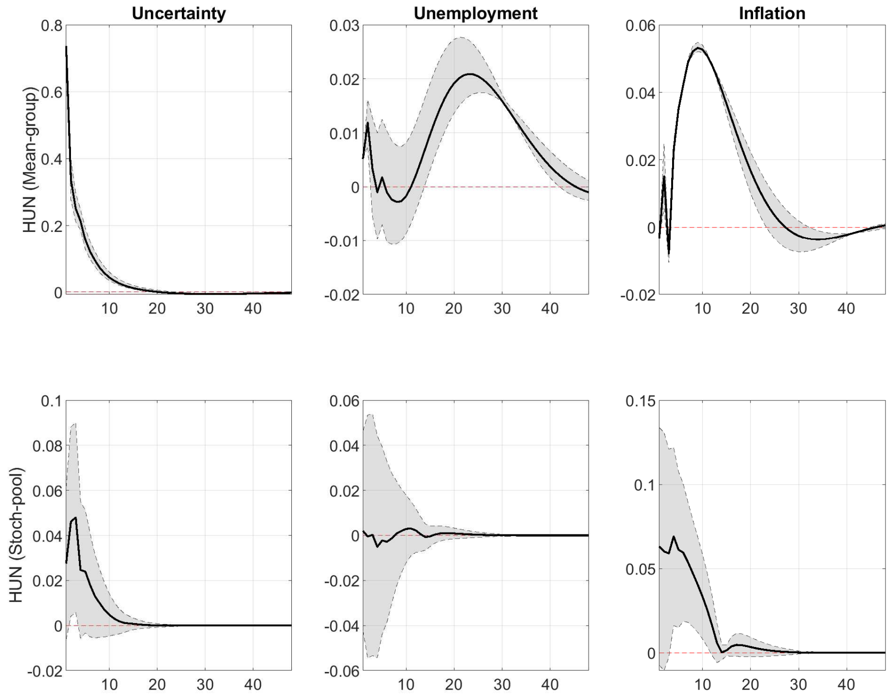


The panels report median impulse responses to one standard deviation shocks to uncertainty. Each column reports responses for a given variable. The source, or measure, of uncertainty is given by the row labels. HUN is the measure of household uncertainty for the Euro area. VSTOXX is the option-implied volatility of the Eurostoxx 50 index. EPU is the Baker et al. (2016) measure of economic policy uncertainty for Europe. The shaded areas reflect 68% confidence intervals.

way to aggregate information across countries. The estimator assumes that the VAR coefficients for each of the units (countries) are potentially heterogeneous but are randomly drawn from a distribution with a common mean. Second, I employ stochastic pooling as in Canova and Pappa (2007) to combine information from country-specific impulse responses. In the stochastic pooling approach, it is the coefficients in the estimated country-specific impulse response functions themselves which are assumed to be heterogeneous and randomly drawn from a distribution with a common mean.[37] Results are reported in Figure A.6

[37]The *average* impulse response is the averaged impulse response from each country weighted by the precision by which each impulse response is generated. Bootstrapped estimates of the variance of impulse response coefficients were used to weigh the impulse responses.

Figure A.6: Panel VAR impulse responses



The panels report impulse responses to one standard deviation shocks to household uncertainty. Each column reports responses for a given variable. The panel VAR method is given by the row labels. The shaded areas reflect 68% confidence intervals.

Country characteristics and the effects of household uncertainty.

To get a sense of what may be driving the heterogeneiety of impulse responses to household uncertainty shocks, I collect several country characteristics variables from the World Banks' World Development Indicators database for the 20 European countries in the sample. I also include variables similar to those documented in Mumtaz et al. (2018) as important factors for heterogeneity across US states. Each country characteristic is the average from 2002-2017, similar in coverage to the sample used in the VAR analysis. Tables A.5 and A.4 report univariate regressions of the cumulated median impulse responses (over a 48 month period) of unemployment and inflation to household uncertainty shocks respectively with country characteristics as explanatory variables.

