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 do not universally behave like negative demand shocks. Notably, household uncertainty shocks are largely inflationary in Europe. Further analysis, including a comparison of results across countries, suggest that factors related to average markups along with monetary policy play a role in the transmission of household uncertainty to inflation. These results lend support to a *pricing bias* mechanism as an important transmission channel.

JEL Codes: D84, E30, E52, E71

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1. Introduction

There is a growing consensus that macro-uncertainty can have adverse effects on the economy.[1] The empirical evidence that have been built up to support this assertion are based on various measures of macro-uncertainty. These measures are closely tied to financial markets, professional forecasts, or news mentions regarding 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. However, direct measures of household uncertainty useful for macroeconomic analysis are quite scarce.[3] This paper helps fill this gap.

In this paper, I construct a new 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 use a simple model to verify the plausibility of some conjectures consistent with the observed results.

[1] See e.g. Bloom (2009, 2014); Jurado et al. (2015); Baker et al. (2016); Carriero et al. (2018), and Dietrich et al. (2022) for a non-exhaustive sample of contributions to the literature in this respect. The severity of these adverse effects may also be time-varying and state-dependent as shown in Caggiano et al. (2014, 2017, 2021).

[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] One example would be Leduc and Liu (2016) who use the *Michigan Consumer Survey* to study the macroeconomic effects of household uncertainty in the US.

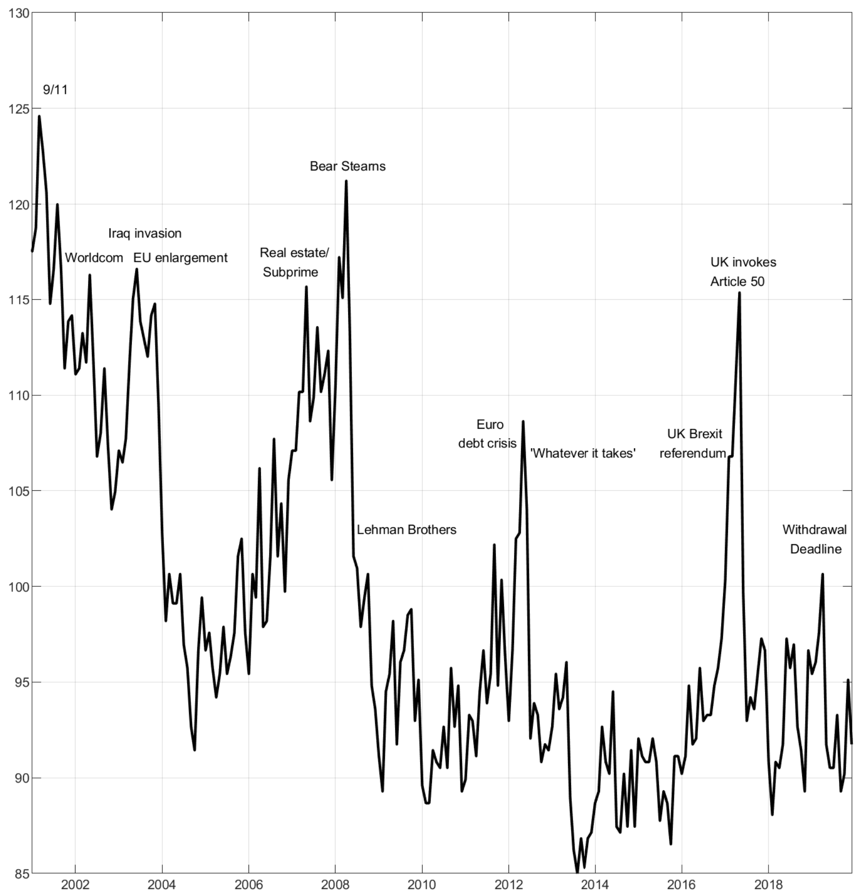
The uncertainty measure is derived from the fraction of households who respond with *Don't know* when answering a few questions in the European harmonized consumer survey. The measure is based on a similar measure in Giavazzi and McMahon (2012) who showed that an increase in uncertainty due to the 1998 German general elections triggered precautionary savings behavior among German households. Specifically, I make use of responses to the four forward-looking questions previously 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 facilitates cross-country comparisons which help uncover key factors associated with the macroeconomic effects of household uncertainty.

Figure 1 illustrates how household uncertainty has evolved over time for the Euro area. The Euro area measure of household uncertainty, HUN, is elevated precisely around events wherein European households would reasonably be more uncertain. Over the period 2002-2019, household uncertainty peaked four times. These follow closely with the enlargement of the European Union, the onset of the Global Financial Crisis coinciding with rising mortgage rates and the housing boom and bust in most of Europe, the European Sovereign Debt Crisis, and Brexit. Other measures of uncertainty for the Euro area, such as the realized volatility of the Eurostoxx 50 index as a measure of uncertainty in financial markets and the Baker et al. (2016) policy uncertainty index for Europe, also peaked around these events. The index is also positively correlated with a new measure of household uncertainty introduced by the European Commission in 2021.[4] On the other hand, at the

[4]The new European Commission household uncertainty measure is derived from responses to a

monthly frequency, household uncertainty is positively correlated with a measure of financial uncertainty but negatively correlated with policy uncertainty.

Figure 1: Household uncertainty in the Euro area



The figure plots the index of household uncertainty (HUN) for the Euro area . The series has been standardized such that 100 represents the 2002-2019 average and 10 points is one standard deviation.

When the measure of household uncertainty is compared to 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 sen-

question, introduced in May 2021, on whether a household's financial situation over the next year is easier or harder to predict.

timent, a perceived worsening of household finances, low output, high unemployment, and higher inflation. 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.[5] While heightened uncertainty is positively correlated with increases in planned durable expenditures, it also leads to more negative views on whether now is the right time to make large purchases.

More importantly, evidence from recursively-identified vector auto-regressions show that while financial uncertainty shocks tend to be deflationary and policy uncertainty shocks tend to have ambiguous effects on inflation, household uncertainty shocks are inflationary for the Euro area. This result also holds for many European countries individually. 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 do not rely on the ordering of variables in the recursive identification strategy used in the vector auto-regressions nor on the recursive identification strategy

[5]Consistent with this assertion, household uncertainty in Europe started increasing as early as 2006 (and well before the peak of the Global Financial Crisis) when mortgage rates started rising as a consequence of housing booms across Europe. See Figure A.3 in the Appendix.

[6]Their measure of household uncertainty is constructed from a different type of response in the US consumer survey. 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 a VAR-based measure of uncertainty shocks on prices using US data.

itself. 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 focus on specific questions in the survey 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 construct the Euro area measure of household uncertainty from information across Euro area countries through factor analysis.

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. 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. 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. In a related strand of the literature, Bachmann et al. (2019) show that increased uncertainty may also lead to an increase in the likelihood and magnitude of price adjustments.[8]

I verify the link between the pricing bias mechanism and inflationary household uncertainty shocks in Europe by comparing the response of inflation to household

[7]This is also referred to as a *precautionary pricing* effect in Born and Pfeifer (2021). See also Fernandez-Villaverde and Guerron-Quintana (2020).

[8]This is because the volatility effect - that 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 as well as Ilut et al. (2020) who show that firms' (Knightian) uncertainty about demand can itself be the source of price rigidities.

uncertainty shocks across European countries. I find substantial heterogeneity, from deflationary uncertainty shocks in Austria, Finland, and Portugal to inflationary uncertainty shocks in Italy, Spain, and Sweden for example. As predicted by theory, the variation in inflationary responses to household uncertainty shocks correlate well with estimated average markups across these countries.[9] Further, when I calibrate a relatively standard New Keynesian model to match the variation in markups across these countries, I am also able to generate a similarly wide range of deflationary and inflationary uncertainty shocks. I also show in additional simulations of the model that variations in the degree of price rigidity can generate both deflationary (low rigidity) and inflationary (high rigidity) uncertainty shocks. These results further reinforce the view that the pricing bias mechanism plays an important role in the transmission of uncertainty shocks to the rest of the economy.

With regard to the differential effects of household, financial, and policy uncertainty on inflation in the Euro area, I find evidence suggesting that the response of monetary policy plays a role on whether these uncertainty shocks are inflationary or not. Fernandez-Villaverde et al. (2015) have earlier shown, using model-based simulations, that an otherwise inflationary uncertainty shock can be deflationary if monetary policy responds to it.[10] To empirically verify this proposition, I construct counterfactual impulse responses from the vector auto-regressions which zero out any potential direct responses by monetary policy to uncertainty shocks. I find that the response of inflation to household uncertainty shocks are largely unchanged in these counterfactual exercises while the responses to financial and policy uncertainty shocks have become more inflationary (less deflationary). Further, using

[9] An alternative to the *pricing bias* mechanism with similar implications is proposed by Gaballo and Paciello (2021) who show that firms strategically increase markups when households become more uncertain about relative prices specifically.

[10] 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).

simulated impulse responses from a New Keynesian model with two sources of uncertainty, I verify that uncertainty shocks can both be inflationary and deflationary if they arise from multiple sources and monetary policy only responds to some of them.

The model simulations also reveal that the documented features of household uncertainty from the vector auto-regressions are better matched by supply-side uncertainty (shocks to the volatility of productivity shocks) rather than demand-side uncertainty (shock to the volatility of preference shocks) in the model. Specifically, only supply-side uncertainty shocks generate a significant positive correlation between markups and inflationary responses as observed in the cross-country vector auto-regressions. One interpretation of this result is that when households respond with *Don't know* in the consumer surveys, they may be expressing their uncertainty about the productive capacity of the economy rather than economy-wide propensities to consume vis-a-vis save. This is consistent with evidence in Andre et al. (2022a,b) who find that households' subjective models of the economy tend to focus on supply-side mechanisms. In addition, shocks to the volatility of productivity - hence profitability - at the firm level may spill over to households through (wage) income uncertainty as shown in Di Maggio et al. (2020).

This paper adds to the literature on measuring macro-uncertainty (e.g. Bloom, 2009; Jurado et al., 2015; Ludvigson et al., 2021; Baker et al., 2016). Bloom (2014) provides an early review of the various measures and sources of uncertainty used in the literature. Focusing on survey-based measures, Bachmann et al. (2013, 2019), and Bachmann et al. (2021) construct measures of uncertainty for German firms. Lahiri and Liu (2006); Boero et al. (2008); Lahiri and Sheng (2010); Abel et al. (2016); Boero et al. (2015); Clements (2014); Rossi and Sekhoposyan (2015); Rossi and Sekhposyan (2017); Jo and Sekkel (2019) and Glas and Hartmann (2022) among others, construct measures of uncertainty based on surveys of professional forecasters. I introduce a new measure of uncertainty associated with a previously under-explored source - households. Relative to other contributions in the literature which focus on household uncertainty around specific events, e.g., Guiso et al. (1996); Giavazzi and McMahon (2012); Coibion et al. (2021) and Dietrich et al. (2022), I study the business cycle implications of household uncertainty using a relatively long time series of observations and across several countries. As with Leduc and Liu (2016) who focus on the US, I make use of consumer surveys to construct a measure of household uncertainty available for many European countries.

This paper also builds on the literature focusing on the pricing bias mechanism as a transmission channel behind the effects of uncertainty shocks on the economy (Born and Pfeifer, 2014; Fernandez-Villaverde et al., 2015; Bianchi et al., 2018; Fernandez-Villaverde and Guerron-Quintana, 2020; Born and Pfeifer, 2021; Andreasen et al., 2021). I provide novel evidence, using vector auto-regressions across a wide range of countries, on the importance of this channel. As with Fernandez-Villaverde et al. (2015); Fasani and Rossi (2018) and Born et al. (2020b), I explore the role of monetary policy and also present new evidence using counterfactual impulse responses from vector auto-regressions that monetary policy responses to uncertainty shocks can be a key factor on whether an uncertainty shock is inflationary or deflationary.

This paper is also related to the literature explicitly accounting for multiple sources or types of uncertainty in macroeconomic models. Born and Pfeifer (2014) consider both policy uncertainty from various sources (i.e. uncertainty regarding both fiscal and monetary policy) and uncertainty about productivity and find that while policy uncertainty shocks have relatively larger effects on output, they are nevertheless quite small. They also find both types of shocks to be inflationary largely due to the pricing bias mechanism. Bianchi et al. (2018) develop a model with both supply-side and demand-side uncertainty with five transmission channels of which three - precautionary savings, pricing bias, and investment risk premium - are quantitatively important. They also find that demand-side uncertainty shocks tend to have no effects on inflation due to opposing forces from the various channels while supply-side uncertainty shocks tend to be deflationary.

The rest of the paper is organized as follows. The next section describes the data used to construct the index of household uncertainty and documents its basic properties. Section 3 reports the empirical evidence regarding the inflationary effects of household uncertainty using vector auto-regressions for the Euro area while section 4 looks into cross-country differences. Section 5 develops a simple New Keynesian model which is used to produce model-based impulse responses to compare with the empirical evidence. Finally, section 6 concludes.

2. 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 contain exogenous variation that could potentially drive business cycle fluctuations.[11] By and large, the focus on this strand of the literature has been on the level of household expectations or average views on the relative state of the economy, a first moment of beliefs typically referred to as sentiment or confidence.

[11] See e.g., Fuhrer, 1988; Ludvigson, 2004; Barsky and Sims, 2012; Leduc and Sill, 2013; Bhandari et al., 2019; Vellekoop and Wiederholt, 2019; Roth and Wohlfart, 2020; Giglio et al., 2021; Liu and Palmer, 2021; Hodbod et al., 2021; Lagerborg et al., 2022, and Georgarakos and Kenny (2022).

Relatively fewer studies have focused on higher moments of household expectations particularly on household uncertainty. For example, 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, and focusing on European households, 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 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 lead to a reduction in exposures to equity markets.

More recently, Coibion et al. (2021) show that perceived macroeconomic uncertainty matters. Using randomized information treatments in a survey of European households, they find that higher perceived macroeconomic uncertainty leads to reduced spending and propensity to invest. Another recent example is Dietrich et al. (2022) who make use of a subjective measure of household uncertainty as well as disagreement in expectations among households from a daily survey which ran during the first 16 months of the Covid-19 pandemic. They show that Covid-19 induced uncertainty could partially explain the observed fall in output during the pandemic.

The measures of household uncertainty used in the aforementioned studies are very granular and rich in the cross-section but tend to be limited in terms of the time dimension. One exception in the literature is the measure of uncertainty in Leduc and Liu (2016) which exploits data from the *Michigan Consumer Survey*. In this paper, I use the European Commission's harmonized consumer survey to construct country-level measures of household uncertainty with sufficient observations across both time and countries making it very 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 weeks of each month.

2.1. Household uncertainty index construction

To construct the measure of household uncertainty, I use households' responses to the same four questions used to construct consumer sentiment indices prior to 2019:[12]

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?

Responses are categorized into one of five or six options (the middle option (*0*) is omitted for the question on the likelihood of saving).

- Much better/more (++)
- Somewhat better/more (+)
- The same (*0*)

[12] Beginning in 2019, the question on expected likelihood to save has been replaced with the question on how the household's financial situation has changed in the *past* 12 months. The change was largely motivated by the desire to improve the index' ability to track consumption.