Table A.4: Regression of cumulated impulse responses of inflation to household uncertainty shocks on country variables

	Beta	**se**	**p-val**	**R-sq**	**Obs**
Markup	1.04	0.62	0.10	0.19	13.00
Share female	-1.58	0.43	0.00	0.41	20.00
Population growth	2.69	0.81	0.00	0.37	20.00
Share secondary educ. (+25)	-0.15	0.06	0.01	0.24	20.00
Life expectancy	0.41	0.20	0.04	0.19	20.00
Income per capita growth	-0.58	0.30	0.05	0.17	20.00
GINI Index	-0.25	0.17	0.15	0.10	20.00
Income share top 10	-0.41	0.28	0.15	0.10	20.00
GDP per capita growth	-0.49	0.36	0.18	0.09	20.00
Credit to GDP	0.01	0.01	0.21	0.08	20.00
Share self-employed	0.10	0.09	0.28	0.06	20.00
Share vulnerable employment	0.11	0.11	0.29	0.06	20.00
Literacy rate	-0.40	0.57	0.49	0.06	9.00
Share tertiary educ. (+25)	-0.10	0.11	0.39	0.04	19.00
Legal rights index	-0.22	0.28	0.45	0.03	20.00
GDP	0.00	0.00	0.53	0.02	20.00
Current Account to GDP	0.05	0.14	0.75	0.01	20.00
Trade to GDP	-0.01	0.02	0.71	0.01	20.00
Savings to GDP	0.06	0.12	0.61	0.01	20.00
Investment to GDP	-0.01	0.25	0.97	0.00	20.00
Labor force participation rate	0.05	0.13	0.69	0.01	20.00
Employment to population	0.01	0.12	0.93	0.00	20.00
Share services	0.05	0.12	0.69	0.01	20.00
Share industry	0.02	0.12	0.87	0.00	20.00
Government to GDP	-0.01	0.25	0.96	0.00	20.00

The dependent variable is the cumulated median impulse response (over a 48-month horizon) of inflation to household uncertainty shocks. Markups are for 2016 and taken from De Loecker and Eeckhout (2020). Other country variables are 2002-2017 averages for 20 European countries obtained from the World Bank World Development Indicators database. The univariate regressions include a constant term.

The regression results indicate that the cumulated impulse response of unemployment to household uncertainty shocks is increasing in average real GDP, the share of vulnerable and self-employed, and decreasing in employment to population and labor force participation ratios. On the other hand, the cumulated impulse response of inflation to household uncertainty shocks is decreasing in income per capita growth, share of population with post-secondary education, and increasing in life expectancy and population growth.

Table A.5: Regression of cumulated impulse responses of unemployment to household uncertainty shocks on country variables

	Beta	se	p-val	R-sq	Obs
Markup	1.32	1.79	0.46	0.04	13.00
Share self-employed	0.28	0.07	0.00	0.45	20.00
Share vulnerable employment	0.30	0.09	0.00	0.38	20.00
Employment to population	-0.22	0.10	0.04	0.18	20.00
Trade to GDP	-0.03	0.02	0.04	0.18	20.00
Share services	0.20	0.11	0.07	0.15	20.00
Share industry	-0.21	0.11	0.07	0.15	20.00
Savings to GDP	-0.20	0.11	0.08	0.14	20.00
GDP per capita growth	-0.61	0.35	0.08	0.14	20.00
Labor force participation rate	-0.21	0.12	0.08	0.14	20.00
Literacy rate	-0.71	0.63	0.26	0.14	9.00
Income per capita growth	-0.50	0.31	0.10	0.12	20.00
Legal rights index	-0.37	0.28	0.18	0.09	20.00
Life expectancy	0.29	0.21	0.16	0.09	20.00
Investment to GDP	-0.31	0.24	0.19	0.08	20.00
GINI Index	0.21	0.17	0.22	0.07	20.00
Income share top 10	0.21	0.30	0.49	0.02	20.00
Share female	-0.61	0.55	0.27	0.06	20.00
Current Account to GDP	-0.10	0.14	0.48	0.03	20.00
GDP	0.00	0.00	0.49	0.02	20.00
Government to GDP	-0.08	0.25	0.76	0.01	20.00
Credit to GDP	0.00	0.01	0.65	0.01	20.00
Population growth	0.21	1.02	0.84	0.00	20.00
Share tertiary educ. (+25)	0.03	0.12	0.78	0.00	19.00
Share secondary educ. (+25)	-0.02	0.07	0.78	0.00	20.00

The dependent variable is the cumulated median impulse response (over a 48-month horizon) of unemployment to household uncertainty shocks. Markups are for 2016 and taken from De Loecker and Eeckhout (2020). Other country variables variables are 2002-2017 averages for 20 European countries obtained from the World Bank World Development Indicators database. The univariate regressions include a constant term.