- 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. This follows the approach taken in Giavazzi and McMahon (2012) who made use of a similar measure focusing on German households' uncertainty around the 1998 German general elections. 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,

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

The measure is available at a monthly frequency for all European Union member countries (and the United Kingdom) as well as several candidate member countries and is constructed for the period January 2002 to December 2019. For most of the succeeding analyses, I will focus on the Euro area as a whole and standardize the measure to an index with 100 representing the mean and 10 points representing one standard deviation.

A non-negligible fraction of households respond with *Don't know* in Europe. There is also sizable variation over time. On average, between 3 to 6% of households are uncertain for a given survey round in the Euro area as a whole. At the national level, average levels of the non-standardized uncertainty measure are quite heterogeneous and the fraction of households who are uncertain can be larger and exhibit much larger variations over time. For instance, the range goes from 2 to over

10% of households in Spain, France, and Italy.[13]

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 as well as 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 and then taking averages of the mean responses across the four questions.

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

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 100.

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

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

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.

[13] See Figure A.1 in the Appendix for time-series plots of household uncertainty measures in all the Euro area countries. See also Figure A.2 for a plot of non-standardized household uncertainty and Table A.3 for an analysis of variation of the household uncertainty measures.

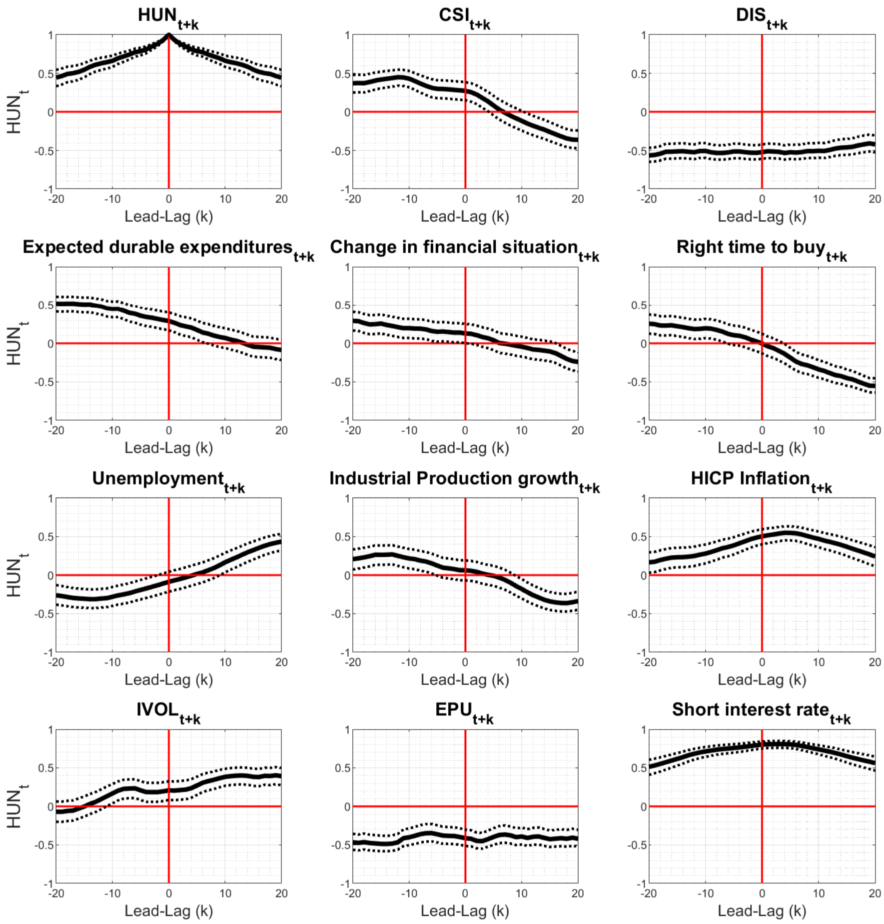
I take monthly data on (log) industrial production, consumer inflation (based on the harmonized index or HICP), the short interest rate (average overnight rate), and the unemployment rate. The industrial production and inflation variables are transformed into year-on-year growth rates while the unemployment rate is in year-on-year differences. Finally, I also include two measures of uncertainty for the Euro area from different sources. The first is the option-implied volatility of the Eurostoxx 50 index (IVOL). The second is the Baker et al. (2016) measure of economic policy uncertainty for Europe (EPU).

Figure 2 reports lead-lag correlations of household uncertainty with other variables for the Euro area. A slightly positive contemporaneous correlation with the consumer sentiment index does not square with the view that the uncertainty measure is a proxy for sentiment (a first moment of beliefs). Periods in time when a larger fraction of households are uncertain also tend to be periods when the average household is relatively more optimistic.

It also appears that increases 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.

The index also seems to capture 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,

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. IVOL 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.

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) and Roth and Wohlfart (2020) 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.

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.[14] 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 although the pattern of correlations indicate a declining trend in this variable. Furthermore, and consistent with this view, the household uncertainty index also seems to loosely track average mortgage lending rates which reflects a significant component to household expenditures. Figure A.3 in the Appendix plots the standardized household uncertainty index against average housing loan rates in the Euro area. It shows that household uncertainty tends to increase when mortgage rates are also increasing, notably during the run-up to the Global Financial Crisis.

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.

Overall, these correlations indicate that fluctuations in the household uncertainty index are not simply idiosyncratic fluctuations reflecting disinterest or apathy of respondents. Nevertheless, the index could be interpreted as capturing fluctuations

[14] 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.

in household inattention to economic conditions. However, to the extent that inattention consequently increases household uncertainty given that more (less) information reduces (increases) uncertainty, this interpretation is compatible with the view that the index captures household uncertainty. Finally, 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.

2.2. Comparison with other uncertainty measures

The dispersion of expectations (or forecasts) usually referred to as disagreement has been used in prior literature as a measure for uncertainty (see e.g., Bloom, 2014 as well as Dietrich et al., 2022 for household uncertainty specifically). As indicated in the top right panel of Figure 2, I find that the household uncertainty measure correlates negatively with the dispersion of household beliefs (DIS). This is not too surprising given prior evidence of the weak link between disagreement and uncertainty based on surveys of professional forecasters (see e.g., Zarnowitz and Lambros, 1987 for an early assessment using US data and Rich and Tracy, 2021 for a more recent analysis using European data).

One reason why these two measures do not correlate well may be that they measure different types or sources of uncertainty. For instance Born et al. (2020a) distinguish between fundamental uncertainty (the volatility of shocks to fundamentals) and uncertainty related to the measurement of fundamentals (the volatility of measurement errors). The former would generate an increase in measures of individual uncertainty (such as a *Don't know* response) and would increase the sensitivity of expectations to new information while the latter would generate an increase in the dispersion of expectations and decrease the sensitivity of expectations to new information. Born et al. (2020a) find evidence in support of this distinction using professional forecaster data. In addition Andre et al. (2022b) show that households may disagree for reasons unrelated to uncertainty (e.g., differences in their mental frameworks of how the economy works) even when given the same information.

The index is positively correlated with the measure for financial uncertainty. The correlation is weak however although this is similar to what Leduc and Liu (2016) document regarding the correlation between their measure of household uncertainty based on the Michigan Consumer Survey and the VIX. On the other hand, the household uncertainty index is negatively correlated with the policy uncertainty measure.[15]

The negative correlation with the policy uncertainty index (EPU) may be linked to the similarly negative correlation with the dispersion of household beliefs (DIS). For instance, Bowen et al. (2021) show that when news is (selectively) shared with local networks, silos and echo chambers can emerge leading to polarization especially if the quality of information is quite low. It could be the case that events which raise policy uncertainty - a news-based index - also tend to polarize households' views leading to an increase in disagreement as well as a lower fraction of households having uncertain views about the economy. This could further be amplified by a confirmation bias in media consumption (Faia et al., 2022) which could further increase the dispersion of views.

Nevertheless, all three measures of uncertainty - household, policy, and financial - tend to rise during large and extreme events (such as crises). As shown in Figure 1, the household uncertainty measure peaks around events that are associated with

[15]These correlations also generally holds true at the country level. See Tables A.4 and A.5 in the Appendix.

macroeconomic uncertainty. The two other uncertainty measures also tend to be heightened in these same periods.[16]

Perhaps a fairer comparison can be made against a new index of household uncertainty introduced by the European Commission in 2021. Beginning May 2021, the European Commission introduced a question directly asking respondents whether their future financial situation is either easier or more difficult to predict. The new question was pilot tested in several countries beginning 2019. The new measure of uncertainty is based on a balance score of the responses to the newly added question (fraction of responses indicating more difficult less fraction of responses indicating more easy). Table 1 reports correlations between the household uncertainty index *HUN* and the European Commission's new household uncertainty index (*EC-Unc*) as well as the dispersion of household expectations (*DIS*).[17]

Table 1: Correlations with the new European Commission uncertainty index

	Full sample		Pilot sample		Rollout sample	
	HUN	EC-Unc	HUN	EC-Unc	HUN	EC-Unc
EC-Unc	0.484	.	0.482	.	0.503	.
DIS	0.010	0.221	0.317	0.041	0.137	0.279

The table reports Pearson correlation coefficients between the household uncertainty index(HUN) and the new European Commission uncertainty (EC-Unc) and the dispersion of expectations (DIS) indices. Reported correlations are between the variables indicated in the column and row labels. The first two columns use the full sample which consists of all available observations from January 2019 up to June 2022 for 30 European countries. The next two columns make use of the pilot sample which restricts the observations to the five pilot countries, Austria, Luxembourg, Poland, Finland, and Albania. The last two columns use only the rollout sample which restricts the sample to a nearly-balanced panel beginning May 2021.

[16] See Figure A.4 in the Appendix. The similarities are even more apparent when the data is filtered through a VAR and the comparison is made on recursively-identified uncertainty shocks as shown in Figure A.5 of the Appendix.

[17] The country coverage for this exercise spans 30 European countries. Relative to the list of countries reported in Table A.1 in the Appendix, the country coverage for this exercise excludes the United Kingdom and Romania and includes Albania, Montenegro, North Macedonia, and Serbia. The difference in country coverage with the rest of the analysis is due to data availability given that the sample period for this exercise is from 2019 to 2022 whereas the rest of the analyses covers the period 2002 to 2019.

The correlation between the new European Commission household uncertainty measure and HUN is positive and significant at about 0.5. This holds even when we restrict the sample to the pilot-testing countries for which we have a longer time series of observations or when we restrict the sample to a nearly balanced one after excluding observations from the pilot-testing phase. In comparison, the correlation between EC-Unc and DIS is much weaker. In addition, the correlation between HUN and DIS is now weakly positive when using only the most recent observations.

As a second exercise, I evaluate to what extent HUN is able to predict the new European Commission uncertainty index (in-sample). Table 2 reports results from a regression of the European Commission's uncertainty index on HUN. Column (1) reports results using all available observations while columns (2) and (3) report results using the pilot (5 countries only) and rollout (beginning May 2021) samples respectively. All specifications include country fixed effects to account for differences in the level of the variables across countries. The statistical significance of the coefficient on HUN is a reflection of the strong correlation between the two variables. Further, HUN along with the country fixed effects can explain about 90% of the variation in EC-Unc.[18] Coincidentally, the estimated coefficient on HUN in column (3) is remarkably close to one. These results indicate that the HUN and the European Commission's uncertainty index are quite similar but one may need to account for country-specific scaling when moving from one to the other.

[18]Without the country fixed effects, HUN can explain about a quarter of the variation in the European Commission's uncertainty measure.

Table 2: Predicting the European Commission uncertainty index with HUN

	(1)	(2)	(3)
HUN	1.1459***	0.7751*	1.0610***
	(0.250)	(0.417)	(0.341)
Sample	Full	Pilot	Rollout
Country FE	Yes	Yes	Yes
R-squared	0.8924	0.9528	0.8748
Obs.	618	185	418

*The table reports regression results with the new European Commission uncertainty measure as the dependent variable and the household uncertainty index (HUN) as the explanatory variable. Standard errors in parentheses; *, **, and *** indicate statistical significance at the 10, 5, and 1% levels respectively. The full sample uses all available observations from January 2019 up to June 2022 for 30 European countries. The pilot sample refers to observations for the five pilot countries, Austria, Luxembourg, Poland, Finland, and Albania for which data is available for roughly over 3 years. The rollout sample refers to the nearly balanced sample of observations from May 2021 to June 2022. All regressions include country fixed effects to account for differences in the levels of the variables across countries.*

The comparisons made in this section indicate that (i) HUN correlates well with another measure for household uncertainty, and (ii) HUN does not correlate well with other measures of macro-uncertainty not directly related to households. Together with the narrative evidence illustrated in Figure 1 which shows that the index is elevated during episodes in which uncertainty is very likely to be high in the Euro area, these pieces of evidence seem to suggest that HUN index is indeed measuring household uncertainty albeit potentially a distinct type or source of uncertainty relative to the one(s) captured by other macro-uncertainty measures associated with financial markets and policy.

3. Inflationary 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 uses data at a monthly frequency and is comprised of a measure for uncertainty, unemployment, inflation, and interest rates and is estimated with three lags.[19]

3.1. Shock identification

Shocks are identified recursively with uncertainty ordered first. The reason for this is that the survey underlying the household uncertainty measure is conducted within the first two weeks of each month. Consequently, it is very plausible that contemporaneous (when viewed at the monthly frequency) shifts in the other variables in the VAR are unlikely to affect the household uncertainty index. Added to this timing (dis-) advantage, the average household is also unlikely to have sufficient incentives or possibly even the ability to monitor these macroeconomic developments in real-time. If anything, recent literature has shown that households are more likely to be inattentive and under-react to new information (Carroll, 2003; Kohlhas and Walther, 2021).[20] Given all of these, a recursive identification strategy with the household uncertainty measure ordered first is adopted.[21]

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

[20] See also D'Acunto et al. (2021a) and D'Acunto et al. (2021b) for evidence of consumer inattention specifically relating to inflation expectations.

[21] The recursive identification strategy used in this paper may also be interpreted as proxy SVAR with the first variable as the instrument for uncertainty. Ordering the uncertainty measure first *internalizes* what would have been the external instrument in a proxy SVAR (or VAR-IV) with valid impulse response estimates even under non-invertibility (Plagborg-Moller and Wolf, 2021) at the potential cost of attenuated impulse responses (Carriero et al., 2015).