Correlation of country characteristics.

Table A.6 reports the correlations of country variables that were found to be most correlated with the variation in cumulated inflation responses to household uncertainty shocks. The left-most columns report correlations using all available observations while the right-most columns report correlations when the sample is restricted to the 10 countries who are also part of the Euro area.

Table A.6: Correlations of country characteristics

	Full sample					Euro area				
	Markup	**Pop growth**	**Life exp**	**Sec Educ**	**Inc growth**	**Markup**	**Pop growth**	**Life exp**	**Sec Educ**	**Inc growth**
Markup	1.000	0.036	-0.106	-0.053	-0.259	1.000	0.090	0.443	-0.313	-0.708
	(13)	(13)	(13)	(13)	(13)	(10)	(10)	(10)	(10)	(10)
Pop growth	0.036	1.000	0.802	-0.195	-0.780	0.090	1.000	0.600	0.244	0.031
	(13)	(20)	(20)	(20)	(20)	(10)	(10)	(10)	(10)	(10)
Life exp	-0.106	0.802	1.000	-0.216	-0.912	0.443	0.600	1.000	-0.270	-0.441
	(13)	(20)	(20)	(20)	(20)	(10)	(10)	(10)	(10)	(10)
Sec Educ	-0.053	-0.195	-0.216	1.000	0.403	-0.313	0.244	-0.270	1.000	0.555
	(13)	(20)	(20)	(20)	(20)	(10)	(10)	(10)	(10)	(10)
Inc growth	-0.259	-0.780	-0.912	0.403	1.000	-0.708	0.031	-0.441	0.555	1.000
	(13)	(20)	(20)	(20)	(20)	(10)	(10)	(10)	(10)	(10)

The table reports Pearson correlation coefficients. Figures in parentheses are the number of observations (countries) used to calculate correlations. Correlation coefficients in the five columns on the right are restricted to Euro area countries. Markups are 2016 estimates from De Loecker and Eeckhout (2020). Other country variables are 2002-2017 averages obtained from the World Bank World Development Indicators database.

For the full country sample coverage, only income per capita growth correlate (negatively) with markup estimates. Population growth and life expectancy are positively correlated with each other and both are negatively correlated with the share of the population with post-secondary education. In turn, population growth and life expectancy are negatively correlated with income per capita growth while the share of the population with post-secondary education is positively correlated with income per capita growth. When the sample is restricted to Euro area countries, average markups are now positively correlated with life expectancy and negatively correlated with post-secondary education.

Robustness to alternative markup estimates.

I collect additional markup data for the countries in my sample from Christopoulou and Vermeulen (2012) and Weche and Wambach (2018).[38] There are substantial differences in the coverage of the markup estimates. First, markups from De Loecker and Eeckhout (2020) are estimates for 2016 and covers 13 countries in my sample, 10 of which are in the Euro area.[39] Further, their estimates for *Europe* are used in place of an estimate for the Euro area. On the other hand I use estimates for 8 countries, all of which are in the Euro area, as well as the Euro area estimates of Christopoulou and Vermeulen (2012) which are averages for the period 1981-2004. Finally, I take 7 country estimates from Weche and Wambach (2018) of which three are in the Euro area and which are averages over the period 2007-2012. All three sources provide estimates for Belgium, Germany, and Finland.

To make these markup estimates comparable, I standardize these estimates in terms of percentage deviations from estimated markups for Germany in each of the respective sources. In turn estimates for Germany across sources are normalized to equal the value in De Loecker and Eeckhout (2020). Table A.7 reports estimated correlations across these markup estimates along with the sample coverages. Given that all of the country estimates in Christopoulou and Vermeulen (2012) are also represented in the estimates from De Loecker and Eeckhout (2020), it is relatively not surprising that there is a strong positive correlation in the markup estimates across these two sources. On the other hand, estimates from Weche and Wambach

[38]Estimates from Christopoulou and Vermeulen (2012) are taken from Table 1 and reflect all sector averages over the period 1981-2004. Estimates from Weche and Wambach (2018) are the same as those used in Figure 5 of their paper and reflect averages for the period 2007-2012. I thank John Weche for graciously providing their detailed data.

[39]These are taken from Table 1 of their paper.

(2018) which are predominantly for non-Euro area countries and of which only four overlap with estimates from De Loecker and Eeckhout (2020), it is also not surprising to find no strong correlation between estimates from these two sources. It should also be noted that given the differences in time periods covered, and particularly differences in trend movements in average markups across countries which are also documented in these references, that the lack of a strong correlation need not indicate inconsistency. Finally, the correlation between markup estimates from Christopoulou and Vermeulen (2012) and Weche and Wambach (2018), which covers three Euro are countries, is positive.

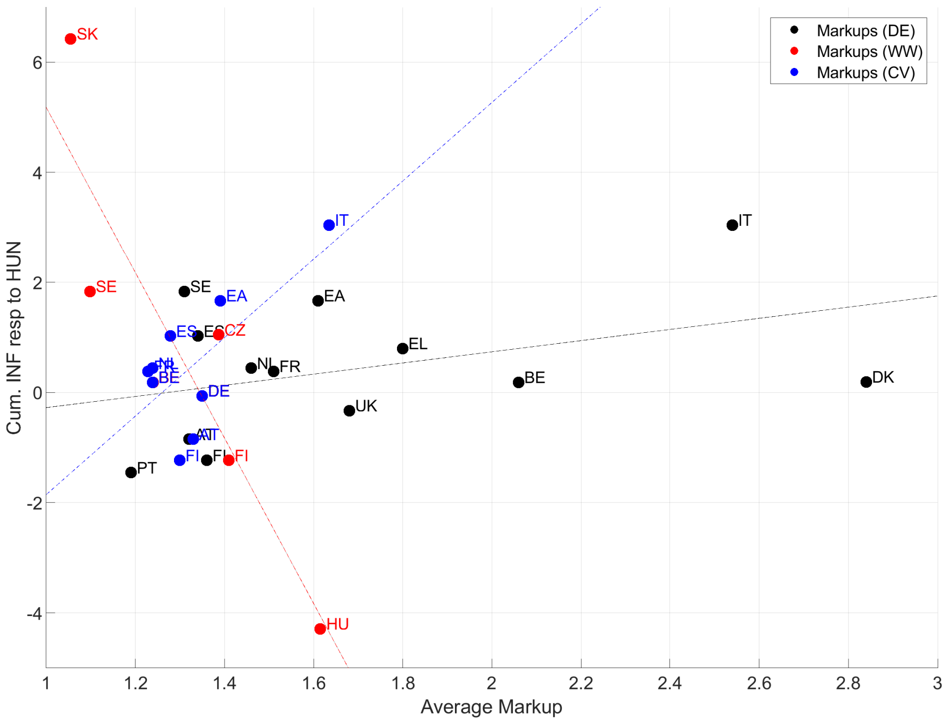
Table A.7: Correlations of markup estimates

	Markup (DE)	**Markup (WW)**	**Markup (CV)**
Correlations			
Markup (DE)	1.00	-0.11	0.68
Markup (WW)	-0.11	1.00	0.68
Markup (CV)	0.68	0.68	1.00
Coverage			
Period	2016	2007-2012	1981-2004
Countries			
Austria	Yes	No	Yes
Belgium	Yes	Yes	Yes
Czechia	No	Yes	No
Germany	Yes	Yes	Yes
Denmark	No	No	Yes
Greece	No	No	Yes
Spain	Yes	No	Yes
Finland	Yes	Yes	Yes
France	Yes	No	Yes
Hungary	No	Yes	No
Italy	Yes	No	Yes
Netherlands	Yes	No	Yes
Portugal	No	No	Yes
Sweden	No	Yes	Yes
Slovakia	No	Yes	No
United Kingdom	No	No	Yes

Markup (DE) are taken from De Loecker and Eeckhout (2020), Markup (WW) are from Weche and Wambach (2018), and Markup (CV) are from Christopoulou and Vermeulen (2012).

Figure A.7 plots these standardized markup estimates against the cumulated response of inflation to household uncertainty shocks. Linear fit lines (dashed) are also included for reference. The figure indicates a positive relationship between markups and inflationary household uncertainty shocks when using the estimates from either De Loecker and Eeckhout (2020) or Christopoulou and Vermeulen (2012). On the other hand, a negative relationship is apparent when using estimates from Weche and Wambach (2018). This difference seems to be driven by the degree to which the various estimates cover Euro area countries. In Table A.8, I regress the cumulated median impulse response of inflation to household uncertainty shocks against these three sources of estimates for markups and include a specification which interacts markups with a dummy variable for Euro area member countries. I also include a specification which adds as an additional control variable income per capita growth which is also one country characteristic with a strong correlation with the documented cumulated impulse responses.