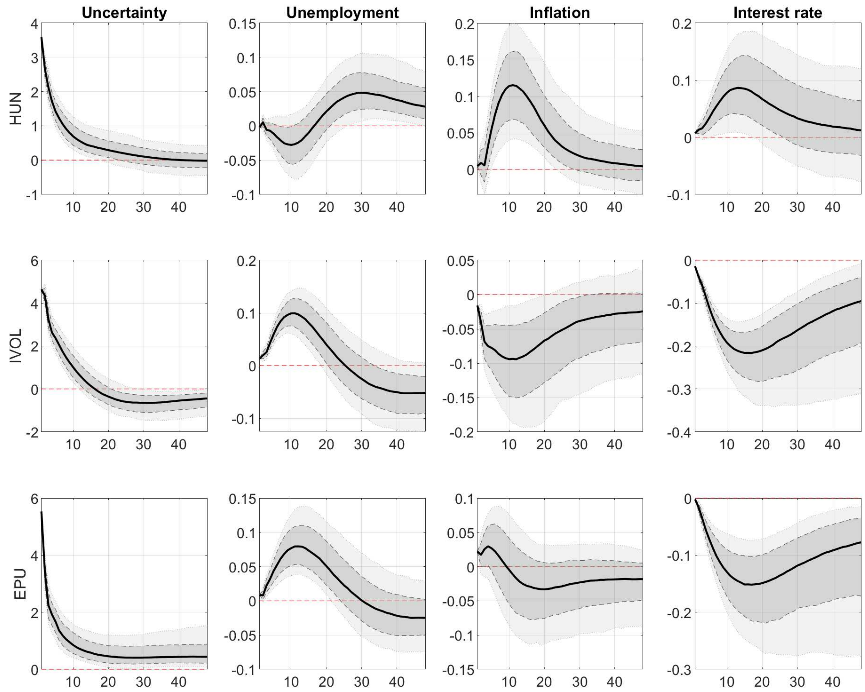
While simple and plausible, the approach has a notable drawback. It specifically assumes that the uncertainty measure is not contemporaneously affected by other shocks in the system. The use of monthly data may mitigate this drawback as recent findings by Carriero et al. (2021) note that there may be limited (contemporaneous) feedback from other shocks to uncertainty at this frequency. Their findings are based on an alternative identification strategy which extends the Lewis (2021) time-varying volatility identification approach and allows for an uncertainty shock to not only affect both the mean and variance of the other variables but also for uncertainty to contemporaneously respond to other shocks. As a robustness exercise, I show in the Appendix that household uncertainty shocks remain inflationary in a setting which uses the Carriero et al. (2021) identification approach.

3.2. Baseline results

Figure 3 plots impulse responses to a one standard deviation positive uncertainty shock when the VAR is estimated using Euro area data . Each row reports results from an estimated VAR which 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 (IVOL) 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 unemployment and lower inflation while the effects of policy uncertainty shocks on inflation appear ambiguous. These results also hold when we focus on country-specific data

Figure 3: Impulse responses to various 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. IVOL 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.

for the five largest economies within the Euro area.[22]

The response of inflation (and interest rates) to household uncertainty shocks are consistent with the model-implied responses to fiscal uncertainty shocks in the analysis of the pricing bias mechanism in Fernandez-Villaverde et al. (2015).[23] On the other hand the response of inflation (and interest rates to a lesser extent) to financial and policy uncertainty shocks are consistent with an extended version of the model in Fernandez-Villaverde et al. (2015) wherein the monetary policy rule

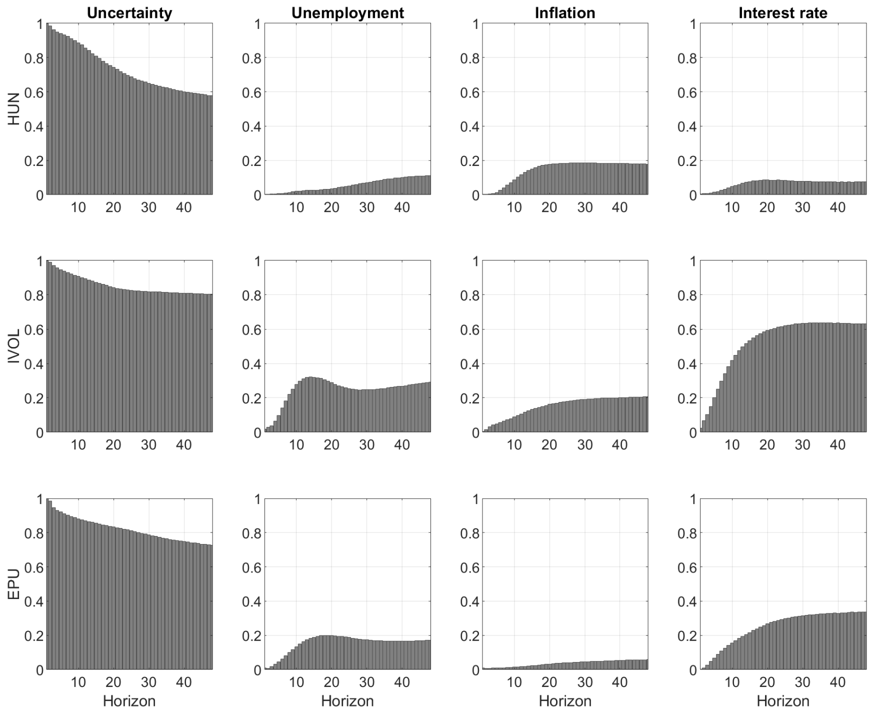
[22] See Figure A.6 in the Appendix. There are quantitative differences in the estimated impulse responses. These differences are explored further in subsequent analyses.
[23] See Figure 7 in Fernandez-Villaverde et al. (2015)

is modified to also react to uncertainty shocks. Regarding the delayed increase in unemployment, this may be a symptom of the precautionary increase in labor supply following an increase in uncertainty (see e.g., Basu and Bundick, 2017 and Giavazzi and McMahon, 2012) coupled with institutional features of labor markets in Europe which tend to have relatively more protection for workers.

These uncertainty shocks are a non-negligible source of macroeconomic fluctuations. Figure 4 plots forecast error variance decompositions for the VARs with household, financial, and economic policy uncertainty measures respectively in each row. These forecast error variance decompositions of the baseline VARs reveal that both household and financial uncertainty shocks can account for about 20% of the forecast error variation in inflation at the 4 year horizon while policy uncertainty shocks account for a substantially smaller fraction. While household uncertainty shocks account for about 10% of the variation in unemployment, financial and economic policy uncertainty account for much larger fractions at 20 to 30% of forecast error variation in unemployment.

It is also quite notable that while financial uncertainty shocks account for a large fraction of variation in the interest rate, which also holds to a lesser degree for policy uncertainty, household uncertainty shocks in comparison do not. Figure 4 shows that the interest rate appears to be most affected by financial and policy uncertainty shocks while inflation is relatively the most affected variable for household uncertainty shocks. These patterns are suggestive of a relatively strong endogenous interest rate response, possibly monetary policy, to financial and policy uncertainty shocks which does not hold for household uncertainty shocks. Section 3.3 investigates the role of monetary policy response in greater detail.

Figure 4: Uncertainty shocks forecast error variance decomposition



The panels report forecast error variance decompositions from VARs with a measure for uncertainty, unemployment, inflation, and the short rate highlighting the share of uncertainty shocks on the vertical axes across forecast horizons of up to 48 months on the horizontal axes. Each row reports results from a VAR which uses a different uncertainty measure identified in the vertical axis labels. The top row reports the VAR with HUN as the measure of household uncertainty for the Euro area, the middle row reports results from the VAR with IVOL which is the option-implied volatility of the Eurostoxx 50 index, and the bottom row reports results from the VAR with EPU which is the Baker et al. (2016) measure of economic policy uncertainty for Europe. Each column reports the forecast error variance decomposition for a given variable indicated by the column labels.

3.3. The role of monetary policy

Why would household uncertainty shocks be inflationary in the Euro area whereas financial and policy uncertainty shocks are not? It is unlikely that the difference is due to the household uncertainty measure being less able to capture factors which trigger deflationary precautionary savings behavior as it is directly based on household surveys and is thus relatively closer to household views than financial or policy uncertainty measures. As earlier indicated, the analysis in Fernandez-Villaverde et al. (2015) gives us some guidance pointing towards the conduct of monetary policy. They show that the inflationary uncertainty shocks arising from a *pricing bias* mechanism can be reconciled with deflation if monetary policy is characterized by augmenting an otherwise standard Taylor-type rule with a term that responds to uncertainty. This line of reasoning is also supported by the results in Fasani and Rossi (2018) who 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.[24]

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.

To verify whether this may indeed be the case, I follow Bachmann and Sims (2012) and Kilian and Lewis (2011) and produce counterfactual impulse responses by zeroing out the direct response of interest rates to uncertainty shocks to evaluate the role of monetary policy response.[25] Table 3 reports the cumulated median response of inflation in these exercises. I find that household uncertainty shocks remain inflationary in the counterfactual exercise although less so. On the other hand,

[24] The link between inflation and the monetary policy response to uncertainty is further supported by evidence in Mumtaz and Theodoridis (2015) who find that US uncertainty shocks may be inflationary for the UK economy which has an independent monetary policy. See also Annicchiarico and Rossi (2015). Further, Caggiano et al. (2017) show, using non-linear vector auto-regressions, that uncertainty shocks are more contractionary when a zero lower bound constraint is binding.

[25] The exercise is still subject to the *Lucas critique* as it tenuously assumes that the change embodied in the counterfactual is sufficiently small so as not to induce a change in the behavior of economic agents. Figures A.12 and A.13 in the Appendix plots the impulse responses. The text introducing these plots provide more information regarding the exercise.

for financial and policy uncertainty shocks, I find a shift towards more inflation (or less deflation). The shift is substantial for policy uncertainty shocks which are now inflationary in the counterfactual exercise. These results indicate that the monetary response to uncertainty shocks (e.g. for policy uncertainty) or lack thereof (for household uncertainty) play an important role on the resulting response of inflation to these shocks.

Table 3: Inflation responses and counterfactual monetary policy

	Inflation cumulated IRF (48 months)	
Uncertainty measure	Baseline	Counterfactual
HUN	2.02	1.66
EPU	-0.79	0.68
IVOL	-2.66	-1.33

The table reports the cumulated median impulse responses of inflation to uncertainty shocks over a four year period from vector auto-regressions using Euro area data. HUN is the measure of household uncertainty for the Euro area. IVOL 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 column Baseline reports results from the baseline specification while the column Counterfactual reports results from the counterfactual exercise zeroing out the response of monetary policy in the baseline specification.

3.4. Robustness exercises

The results are robust to alternative shock identification strategies which do not rely on the assumption that the uncertainty measure is not contemporaneously affected by other shocks to the economy. Although Carriero et al. (2021) find that this identification strategy may be appropriate for identification of uncertainty shocks when using data at the monthly frequency, I nevertheless show that I obtain similar results when using a different approach to identification. Specifically, I use identification via time-varying volatility following the approach taken in Carriero et al. (2021) as a robustness exercise. The approach, which allows for other shocks to contemporaneously affect the uncertainty measure (and vice versa), also allows for non-linear effects of uncertainty on the other variables in that uncertainty can also amplify the impact of other shocks on macroeconomic variables. Results reported in the Appendix show that household uncertainty shocks remain inflationary even after using this alternative shock identification approach. I also obtain similar results in an alternative recursive identification strategy with the uncertainty variable ordered last.[26]

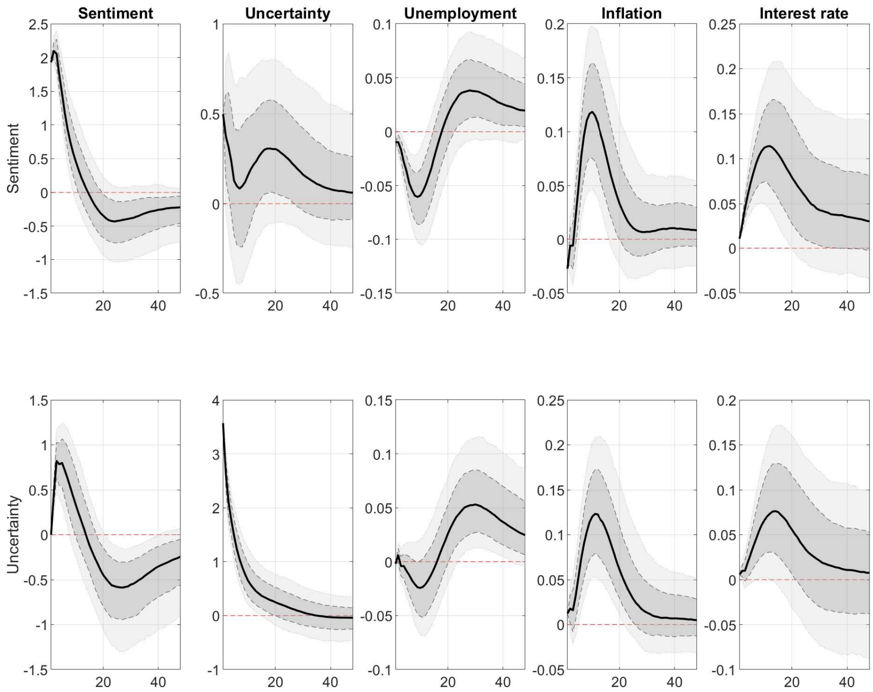
Another concern may be that the household uncertainty measure is picking up variation in other dimensions to household expectations, specifically consumer sentiment or confidence. If the uncertainty measure co-moves with confidence, then the impulse responses may also be picking up the effects of an inflationary confidence-driven increase in aggregate demand. A related concern is that an increase in the household uncertainty measure may be driven by endogenous inattention which tends to increase when households are optimistic. This is a concern given that even if inattention were to reduce households' information sets, it will not trigger precautionary savings behavior as the increase in inattention is itself driven by an increase in confidence. To mitigate both of these concerns, I run another set of vector autoregressions which account for changes in consumer sentiment or confidence.

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 the 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

[26] See Figures A.11 and A.9 in the Appendix.

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.

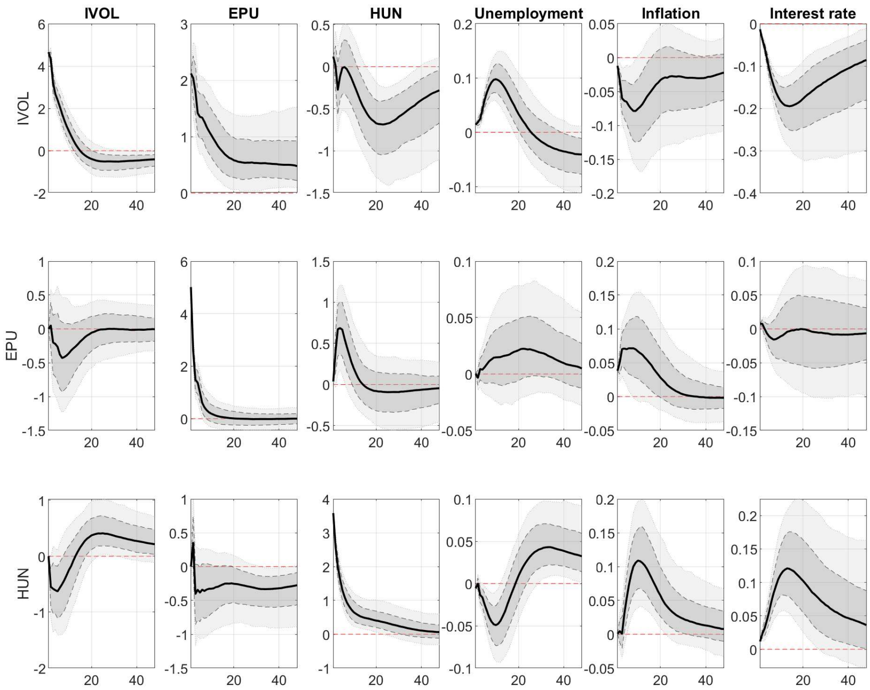
Figure 5: Impulse responses in a VAR with consumer sentiment



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 source of the shock is given by the left-most row labels. The shaded areas reflect 68% and 90% confidence sets.

The inflationary effects of household uncertainty shocks remain even if we account for uncertainty arising from multiple sources. Figure 6 plots impulse responses in a VAR much like in the benchmark analysis but with three measures for uncertainty along with the other variables: IVOL, 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, still leads to higher unemployment and lower inflation. 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. Interestingly, policy uncertainty shocks, ordered second, now also induce higher unemployment and inflation.

Figure 6: 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. IVOL 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.

These findings are also robust to other potential concerns. In the Appendix, I show that the results remain when I replace the interest rate variable with the Wu and Xia (2016) shadow short rate which helps account for periods when unconventional monetary policy were implemented in the Euro area. The same results also hold even when I augment the VAR specification with linear trends and seasonal dummies (month-specific constant terms).

Finally, I obtain similar results under alternative measures of household uncertainty for the Euro area. I still find that household uncertainty shocks are inflationary when the uncertainty index is constructed only from responses to the two questions in the survey concerning household expectations on the general economic situation and unemployment. The same results are obtained when the Euro area uncertainty index is constructed by employing a common factor approach to identifying Euro area household uncertainty. Lastly, household uncertainty shocks differ from shocks to the dispersion of household beliefs. In a VAR with household dispersion of beliefs instead of household uncertainty, I find that household dispersion shocks tend to be mildly deflationary. Impulse responses documenting these findings are reported in the Appendix.[27]

4. Cross-country heterogeneity

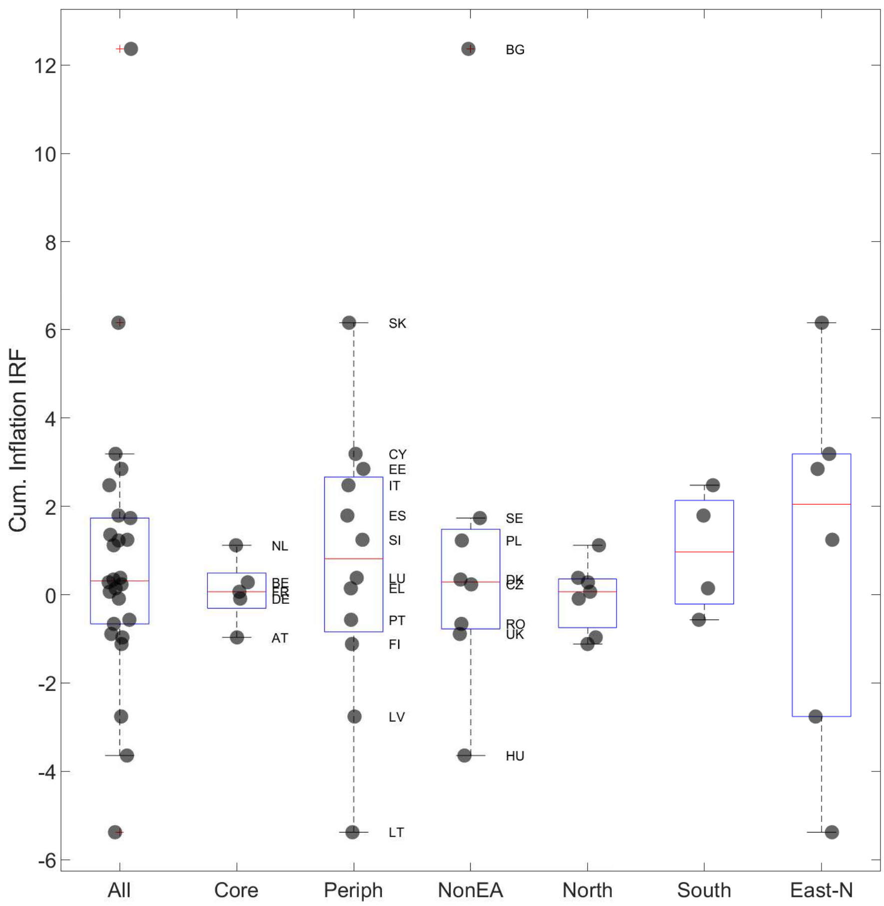
These results mask significant heterogeneity across European countries. I repeat the VAR exercise for each of the 17 individual Euro area countries (excluding Ireland and Malta) as well as for 8 non-Euro area countries (Bulgaria, Czechia, Denmark, Hungary, Poland, Romania, Sweden, and the United Kingdom).[28] Figure 7 plots cumulated median impulse responses, over a 48 month horizon, of inflation to household uncertainty shocks (vertical axis) as box plots across several country groupings (horizontal axis).

As shown in the leftmost group of cumulated impulse responses in Figure 7 encompassing the full sample of countries, the response of inflation to household

[27] See Figures A.6 to A.10 in the Appendix.

[28] Some European countries were omitted due to data constraints. The VAR includes linear time trends and month-specific intercepts to help control for country differences and secular trends. Nevertheless the household uncertainty indices for Cyprus, Lithuania, and Slovakia may have some structural breaks that have been left unaddressed.

Figure 7: Cumulated impulse responses to household uncertainty by country groups



The dots represent cumulated median impulse responses of inflation, over a 48-month horizon, from one standard deviation shocks to household uncertainty for 25 European countries. The impulse responses are taken from a recursively-identified VAR estimated with three lags and includes linear time trends and month-specific constant terms. The red lines denote the median for each group and the blue squares cover the inter-quartile range. The leftmost category ***All*** *reports all observations. The next three categories splits the countries into core (Austria, Belgium, Germany, France, and the Netherlands), periphery, and non Euro area countries. The dots for these categories have been labeled with country codes which are the official European Union designations. The mapping between country codes and country names are given in Table A.1. The last three categories in the rightmost part of the plot splits the Euro area countries geographically into North, South, and East (or new member) countries.*

uncertainty shocks over a 4 year horizon vary substantially from as low as nearly 6% deflation in Lithuania to as much as over 12% inflation in Bulgaria. The next three country groupings, which splits the countries into core (Austria, Belgium, Germany, France, and the Netherlands), periphery, and non-Euro area countries, indicate that the average response of inflation does not differ much across these country groupings. Finally, in the last three country groupings at the rightmost section of Figure 7, which splits Euro area countries geographically into North, South, and East (or new member countries), it seems that the average response of inflation tends to be marginal higher in the Southern European countries relative to the Northern European countries.

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 or across different measures of uncertainty, 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, albeit a small sample. I use estimated average markups over the period 2002 to 2016 for 13 countries in the sample for which data is available from De Loecker and Eeckhout (2020) and find a positive correlation between average markups and inflationary responses to household uncertainty. The positive correlation between markups and inflationary household uncertainty shocks is statistically significant. In Table 4, I report results from regressions of the cumulated median response of inflation to household uncertainty shocks against markup estimates. I include specifications which control for differences across Euro area and non-Euro area member countries, large (5 largest) and small Euro area member countries, country size in terms of real GDP, levels of development as proxied with real GDP per capita, financial development as proxied with the ratio of stock market capitalization to GDP, trade intensity in terms of the ratio of the current account to GDP, and general economic structure in terms of the share of the Services sector value-added to GDP.[29] The regression results reported in Table 4 affirm the statistical significance of the relationship between markups and inflationary household uncertainty shocks even after controlling for these factors. Further, the results reported in column 2 are consistent with Born et al. (2020b) who show that if monetary policy is also relatively insensitive to domestic inflation such as for small member countries in a currency union, the inflationary effects of uncertainty shocks tend to be dampened as it mitigates pricing bias behavior.

[29]Country characteristics are obtained from the World Bank World Development Indicators database and are averages over the period 2002-2018.

Table 4: Regression of cumulated impulse responses of inflation to household uncertainty shocks on markups

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Markup	1.8610	1.3060	1.9196	1.9455	1.9593	1.8843	1.8920
	(1.0279)	(1.0143)	(1.1848)	(1.1647)	(1.1906)	(1.1420)	(1.1748)
NonEA		0.5360	-0.1830	-0.1012	-0.2332	-0.2626	-0.1853
		(0.7435)	(0.7801)	(0.8814)	(0.8479)	(0.7810)	(0.7772)
Large		1.2679					
		(0.6405)					
Control			RGDP	RGDPPC	MktCap	Trade	ShareSER
R-squared	0.2296	0.4665	0.2343	0.2374	0.2362	0.2570	0.2355
Obs.	13	13	13	13	13	13	13

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 years 2002-2016 and taken from De Loecker and Eeckhout (2020). The omitted country group category in column 2 are the smaller Euro area countries excluding the 5 largest (DE, FR, IT, ES, and NL). The omitted country group category in columns 3 to 7 are the Euro area member countries. RGDP is real GDP, RGDPPC is real GDP per capita. MKTCAP2GDP is the ratio of stock market capitalization to GDP. CA2GDP is the ratio of the Current Account to GDP. SVC2GDP is the share of Services sector Value-added to GDP. Country characteristics are averages over the period 2002-2018.

The correlation between inflationary household uncertainty shocks and average markups is also not driven by other country characteristics related to labor market conditions and institutional quality. In regressions reported in Table A.7 in the Appendix where I also control for labor market features such as average unemployment rates, labor force participation rates, and the share of vulnerable to total employment, the positive relationship between markups and and inflationary household uncertainty shocks remain statistically significant. The same can be said when I control for differences in institutional quality across countries in terms of the ease of doing business and legal rights. These characteristics cover a broad range of economic factors 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.

These results, small sample notwithstanding, indicate that a mechanism which relates to average markups play an important role in the transmission of household uncertainty to the macroeconomy for European countries, e.g., a *pricing bias* mechanism. In the next section, I develop a simple New Keynesian model to verify whether the magnitude of variation in average markups across European countries can feasibly generate similar magnitudes of variation in the cumulative response of inflation to macro-uncertainty shocks produced by the vector auto-regressions.

5. Model-implied inflation responses to uncertainty

In this section, I make use of a simple New Keynesian model calibrated to the Euro area to (i) verify whether the magnitude of correlations between markups and inflationary uncertainty shocks uncovered in the previous section is sensible, (ii) explore whether differences in the degree of price rigidities may be pertinent to the observed cross-country heterogeneity, and (iii) verify whether differences in monetary policy response can simultaneously account for inflationary household uncertainty shocks and deflationary financial uncertainty shocks within the same economy. In what follows, I briefly describe the key points of the model.

5.1. A basic New Keynesian model

Households. Risk-averse households maximize the discounted value of utility from consuming a stream of differentiated goods. These are paid for with wage income derived from the supply of labor and transfers of firm profits taken as exogenous by households. Households can also save in a one-period risk-free asset in zero net supply. The utility that households derive from consumption and labor in each period in time are hit with preference shocks. The volatility of these preference shocks are also time-varying and hit with what I will refer to as demand-side uncertainty shocks following Basu and Bundick (2017) and Bianchi et al. (2018). Households take prices as given and choose how much of each good indexed by j to consume, how much labor to supply, and how much to save. In particular they solve the following program:

$$
\begin{aligned}
max \qquad & \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \tilde{b}_t U(C_{t+s}, L_{t+s}) && (4)\\
\text{subject to:} & \\
U(C_t, L_t) &= \frac{(C_t - \theta C_{t-1})^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\kappa}}{1+\kappa} && (5)\\
C_t &= \left[\int_0^1 C_t(j)^{\frac{\eta-1}{\eta}} dj\right]^{\frac{\eta}{\eta-1}} && (6)\\
B_{t+1} &= W_t L_t + R_t B_t + \Phi_t - \int_0^1 P_t(j) C_t(j) dj && (7)
\end{aligned}
$$

where the preference shock is given by $\tilde{b}_t = \bar{b}/(1+b_t)$ and $log(b_t) = \rho_b log(b_{t-1}) + \sigma_{b,t}\varepsilon_{b,t}$. Finally, the volatility of the preference shock is also auto-regressive and given by $log(\sigma_{b,t}) = (1-\rho_{vb})log(\bar{\sigma}_b) + \rho_{vb} log(\sigma_{b,t-1}) + \varepsilon_{vb,t}$. Optimality yields the following,

$$
\begin{aligned}
C_t(j) &= C_t \left[\frac{P_t(j)}{P_t}\right]^{-\eta} && (8)\\
L_t^{\kappa} &= X_t^{-\sigma} \frac{W_t}{P_t} && (9)\\
X_t &= \frac{\tilde{b}_t}{\tilde{b}_{t-1}} \beta \mathbb{E}_t \left[X_{t+1} R_{t+1} \frac{P_t}{P_{t+1}}\right] && (10)
\end{aligned}
$$

where $X_t = (C_t - \theta C_{t-1}^{-\sigma}) - \theta\beta(\tilde{b}_t/\tilde{b}_{t-1})\mathbb{E}_t[(C_{t+1} - \theta C_t^{-\sigma})]$ and $P_t = \left[\int_0^1 P_t(j)^{1-\eta}\right]^{\frac{1}{1-\eta}}$.

Firms. Monopolistic-competitive firms produce differentiated goods using labor as the sole factor of production and set prices subject to *Rotemberg* price adjustment costs.[30] Firms maximize the discounted sum of expected profits using households' stochastic discount factor, $q_{t+s} = (X_{t+s}P_t)/(X_tP_{t+s})$:

$$max \qquad \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s q_{t+s} \Phi_{t+s}(j) \tag{11}$$

subject to:

$$\Phi_{t+s}(j) = P_t(j)C_t(j) - W_tL_t(j) - \frac{\delta}{2} P_t C_t \left[\frac{P_t(j)}{P_{t-1}(j)} - \pi^* \right]^2 \tag{12}$$

$$C_t(j) = C_t \left[\frac{P_t(j)}{P_t} \right]^{-\eta} \tag{13}$$

$$C_t(j) \leq Y_t(j) = A_tL_t(j) \tag{14}$$

A common technology process governs the transformation of labor into differentiated goods. Technology follows an auto-regressive process, $log(A_t) = (1-\rho_A)log(\bar{A}) + \rho_A log(A_{t-1}) + \sigma_{A,t,}\varepsilon_{A,t}$. More importantly, innovations to technology are hit with volatility shocks which themselves are auto-regressive, $log(\sigma_{A,t}) = (1-\rho_v)log(\bar{\sigma_A}) + \rho_v log(\sigma_{A,t-1}) + \varepsilon_{,Av,t}$. These volatility shocks correspond to supply-side uncertainty in the model.

Aggregation and monetary policy. Aggregating a symmetric equilibrium yields the following equations,

$$C_t = A_tL_t - \frac{\delta}{2} C_t \left[\pi_t - \pi^*\right]^2 \tag{15}$$

$$w_t = \lambda_{y,t} A_t \tag{16}$$

$$(1-\eta\lambda_{c,t})C_t = \delta C_t \pi_t(\pi_t - \pi^*) - \delta \frac{\tilde{b}_t}{\tilde{b}_{t-1}} \beta \mathbb{E}_t \left[\frac{X_{t+1}}{X_t} C_{t+1} \pi_{t+1}(\pi_{t+1} - \pi^*) \right] \tag{17}$$

$$1 = \lambda_{y,t} + \lambda_{c,t} \tag{18}$$

[30] 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 more deflationary uncertainty shocks relative to *Calvo*-type nominal rigidities.

where $\pi_t \equiv P_t/P_{t-1}$, $w_t \equiv \frac{W_t}{P_t}$, and $\lambda_{y,t}$ and $\lambda_{c,t}$ are the multipliers on production and demand respectively in the firms' problem.