Figure A.7: Alternative markup estimates



The dots represent cumulated median impulse responses from shocks to household uncertainty against average markup estimates from De Loecker and Eeckhout (2020); Weche and Wambach (2018) and Christopoulou and Vermeulen (2012).

The regression results, particularly the coefficients reported in columns 2,3,7 and 8 of Table A.8, confirm the hypothesis that there is a positive relationship between markups and inflationary household uncertainty shocks for Euro area countries. On the other hand, regression results when using estimates from Weche and Wambach (2018) which cover mostly non-Euro area countries suggest a negative relationship.

Table A.8: Regression of cumulated impulse responses of inflation to household uncertainty shocks on markups

Dep. var.: Cum Inflation IRF	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Constant	-1.433	1.939	1.883	20.199	20.841	16.660	-8.548	-4.277
	(1.131)	(1.661)	(2.037)	(4.425)	(5.321)	(3.990)	(3.874)	(5.087)
Markup (DE)	1.040	-0.707	-0.706					
	(0.648)	(0.810)	(0.860)					
Markup (WW)				-15.018	-15.198	-14.994		
				(3.352)	(4.066)	(2.686)		
Markup (CV)							6.731	3.987
							(2.912)	(3.576)
Dum EA		-5.609	-5.641		-11.094	-5.005		
		(2.043)	(2.243)		(20.969)	(14.115)		
Markup (DE) x Dum EA		3.154	3.194					
		(1.087)	(1.369)					
Markup (WW) x Dum EA					7.611	4.962		
					(15.727)	(10.451)		
Income per cap growth			0.044			1.574		-1.065
			(0.803)			(0.712)		(0.866)
R-squared	0.189	0.581	0.581	0.801	0.838	0.953	0.471	0.594
Obs	13	13	13	7	7	7	8	8

The dependent variable is the cumulated median impulse response (over a 48-month horizon) of inflation to household uncertainty shocks. Markup (DE) are for the year 2016 and taken from De Loecker and Eeckhout (2020). Markup (WW) are averages for the period 2007-2012 from Weche and Wambach (2018). Markup (CV) are averages for the period 1981-2004 from Christopoulou and Vermeulen (2012). Dum EA is a dummy variable for Euro area member countries since 2002.

Model and calibration appendix.

The model's calibrated parameters are reported in the table below.

Table A.9: Calibrated parameters

Parameter		Symbol	Value	Target
Demographics index		g	0.0041-0.0043	Cross-section of life expectancy and population growth
Deep habits		$\tilde{\theta}$	0.9028-0.9209	Cross-section of markups
Discount factor		β	0.99	Annual real rate of 4%
Risk aversion		σ	3	Following Ravn et al. (2010)
Inverse labor elasticity		κ	0.5	Following Ravn et al. (2010)
Demand elasticity		η	3.02	European average markups
			1.92-7.09	Country-specific markups
Price rigidity		δ	17.5	Equivalent to average Calvo price duration of 3 quarters
Monetary policy				
	Persistence	ρ_r	0.925	Determinacy (Zubairy, 2014)
	Inflation coefficient	α_π	1.5	Conventional values
	Output coefficient	α_y	0.2	Conventional values
	Uncertainty coefficient	α_v	0.0045	Range of deflationary uncertainty shocks
Productivity				
	Mean	$\bar{A}$	exp(5.85)	Steady state labor (h) of 0.33
	Persistence	ρ_a	0.96	Fernald (2014)
	Volatility	σ_a	0.008	Fernald (2014)

The parameter for demand elasticity is set to 3.02 in the first set of calibrations which gives rise to steady state markup of 1.61 equal to the European average in the data. In the second set of calibrations where the parameter is set to match observed markups in the data (ranging from 1.19 to 2.54), the parameter η takes values between 1.92 and 7.09.