Finally, a monetary authority determines the rate of interest on the one-period asset which is in zero net supply. It does so according to a Taylor-type rule of the following form,

$$\frac{R_t}{R^*} = \left[\frac{R_{t-1}}{R^*}\right]^{\rho_r} \left[\frac{\pi_t}{\pi^*}\right]^{\alpha_\pi(1-\rho_r)} \left[\frac{Y_t}{Y^*}\right]^{\alpha_y(1-\rho_r)} \left[\frac{\sigma_{A,t,}}{\bar{\sigma}_A}\right]^{\alpha_v(1-\rho_r)} \left[\frac{\sigma_{b,t}}{\bar{\sigma}_b}\right]^{\alpha_{vb}(1-\rho_r)} \tag{19}$$

where R^* is the natural rate, π^* is the inflation target, and Y^* is steady state output. The last two terms allow for monetary policy to respond to uncertainty shocks if the parameters α_v and α_{vb} are non-zero. Equation 19 along with equations 9, 10, and equations 15 to 18 determine equilibrium in the model.

Calibration. A key parameter in the model, given the envisioned exercises, is the elasticity of substitution across goods denoted with η. The parameter is calibrated to match average markups from De Loecker and Eeckhout (2020) by matching them to the (deterministic) steady state markup given by $\eta/(\eta-1)$. The baseline calibration is set to match the Euro area average markup.[31] I then simulate versions of the model where I change the value of this parameter to match average markups for each of the 13 European countries with markup estimates.

Another parameter of interest is the degree of price stickiness δ. The baseline value for the price stickiness parameter is calibrated to approximately match an average price duration of just over 4 quarters in a Calvo sticky-price setting.[32] This

[31] The Euro area average is the weighted (by real GDP) average markups of the 10 Euro area countries in the De Loecker and Eeckhout (2020) sample. These 10 countries account for approximately 95% of Euro area GDP.

[32] This is achieved by equating the slopes of the resulting (linearized) Phillips Curves from both settings. If the Calvo parameter is given by v, then the approximately equivalent Rotemberg parameter δ is given by $\delta = [(\eta-1)v]/[(1-v)(1-\beta v)]$.

estimate is obtained from column 4 of Table 2 in Gautier et al. (2022) who find an average frequency of monthly price changes excluding sales of about 8.5% for the Euro area over the period 2010-2019. In a second exercise, I simulate the response of inflation to uncertainty shocks when I vary the degree of price stickiness to match estimates for 11 Euro area countries obtained from Gautier et al. (2022) which ranges from an average duration of 2.9 to 7.3 quarters.

A third set of parameters of interest are the coefficients on uncertainty in the monetary policy rule, α_v and α_{vb}. These are set to zero in the baseline calibration. In a third set of simulation exercises, I let monetary policy respond to demand-side uncertainty shocks (increase the value of α_{vb}) and ascertain what values would be necessary to get approximately a zero cumulated inflation response over a four year horizon and approximately the same deflationary response as financial uncertainty shocks in the VAR exercises in Section 3.

The other parameters of the model take values that are standard in the literature. Table A.8 in the Appendix provides a full description of all the parameters and how they are calibrated. Once calibrated, the model is solved using third order perturbation methods (Andreasen et al., 2018) and I simulate how the economy reacts to a one standard deviation uncertainty shock. The variance of the volatility processes for both demand- and supply-side uncertainty are calibrated so that simulated results using the Euro area average markup also match the cumulative impulse response of inflation to household uncertainty shocks over a 4 year period from the vector auto-regression for the Euro area in section 3.[33] When calculating impulse responses from the model, I follow Basu and Bundick (2017) and essentially

[33]The estimated cumulated response of inflation to household uncertainty shocks over a four year horizon is 1.37% for the Euro area in a vector auto-regression which augments the baseline specification with linear time trends and month-specific constant terms - the specification used in section 4 to make cross-country impulse responses relatively more comparable.

calculate generalized impulse responses initialized at the stochastic steady state.[34]

5.2. *Simulated markups and inflation*

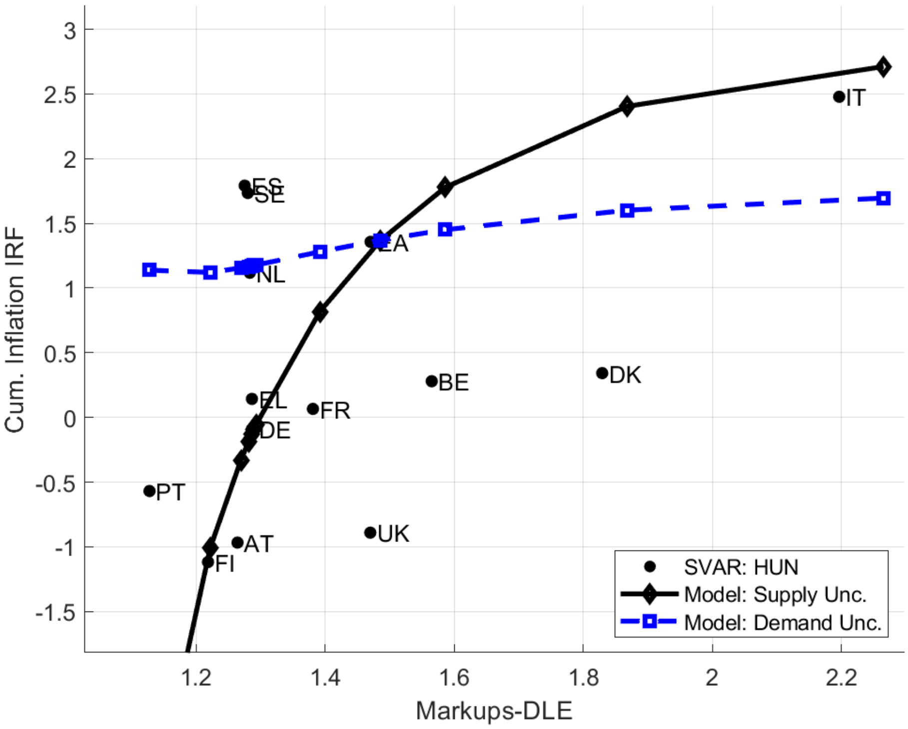
The first exercise looks at the response of inflation to uncertainty shocks over a range of average markups. Figure 8 plots cumulated inflation impulse responses to supply-side (connected black diamonds) and demand-side (connected blue squares) uncertainty shocks over a four year period on the vertical axis with the respective calibrated average markups in the horizontal axis. For comparison, I also plot the cumulated inflation responses across Euro area countries and their corresponding average markups from the vector auto-regressions in section 4. These are denoted with black dots and are also labeled with country codes.

Figure 8 shows that variations in the elasticity of substitution, and consequently average markups, are sufficient to generate a wide range of inflationary responses to supply-side uncertainty. While it is clear that variations along this one dimension would not be enough to completely explain the variation in the data, the results show that calibrating to the range of markups from a high value (e.g., Italy) to a low one (e.g., Finland) can generate responses much like the highly inflationary response in Italy or the deflationary response in Finland obtained from the vector auto-regressions.

On the other hand, it is also notable that variations in markups do not significantly change the response of inflation to demand-side uncertainty shocks in the

[34] This is done by simulating a *burn in* period of 500 quarters to allow the economy to drift to its stochastic steady state before introducing the shock of interest. As such, these impulse responses reflect the *average* effects of the shock of interest as represented by the initialized values at the stochastic steady state. See Andreasen et al. (2021) for a novel solution method which allows for uncovering the state-dependent effects of uncertainty shocks. Further, impulse responses, except for the endogenous volatility variables, are in % deviations from a simulation with no shocks. See Figures A.15 to A.18 in the Appendix for plots of impulse responses to all model shocks.

Figure 8: Inflation IRFs and markups: Model vs Data



The connected diamonds in black represent simulated cumulated impulse responses of inflation to a supply-side uncertainty shock from different calibrations of markups in the New Keynesian model. The connected squares in blue represent simulated cumulated impulse responses of inflation to demand-side uncertainty shocks from different calibrations of markups in the New Keynesian model. Each dot represents the median cumulated impulse response of inflation to household uncertainty shocks and average markups by country from a vector auto-regression. The vertical axes indicate the cumulated median impulse response, over a 48-month horizon, of inflation to shocks to household uncertainty for the vector auto-regressions or to demand- or supply-side uncertainty shocks for the New Keynesian model. The VAR impulse responses are taken from recursively-identified HUN shocks in a VAR estimated with three lags and includes linear time trends and month-specific constant terms. Markups are averages over the period 2002-2016 and taken from De Loecker and Eeckhout (2020). Each observation has been labeled with country codes which are official European Union designations. The mapping between country codes and country names are given in Table A.1.

model. An examination of the responses of the other variables to uncertainty shocks indicate that precautionary savings and labor supply behavior may be stronger under demand-side uncertainty shocks.[35] Relative to supply-side uncertainty shocks, households work harder for lower real wages under demand-side uncertainty shocks.

Perhaps, one lesson from this exercise is that the household measure of uncertainty (HUN) may be thought of as a proxy for a type of macro-uncertainty that is

[35] See Figures A.17 and A.18 in the Appendix.

closer to the way supply-side uncertainty is introduced in the model. That is, when households respond with *Don't know* when asked about the general state of the economy or the number of unemployed, they are possibly expressing their uncertainty about the productive capacity of the economy rather than uncertainty about their (or their peers') relative desires to consume.[36] This is consistent with evidence from Andre et al. (2022a) and Andre et al. (2022b) who find that households' subjective models of the economy tend to focus on supply-side mechanisms.

In earlier work, Bianchi et al. (2018) develop a model with both supply and demand-side uncertainty shocks as is done in this paper. They find that the precautionary savings and nominal pricing bias mechanisms have opposite effects on inflation and tend to cancel each other out when it comes to demand-side uncertainty. On the other hand, they find that the nominal pricing bias mechanism is not quantitatively important for supply-side uncertainty and therefore tends to be deflationary. Their results could potentially be replicated by the model in this paper if the calibration were to be tweaked to have low levels of price rigidities and monetary policy responding to the demand-side uncertainty shock. Instead, under the baseline calibration that I use where the degree of price rigidity is set to match an average price duration of just over 4 quarters in a Calvo setting, I find that both demand-side and supply-side uncertainty shocks are inflationary in my model.

5.3. Importance of price rigidities

In the next exercise, I examine the sensitivity of the response of inflation to uncertainty shocks with respect to the degree of price rigidities. Price rigidities have been identified as important to understanding the effects of uncertainty particularly

[36] See the Appendix for a more detailed example.

in generating declines in economic activity as observed in the data.[37] To verify whether differences in the degree of price rigidities across countries can generate large differences in the response of inflation to uncertainty shocks, I simulate the model under various calibrations of the price rigidity parameter δ. I take estimates of price rigidities from Gautier et al. (2022) for 11 Euro area countries and the Euro area as a whole.[38] The range goes from an average implied price duration of 2.9 quarters for Belgium to 7.3 quarters for Italy.

Figure 9 plots the resulting cumulated response of inflation to uncertainty shocks on the vertical axis for these calibrations with the implied price duration in the horizontal axis. The black diamonds refer to the cumulated inflation responses to supply-side uncertainty shocks while the blue squares correspond to the cumulated inflation responses to demand-side uncertainty shocks. The point of intersection identifies the baseline calibration where the shock variances have been calibrated to precisely generate the same value as in the vector auto-regression for the Euro area.

First, the figure indicates that indeed the response of inflation to uncertainty shocks also depend on the degree of price rigidities. The response of inflation to both demand-side and supply-side uncertainty shocks are generally hump-shaped over price rigidities but have very different points of inflections.[39] For example, given the calibration of the other parameters in the model, for low degrees of price rigidities we have deflationary supply-side uncertainty shocks and inflationary demand-side uncertainty shocks as in Bianchi et al. (2018).[40] However as

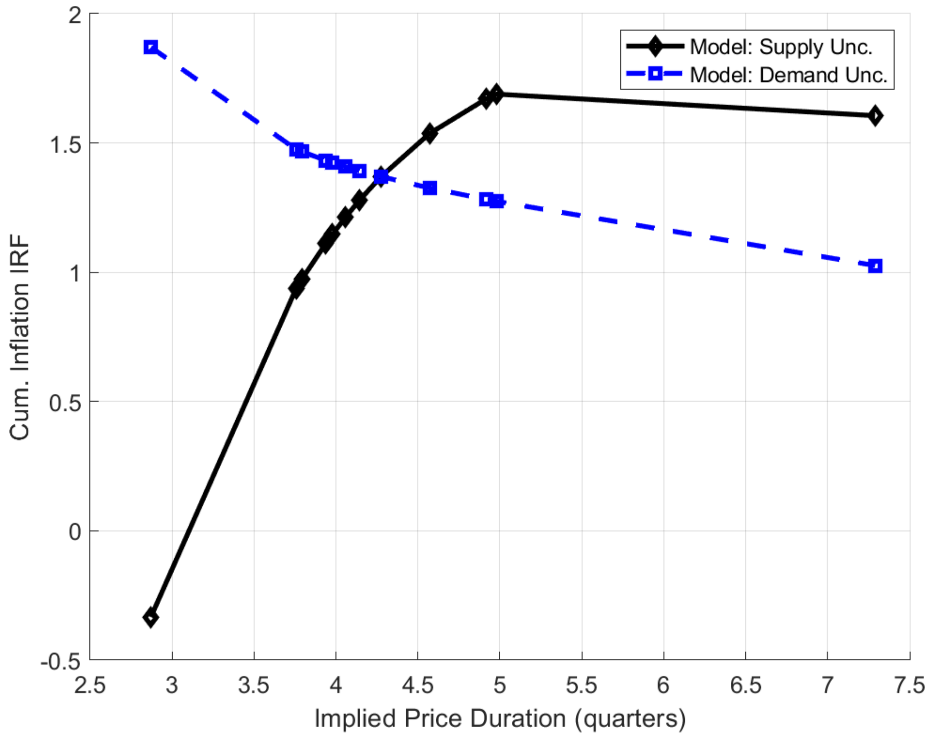
[37] See e.g., Basu and Bundick (2017), Bianchi et al. (2018), Fernandez-Villaverde and Guerron-Quintana (2020) and Born and Pfeifer (2021).

[38] The estimates are derived from the monthly frequency of price changes excluding sales reported in column 4 of Table 2 in Gautier et al. (2022).

[39] This becomes quite clear from simulations of the model where calibrations of the price rigidity parameter include extreme values from an average duration of 1 quarter to 16 quarters.

[40] More accurately, Bianchi et al. (2018) find that demand-side uncertainty shocks tend to have no effect on inflation while supply-side uncertainty shocks are deflationary. This can be replicated

Figure 9: Inflation IRFs and price rigidity



The connected diamonds in black represent simulated cumulated impulse responses of inflation to a supply-side uncertainty shock from different calibrations of the degree of price rigidities in the New Keynesian model. The connected squares in blue represent simulated cumulated impulse responses of inflation to a demand-side uncertainty shock from the same calibrations. The vertical axes indicate the cumulated impulse response, over a 4-year horizon, of inflation. The horizontal axis reports the implied duration of prices in a Calvo setting that would be most similar to the price adjustment cost parameter in the Rotemberg price adjustment cost setting used in the model.

the degree of price rigidity increases, we get a reversal and now supply-side uncertainty shocks are more inflationary than demand side uncertainty shocks. Note that the exact point of intersection is an artifact of the calibration and one should only interpret the qualitative or relative differences depicted in the figure.

These results confirm that differences in price rigidities across countries can also be a candidate factor for why inflation differs in its response to uncertainty shocks across European countries. Moreover, assuming that the household measure of uncertainty (HUN) proxies for supply-side uncertainty as indicated to be the case

when the monetary policy rule is calibrated to respond to demand-side uncertainty shocks.

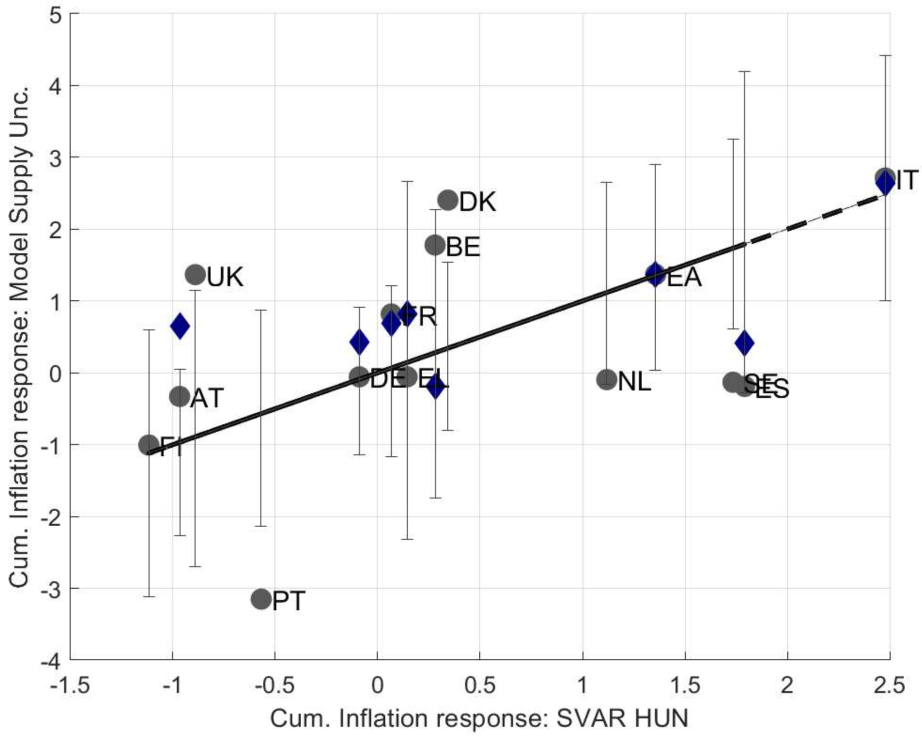
in the previous simulation exercise, one can get either deflationary or inflationary uncertainty shocks also by varying the degree of price rigidities.

As a complementary exercise, I also simulate the model where both the elasticity of substitution and degree of price rigidities are calibrated to match markup estimates from De Loecker and Eeckhout (2020) and the frequency of price changes from Gautier et al. (2022) for 7 Euro area countries and the Euro area as a whole. Figure 10 plots the cumulated response of inflation to supply-side uncertainty shocks in the model as against the estimated inflation responses from vector auto-regressions.[41]

As Figure 10 shows, the calibrated model does relatively well in matching empirical estimates of the response of inflation to household uncertainty shocks across several countries. This is despite the simplicity of the model and the fact that only two parameters are changed in each calibration. Calibrating the model to match the degree of price rigidities on top of matching average markups seems to improve the fit between the model and the data in all cases except for Austria. There are of course instances when the calibration does not match the data quite well, e.g., it overestimates the inflationary response to uncertainty shocks for Portugal and Sweden and underestimates the inflationary response to uncertainty shocks for the United Kingdom and Denmark. This only goes to show that there are other factors, not accounted for by the model, which may be quite relevant to the transmission of uncertainty shocks to inflation. Nevertheless, these exercises show that there are significant country differences in the transmission of uncertainty shocks to inflation and that factors related to the pricing bias mechanism are among them.

[41] See Figure A.14 in the Appendix for a comparison of the responses of inflation to demand-side uncertainty in the model against the responses of inflation to financial uncertainty obtained from vector auto-regressions.

Figure 10: Inflation IRFs: Model calibration vs. SVAR



The gray dots represent simulated cumulated impulse responses of inflation to a supply-side uncertainty shock from calibrations of the model to match average markups for 14 regions in the Euro area against estimated cumulated impulse responses of inflation to household uncertainty shocks from vector auto-regressions. The blue diamonds represent simulated cumulated impulse responses of inflation to a supply-side uncertainty shock from calibrations of the model to match average markups and degrees of price rigidity for 8 regions in the Euro area against estimated cumulated impulse responses of inflation to household uncertainty shocks from vector auto-regressions. The vertical axes indicate the model-simulated cumulated impulse response, over a 4-year horizon, of inflation to supply-side uncertainty shocks. The horizontal axis reports the cumulated impulse response, over a 4-year horizon, of inflation to household uncertainty shocks from vector auto-regressions. The 45 degree black line is also indicated for reference. The vertical lines, each centered on the 45 degree diagonal line, represent the 68% confidence band around the vector auto-regression cumulated impulse responses.

5.4. The role of monetary policy revisited

In a final exercise, I explore to what extent and by how much monetary policy has to directly respond to uncertainty shocks in order to mitigate or even overturn the inflationary effect of uncertainty shocks. Following Basu and Bundick (2017), I treat the demand-side uncertainty shock as the model equivalent for financial uncertainty shocks derived from IVOL in the empirical section of the paper. Consequently, in an attempt to replicate the evidence of deflationary financial uncertainty shocks from the vector auto-regressions, I consider alternative monetary policy rules which respond to demand-side uncertainty shocks by increasing the value of the parameter α_{vb} which was set to zero in the baseline specification. Panel A of Table 5 reports the simulation results.

Table 5: Inflation responses and monetary policy

Panel A. Model-implied responses of inflation

Monetary policy		Cum. Inflation (16 quarters)	
α_v	α_{vb}	Supply Unc.	Demand Unc.
0.0000	0.0000	1.37	1.37
0.0000	0.0002	1.37	0.02
0.0000	0.0004	1.37	-1.13

Panel B. Cumulated responses of inflation from SVARs

Uncertainty measure		Cum. Inflation (48 months)
Household	HUN	1.37
Policy	EPU	0.58
Financial	IVOL	-1.10

Panel A of the table report the cumulated impulse responses of inflation to uncertainty shocks over a four year period from the model under different assumptions regarding the monetary policy response to uncertainty shocks. Each row reports results from a particular parameter configuration of the monetary policy rule. The first two columns report the values of the parameters governing the monetary policy response to supply-side (α_v) and demand-side (α_{vb}) uncertainty shocks. The last pair of columns report the cumulated model-implied inflation responses to supply-side and demand-side uncertainty shocks. Panel B reports the cumulated response of inflation to household, financial, and policy uncertainty shocks for the Euro area from vector auto-regressions.

As in Fernandez-Villaverde et al. (2015) whose parameter governing the monetary policy response to uncertainty was set to 0.005, the necessary values to generate deflationary uncertainty shocks for the equivalent parameter in this model is quite small. As reported in Table 5, a parameter value of 0.0002 is sufficient to produce a near-zero inflationary response to (demand-side) uncertainty shocks while a slightly larger value of 0.0004 is needed to generate a deflationary response to uncertainty shock much like the 1.1% deflation obtained in a vector auto-regression with IVOL for the Euro area. Most importantly, this exercise shows that if an economy is faced with uncertainty shocks from multiple sources and monetary policy responds to only some of them as is the case in the bottom row of Panel A of Table 5, then one could simultaneously get deflationary and inflationary uncertainty shocks depending on where they originate from.

6. 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. I show that while measures of household, financial, and policy uncertainty all tend to increase around the same general periods, 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 which lower both economic activity and inflation. Instead, household uncertainty shocks are inflationary in Europe and have a delayed impact on unemployment. One explanation may be a relatively strong *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 of responses across countries also indicate a link between average markups and inflationary uncertainty shocks.

Simulation exercises from a basic New Keynesian model provide some support for these conjectures. Varying the elasticity of substitution across differentiated goods to match average markups across countries can generate a similar range of deflationary and inflationary responses to supply-side uncertainty shocks as in the vector auto-regressions. Further, varying the degree of price rigidities could also feasibly generate the same type of variation. Nevertheless, the model is quite simple in terms of characterizing financial and labor markets. Frictions in labor markets in particular have also been identified as key to the transmission of uncertainty shocks and incorporating them may prove useful in matching the delayed response of unemployment to household uncertainty shocks. Results obtained from models of uncertainty shocks and with richer labor and financial markets would complement those documented in this paper.[42]

I also find that the monetary policy response to uncertainty shocks play a role in whether uncertainty shocks are inflationary or deflationary. Model-based simulations confirm that the differential responses of monetary policy to uncertainty shocks arising from various sources can help explain the empirical evidence of inflationary household uncertainty shocks on the one hand and deflationary financial uncertainty shocks on the other in the Euro area. Whether or not monetary policy should do so is another question entirely. When monetary policy raises rates in the presence of uncertainty shocks, it aggravates the decline in output. Evaluating the optimal monetary policy response to uncertainty shocks would require a more thorough analysis. As this is already outside the scope of the paper, this exercise is left for future research.

Altogether, these results indicate that there are potentially several distinct sources of macro-uncertainty with differing aggregate effects. These effects may also drastically differ across countries with different economic features. It is hoped that the introduction of a new measure of household uncertainty available for a wide range of countries and a long period of time would help instigate further research and

[42]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.

deepen our understanding of the effects of uncertainty on the economy.

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Appendix

Data sources and household uncertainty

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) for Europe is obtained from their website while the option-implied and realized volatility measures of financial uncertainty are taken from *Stoxx Ltd* and Macrobond.[43] Average markups are taken from De Loecker and Eeckhout (2020) and available for 13 countries in the sample. The markup estimate for the Euro area is calculated as the weighted average (using real GDP) of the Euro area country average markups. These estimated markups are averages for the years 2002-2016. Finally, additional country characteristics are obtained from the World Bank's World Development Indicators database and are averages over the period 2002-2018.

The calculation for the various survey-based indices are detailed in the main text. The codes for countries and regions covered in the analysis are reported in Table A.1 and variable descriptions are provided in Table A.2.

Table A.1: Country codes

Region	Symbol	Region	Symbol
Austria	AT	Belgium	BE
Bulgaria	BG	Cyprus	CY
Czechia	CZ	Germany	DE
Denmark	DK	Estonia	EE
Greece	EL	Spain	ES
Finland	FI	France	FR
Croatia	HR	Hungary	HU
Ireland	IE	Italy	IT
Lithuania	LT	Luxembourg	LU
Latvia	LV	Malta	MT
Netherlands	NL	Poland	PL
Portugal	PT	Romania	RO
Sweden	SE	Slovenia	SI
Slovakia	SK	United Kingdom	UK
Euro Area	EA		

[43] IVOL and EPU were obtained from https://www.policyuncertainty.com/ and https://www.stoxx.com/index-details?symbol=V2TX respectively.

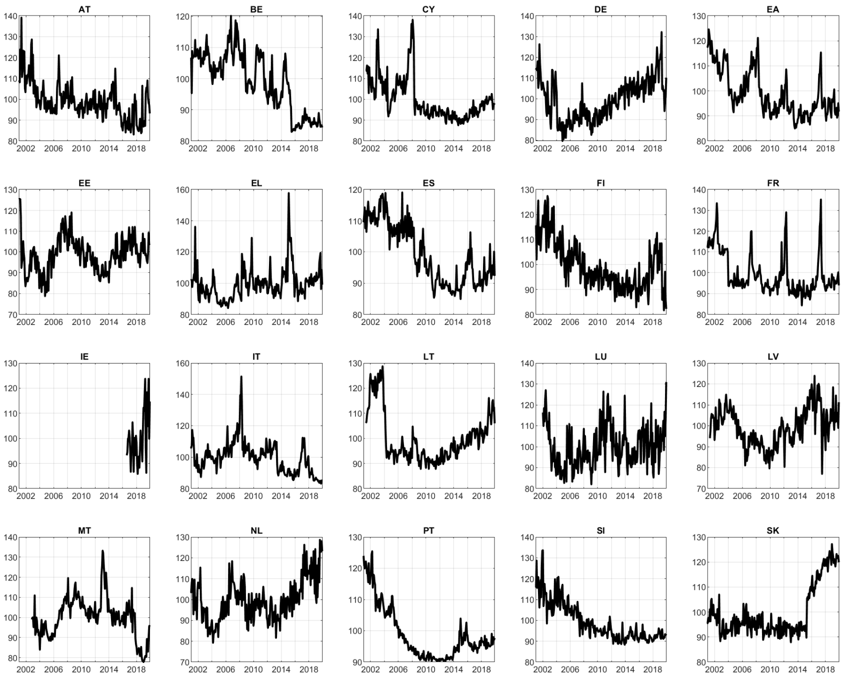
Table A.2: Data description

Variable name	Description	Source
HUN	Index of household uncertainty	Author's calculations, Consumer survey
EPU	Baker et al. (2016) policy uncertainty indices	https://www.policyuncertainty.com
IVOL	Option-implied volatility of Eurostoxx 50	Stoxx Ltd.
RVOL	Realized volatilty of daily stock price indices	Author's calculations, Macrobond
CSI	Consumer sentiment index	Author's calculations, Consumer survey
DIS	Index of household belief dispersion	Author's calculations, Consumer survey
Expected durable expenditures	Index of household planned durable expenditures	Author's calculations, Consumer survey
Right time to buy	Index of household views on right time to make large purchases	Author's calculations, Consumer survey
Change in financial situation	Index of change in household financial situation	Author's calculations, Consumer survey
Industrial production growth	Y-o-y change in log industrial production	Statistical Data Warehouse
Inflation	Y-o-y change in log HICP	Statistical Data Warehouse
Unemployment	Y-o-y difference in unemployment rate	Statistical Data Warehouse
Interest rate	Daily market rate (EONIA for EA countries)	Statistical Data Warehouse
Shadow rate	implied short rate from the term structure	Wu and Xia (2016)
Markups	Averages of estimates for 2002-2016	De Loecker and Eeckhout (2020)
Real GDP per capita	Real GDP per capita	World Bank WDI
Real GDP	Constant 2010 USD	World Bank WDI
Ease of doing business	World Bank index for ease of doing business	World Bank WDI
Legal rights index	Strength of legal rights (0=weak to 12=strong)	World Bank WDI
Market Capitalization to GDP	Stock market capitalization to GDP ratio	World Bank WDI
Current Account to GDP	Current account balance to GDP	World Bank WDI
Trade to GDP	Total trade to GDP	World Bank WDI
Share of Services to GDP	Services value added to GDP	World Bank WDI
Labor Force Participation Rate	Labor force to population ratio (15+)	World Bank WDI
Share of vulnerable employed	Estimated share to total employment	World Bank WDI
Share of self-employed	Self-employed to total employment	World Bank WDI
GINI coefficient	World Bank estimate	World Bank WDI

World Bank data are averages over the period 2002-2018. Markups are 2002-2016 averages. IVOL and EPU for the Euro area are V2TX and the Baker et al. (2016) index for Europe respectively. The country-specific EPU measures are obtained from https://www.policyuncertainty.com/. The country-specific RVOL are the realized volatilities (calculated as the volatility of daily returns within a given month) of the Eurostoxx 50, BEL20, PX50, DAX40, IBEX35, CAC40, and the FTSE MIB Index for the Euro area, Belgium, Czechia, Germany, Spain, France, and Italy respectively. The realized volatilities of the FTSE 100, FTSE ATHEX Large Cap, BUX, LuxX, AEX, OMXC20, and OMX Helsinki 25 are used for the United Kingdom, Greece, Hungary, Luxembourg, Netherlands, Denmark and Finland respectively. The realized volatilities of the OMX Riga, OMXS30, OMX Tallinn, OMX Vilnius, WIG20, PSI20, and Wiener Borse Index are used for Latvia, Sweden, Estonia, Lithuania, Poland, Portugal and Austria respectively.