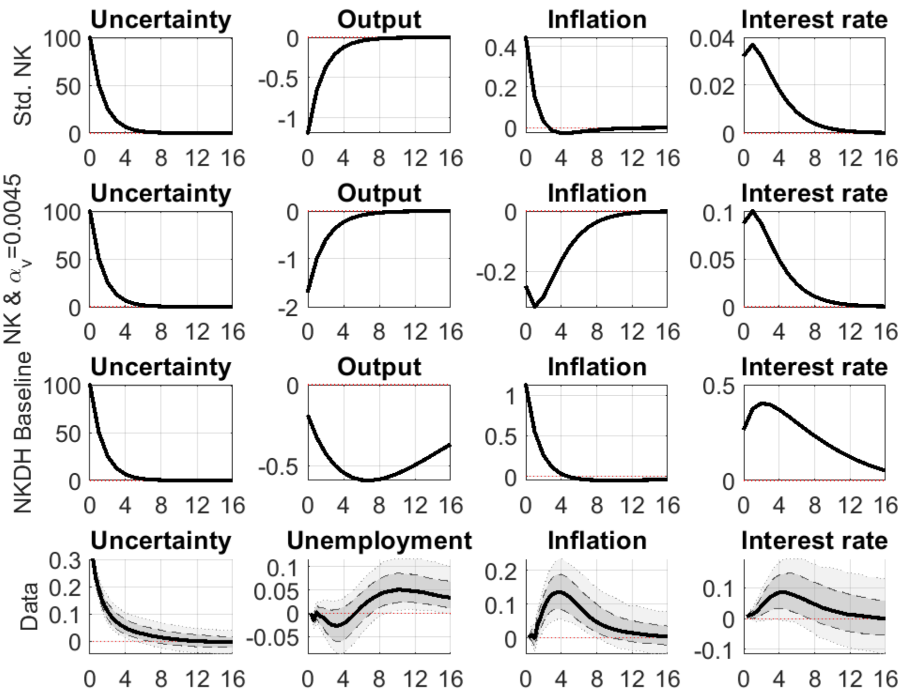
It should be noted that the parameters relating to monetary policy are different than those typically assumed in the literature. Notably, the persistence parameter is significantly larger at 0.925. This is because of altered determinacy conditions in New Keynesian models with deep habits (see Zubairy, 2014). Since deep habits can lead to self-fulfilling demand expectations and consequently indeterminacy, the persistence parameter in the monetary policy rule has been enlarged to ensure determinacy in all calibrations for the deep habits parameter. Further the calibrated value of the uncertainty coefficient in the monetary policy rule is lower but close to the 0.005 value in Fernandez-Villaverde et al. (2015). This small adjustment was done to better match the range of observed inflation impulse responses to uncertainty shocks in the data.

For reference on the implications of deep habits in the model, the next two figure shows impulse responses to an uncertainty shock in a similarly calibrated standard New Keynesian model, the baseline New Keynesian model with Deep habits, and two variations of the baseline model. The baseline model corresponds to the calibration for the Euro area. The standard New Keynesian model is similarly calibrated to the baseline except that the deep habits parameter is set to zero and monetary policy does not respond to uncertainty shocks ($\alpha_v = 0$). A second version of the standard New Keynesian model in which the monetary policy rule includes an uncertainty term is also simulated. Figure A.8 plots impulse responses over a four-year period to uncertainty shocks from the standard New Keynesian model, the New Kenyesian model with the augmented monetary policy rule, the baseline calibration of the model, and the baseline VAR from the main text.

Deep habits generate more hump-shaped and more persistent responses. Since uncertainty shocks are also more inflationary, it also generates an interest rate response that is increasing in uncertainty shocks.

I next consider variations in the monetary policy rule in the baseline model. In the first variation of the baseline model, the coefficient on output in the monetary policy rule is increased to 0.8 from 0.2 in the baseline model ($\alpha_y = 0.8$). In the