Figure A.1 plots the time-series evolution of the household uncertainty measure for all Euro area countries as well as the Euro area average.

Figure A.1: Household uncertainty across the Euro area



The panels plot the household uncertainty measure, HUN, for all Euro area countries as well as the Euro area average. All of the indices have been standardized such that 100 represents the mean and 10 points represent one standard deviation.

Figure A.2 plots the non-standardized household uncertainty measures for the Euro area and the five largest member countries. The indices capture the average fraction of households responding with *Don't know* to four questions in the consumer survey.

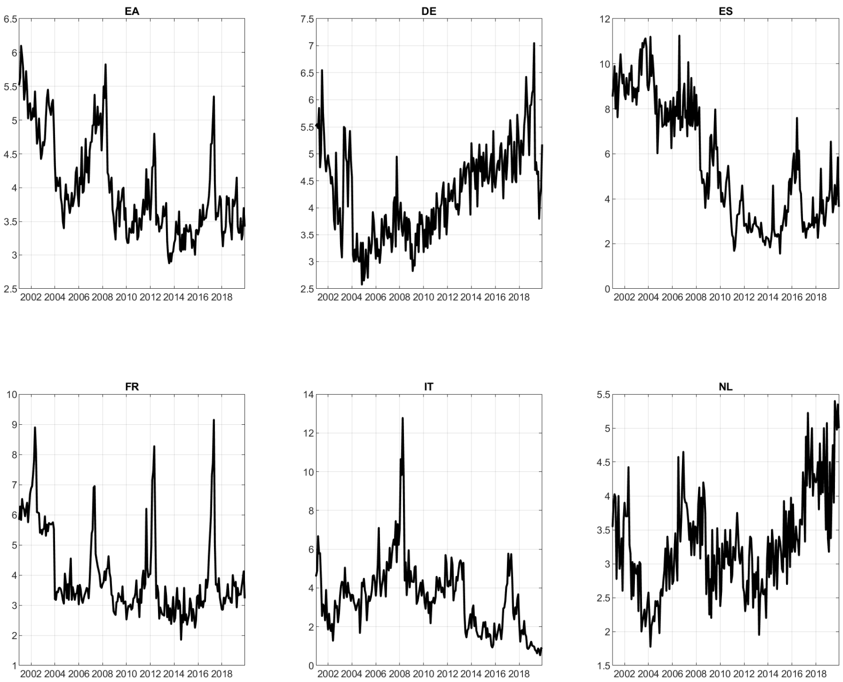
Table A.3 reports an analysis of variance of the non-standardized household uncertainty measure for a panel of Euro area countries across time and countries.

Table A.3: Analysis of variance of HUN for Euro area countries

Source	Sum Sq.	d.f.	Mean Sq.	F	Prob>F
Time	3367.6606	239	14.0906	2.5007	0.0000
Country	54731.9504	18	3040.6639	539.6402	0.0000
Error	22538.4517	4000	5.6346		
Total	79414.7603	4257			

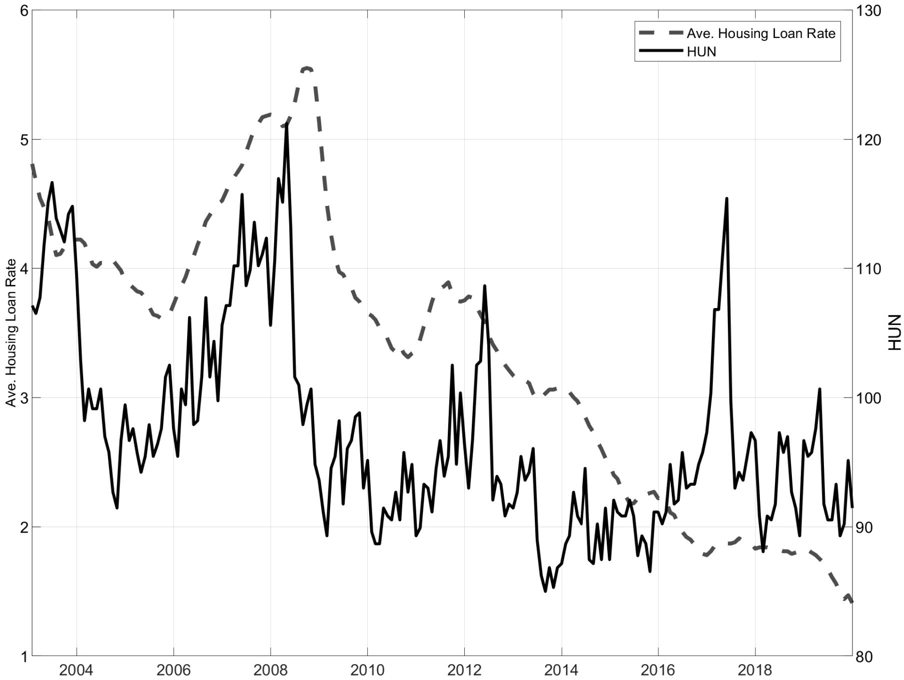
HUN is the (non-standardized) measure for household uncertainty. The table reports variance decomposition of the HUN measure for all 19 Euro area countries over the period 2000-2019.

Figure A.2: Non-standardized household uncertainty measures in the Euro area



The panels report the non-standardized measure for household uncertainty, HUN, for the 5 largest economies in the Euro area and the Euro area as a whole. The values represent the average fraction of households responding with Don't know for each survey date (e.g. a value of 6 in the index would mean that 6 % of households responded with Don't know).

Figure A.3: Household uncertainty and average housing loan rates in the Euro area

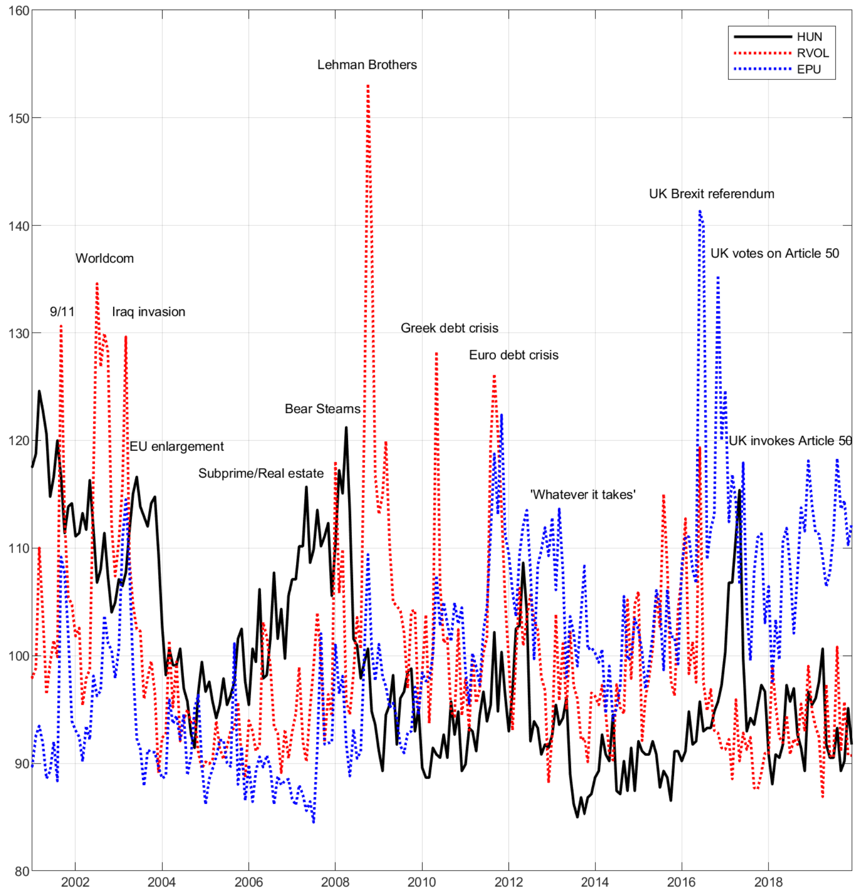


The solid black line plots the standardized household uncertainty index, HUN, for the Euro area on the right vertical axis. The dashed gray line plots average housing loan rates for the Euro area obtained from the ECB Statistical Data Warehouse on the left vertical axis.

Comparison of uncertainty measures in Europe

Figure A.4 plots the time-series of household uncertainty (HUN), realized stock market volatility (RVOL), and policy uncertainty (EPU) for the Euro area. The figure also identifies significant events associated with heightened macro-uncertainty at the corresponding periods in time that they occur. The realized volatility of the Eurostoxx 50 index (RVOL) tracks very well the time-series of option-implied volatility of the same index, V2TX (IVOL), and is available for a longer period of time.

Figure A.4: Comparison of measures of uncertainty for the Euro area



HUN is the Euro area index of household uncertainty. RVOL is the realized volatility of the Eurostoxx 50. 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 where 100 represents the respective means and 10 is one standard deviation.

Tables A.4 and A.5 report correlations between household, financial, and policy uncertainty for the Euro area and several European countries.

Table A.4: Correlations of household uncertainty with policy uncertainty

	EPU
Euro area	-0.413
Germany	0.275
Spain	-0.669
France	-0.202
Italy	-0.222
Netherlands	-0.235

The table reports Pearson correlation coefficients between household uncertainty and policy uncertainty. EPU is the Baker et al. (2016) measure of economic policy uncertainty for Europe and the five countries taken from https://www.policyuncertainty.com/.

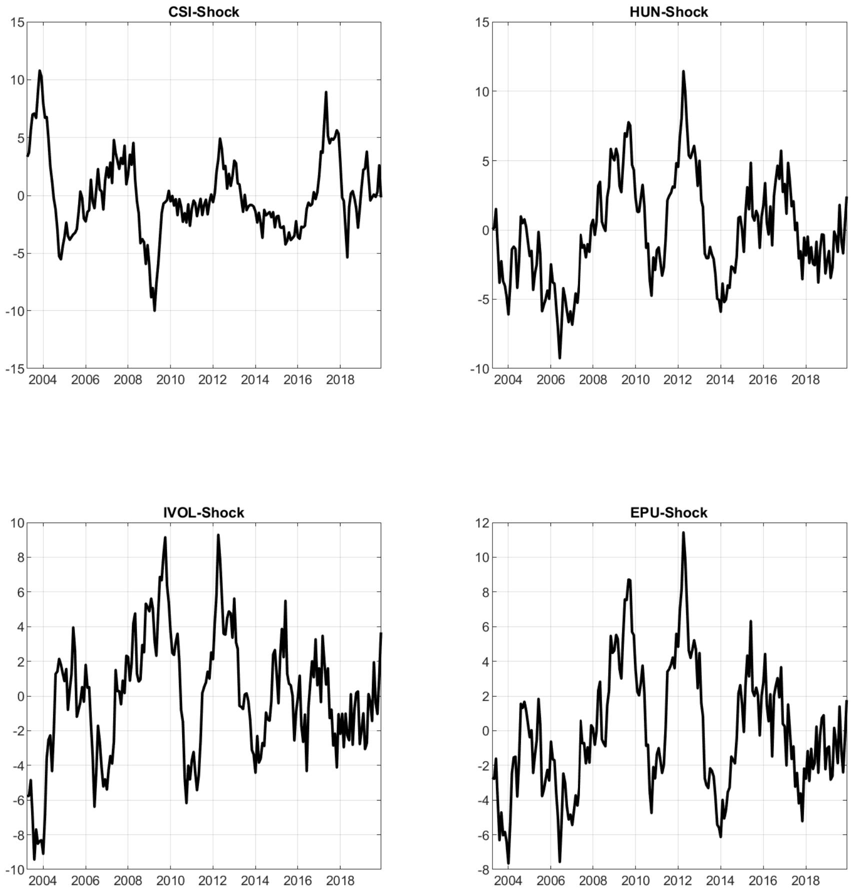
Table A.5: Correlations of household uncertainty with realized stock market volatility

Country	Corr	Country	Corr	Country	Corr
Euro area	0.157	United Kingdom	0.024	Latvia	-0.130
Belgium	0.166	Greece	0.370	Sweden	-0.160
Czechia	0.255	Hungary	-0.081	Estonia	0.154
Germany	-0.068	Luxembourg	0.084	Lithuania	-0.129
Spain	0.001	Netherlands	-0.182	Poland	0.117
France	0.164	Denmark	-0.059	Portugal	-0.121
Italy	0.007	Finland	0.134	Austria	-0.104

The table reports Pearson correlation coefficients between household uncertainty and realized stock market volatility for the Euro area and thirteen countries for which both measures of uncertainty are available. The country-specific RVOL are the realized volatilities (calculated as the volatility of daily returns within a given month) of the Eurostoxx 50, BEL20, PX50, DAX40, IBEX35, CAC40, and the FTSE MIB Index for the Euro area, Belgium, Czechia, Germany, Spain, France, and Italy respectively. The realized volatilities of the FTSE 100, FTSE ATHEX Large Cap, BUX, LuxX, AEX, OMXC20, and OMX Helsinki 25 are used for the United Kingdom, Greece, Hungary, Luxembourg, Netherlands, Denmark and Finland respectively. The realized volatilities of the OMX Riga, OMXS30, OMX Tallinn, OMX Vilnius, WIG20, PSI20, and Wiener Borse Index are used for Latvia, Sweden, Estonia, Lithuania, Poland, Portugal and Austria respectively.

Figure A.5 plots the time-series of uncertainty shocks recovered from a recursively-identified VAR with the variables consumer sentiment, uncertainty, unemployment, inflation, and interest rate.