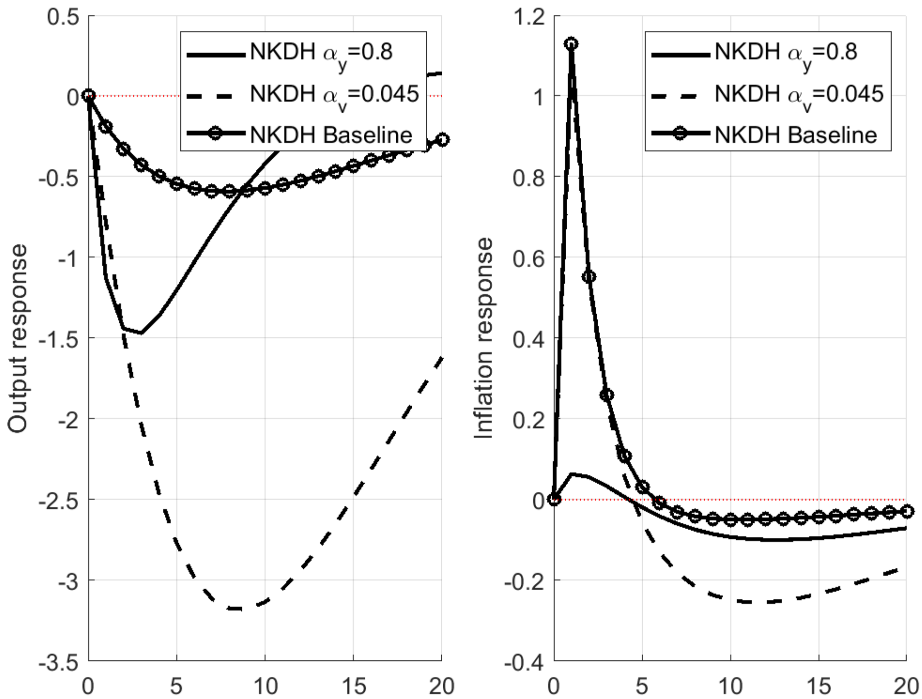
Figure A.8: Impulse responses to uncertainty shocks and deep habits



Each panel plots impulse responses to a shock to uncertainty. The models are similarly calibrated. The baseline model corresponds to the model with deep habits calibrated to Euro area demographics.

second variation, the sensitivity to uncertainty shocks is raised to 0.045 from 0.0045 ($\alpha_v = 0.045$). Figure A.9 plots impulse responses. Consistent with Fernandez-Villaverde et al. (2015) and Fasani and Rossi (2018), both of the modifications to the monetary policy rule considered can lead to deflationary uncertainty shocks.

Figure A.9: Impulse responses to uncertainty shocks and monetary policy



Each panel plots impulse responses to a shock to uncertainty. Other than the specified parameters, the models are similarly calibrated. The baseline model corresponds to the model with deep habits calibrated to Euro area demographics.

Volatility shocks in the model and the survey-based household uncertainty measure.

In the following, I propose a plausible link between uncertainty shocks in the model and the survey-based measure of household uncertainty taken from the data. First, we can simplify the characterization of model-implied households' expectations on the future state of the economy with productivity growth as it is the only variable hit with shocks in the model. That is, in responding to a hypothetical survey, one can assume that model-implied household views on the state of the economy is reasonably approximated by their views on productivity growth.

In the model, productivity growth is given by,

$$g_{t+1} \equiv log\left(\frac{A_{t+1}}{A_t}\right) = (1-\rho_A)(log(\bar{A}) - log(A_t)) + \sigma_{A,t+1}\varepsilon_{a,t+1}$$

where $\varepsilon_{a,t+1} \sim i.i.d.\,\mathcal{N}(0,\sigma_a^2)$ and $log(\sigma_{A,t+1}) = \rho_v log(\sigma_{A,t}) + \varepsilon_{v,t+1}$. Conditional on information available to the households at time t, the growth forecast is a Normally-distributed random variable.

$$g_{t+1|t} \sim \mathcal{N}((1-\rho_A)(log(\bar{A}) - log(A_t)), \sigma^2_{A,t+1|t}\sigma_a^2)$$

If we assume that, when responding to a survey, households respond with $g_{t+1|t}$ only if the associated expected forecast error is within some threshold s_j^2 which differs across households, then a household j will choose to answer the option *Don't know* when the expected forecast error variance exceeds their threshold.

Suppose this threshold is log-normally distributed with mean $\bar{s}$ and variance v^2, $log(s_j^2) \sim \mathcal{N}(\bar{s}, v^2)$ in the cross-section of households. Then, the fraction of households who choose the option *Don't know* - the household uncertainty index

(HUN_t) - is given by,

$$HUN_t = \Phi\left(\frac{log(\sigma^2_{A,t+1|t}\sigma^2_a) - \bar{s}}{v}\right)$$

where $\Phi()$ is the standard normal cumulative density function and HUN_t is an increasing function of volatility shocks $\varepsilon_{v,t}$. Note further that the volatility shocks in the stochastic volatility setting adopted in this paper bear some resemblance to the way that ambiguity shocks are introduced in Ilut and Schneider (2014).

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