Figure A.5: Implied uncertainty shocks from a recursively identified VAR for the Euro area

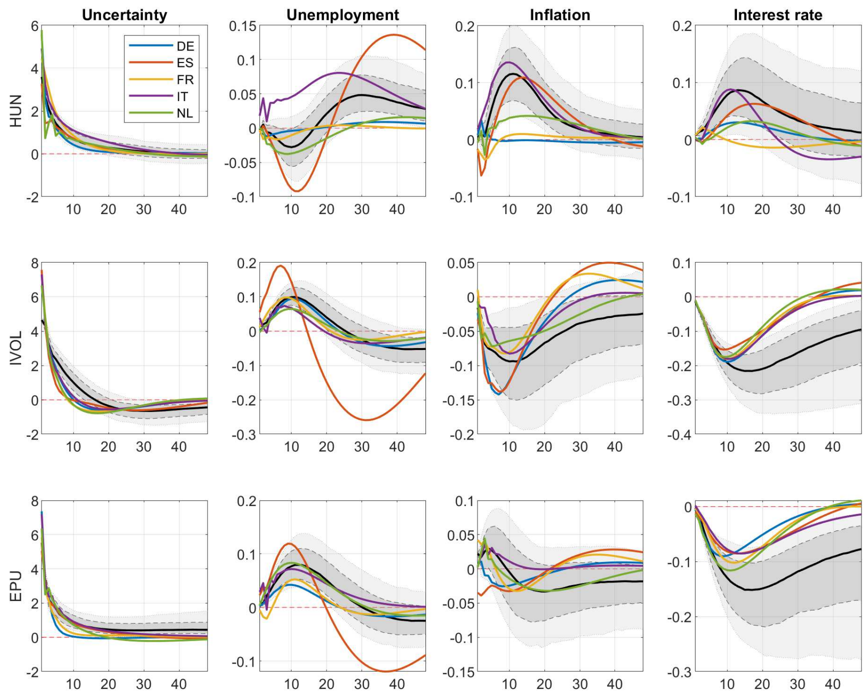


The panels plot the (annualized) uncertainty shock series recovered from recursively-identified VARs of the variables: consumer sentiment, an uncertainty measure, unemployment, inflation, and interest rate. Three VARs are estimated each using a different measure of uncertainty. These are HUN, household uncertainty, IVOL, the option-implied volatility of the Eurostoxx 50 index, and EPU, the Baker et al. (2016) measure of economic policy uncertainty for Europe. The recovered uncertainty shock series are plotted in the top right, bottom left, and bottom right for HUN, IVOL, and EPU respectively. The uncertainty measure is ordered second in the VAR. For comparison, the recursively-identified consumer sentiment shock (ordererd first) from the VAR with household uncertainty is reported in the top left panel.

Robustness regarding the effects of uncertainty on inflation.

Similar results to the baseline are obtained when the VAR is estimated using data for each of the 5 largest Euro area countries. Household uncertainty shocks are largely inflationary when using Italian, Spanish, or Dutch data. Household uncertainty shocks appear to also be mildly inflationary when using German data. On the other hand financial uncertainty shocks, as proxied with the realized volatility of stock indices, tend to be deflationary. Finally, country-specific economic policy uncertainty shocks appear to have ambiguous or zero inflationary effects.

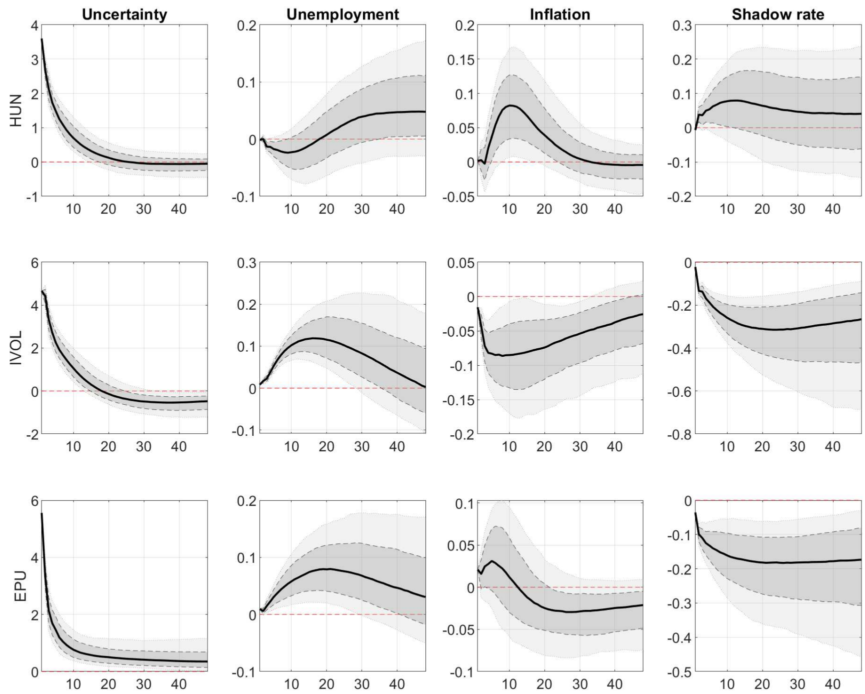
Figure A.6: Impulse responses for 5 Euro area countries



The panels report median impulse responses to one standard deviation shocks to household uncertainty, realized volatility of stock markets, and policy uncertainty for 5 Euro area countries. Germany is blue, Spain is red, France is yellow, Italy is purple, and the Nertherlands is green. The country-specific RVOL are the realized volatilities (calculated as the volatility of daily returns within a given month) of the CAC40, DAX30, FTSE Benchmark MIB Index, Euronext AEX, and IBEX35 indices for France, Germany, Italy, Netherlands, and Spain respectively. The EPU policy uncertainty measures are the country-specific Baker et al. (2016) indices taken from https://www.policyuncertainty.com/. The impulse responses for the Euro area average are reported in black with accompanying 68% and 90% confidence sets in shades of gray. Each column reports responses for a given variable and the uncertainty measure used in the VAR is given by the row labels.

The main results remain even when accounting for unconventional monetary policy measures in a VAR which replaces the short rate with the Wu and Xia (2016) shadow short rate. Figure A.7 plots impulse responses to uncertainty shocks in VARs which include a measure for the shadow short rate.

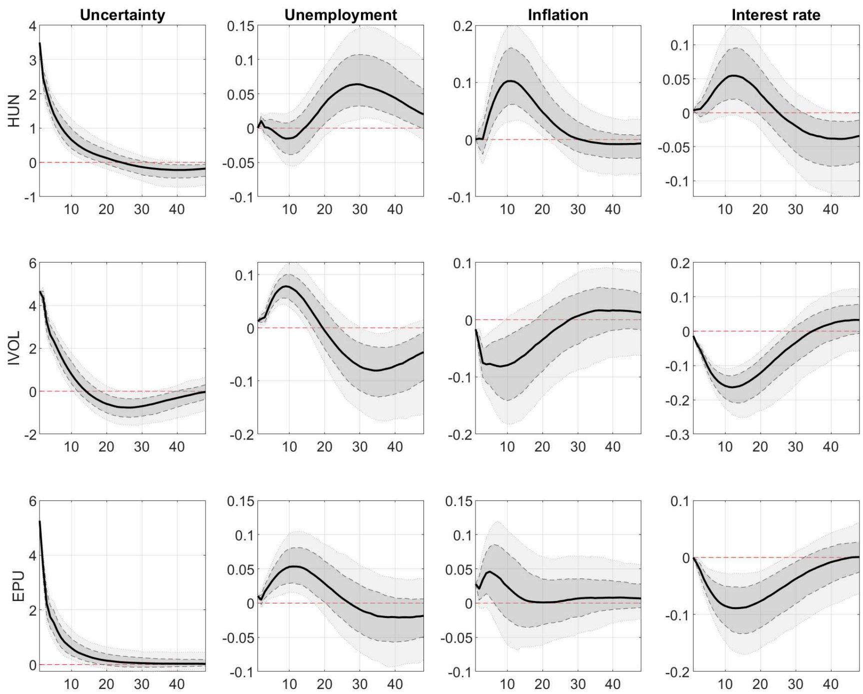
Figure A.7: Impulse responses in a VAR with shadow short rate



The panels report median impulse responses to one standard deviation shocks to household, financial, and policy uncertainty in VARs with the Wu and Xia (2016) shadow short rate. 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. IVOL 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 main results remain even when accounting for medium to long run secular trends and seasonality in the data. Figure A.8 plots impulse responses to uncertainty shocks in VARs with (exogenous) linear time trends and month-specific intercepts.

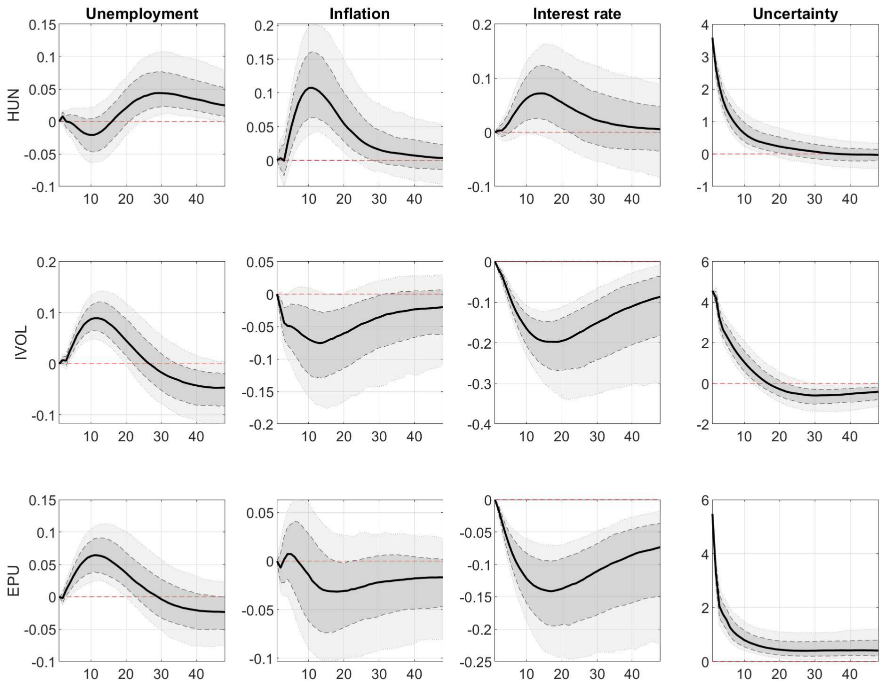
Figure A.8: Impulse responses in a VAR with seasonal indices and linear trends



The panels report median impulse responses to one standard deviation shocks to household, financial, and policy uncertainty in VARs with (exogenous) linear time trends and month-specific constants. 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. IVOL 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 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 A.9 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.

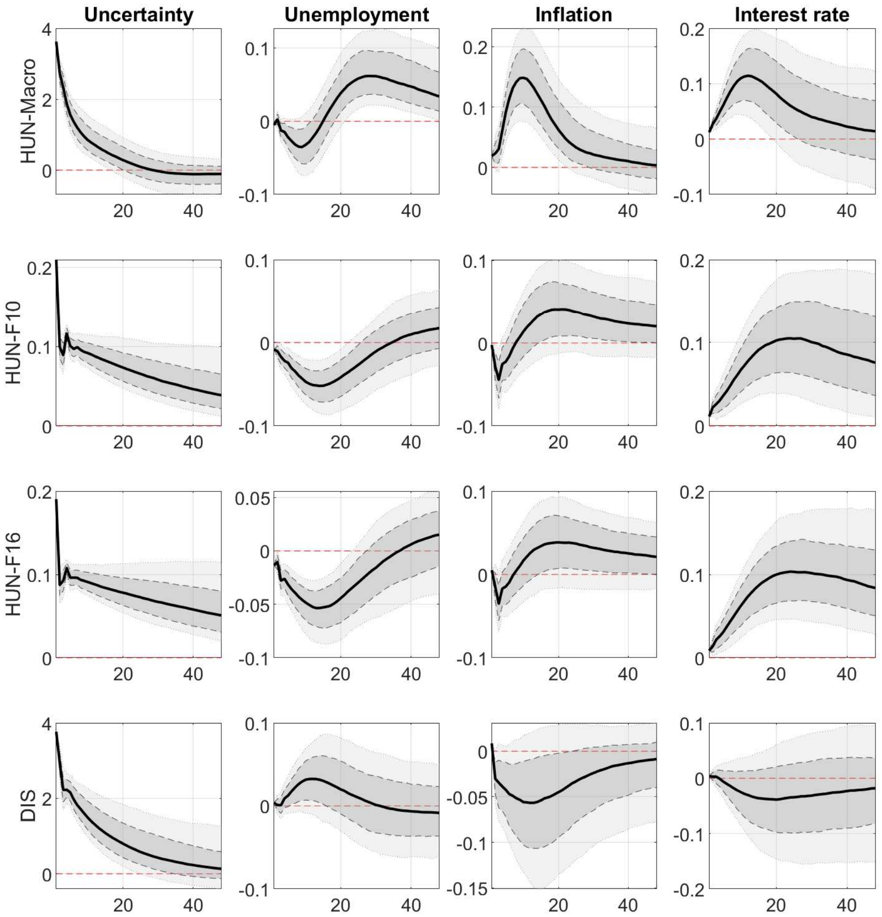
Figure A.9: Uncertainty ordered last impulse responses



The panels report median impulse responses to one standard deviation shocks to household, financial, and policy uncertainty in a recursively-identified VAR with the uncertainty variable ordered last. 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. IVOL 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.

Inflationary household uncertainty shocks are also obtained when the household uncertainty index is constructed solely from two questions pertaining to households' expectations about future economic activity and unemployment ($HUN - Macro$) and when the measure is the common factor from country-level measures of household uncertainty for 10 countries which have been in the Eurozone for the full sample period ($HUN - F10$) or for all Euro area countries in the sample ($HUN - F16$). Figure A.10 plots impulse responses to shocks based on these alternative measures household uncertainty. Impulse responses to household disagreement (DIS) are also reported in the bottom row.

Figure A.10: 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 measure of uncertainty is given by the row labels. HUN-Macro is the measure of household uncertainty using only survey responses to expected future economic activity and unemployment. HUN-F10 is the common factor in each of the household uncertainty indices from the 10 Euro area countries which have been members since 2002. HUN-F16 is the common factor in each of the household uncertainty indices from all of the Euro area countries in the sample. DIS is the dispersion of household expectations. The shaded areas reflect 68% and 90% confidence sets.

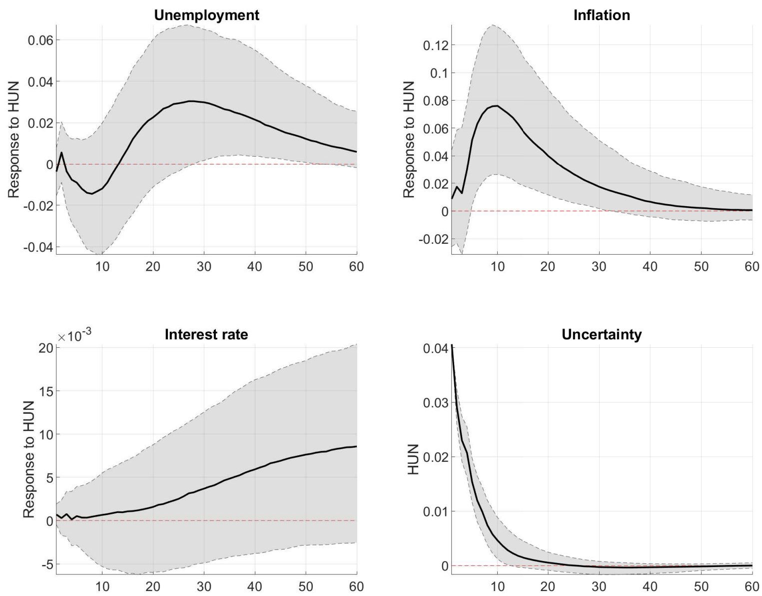
Impulse Response Functions under time-varying volatility identification.

Household uncertainty shocks are still inflationary when such shocks are identified using the Carriero et al. (2021) identification strategy. The model is given by,

$$\begin{aligned} Y_t &= \Pi_y(L)Y_{t-1} + \Pi_h(L)log(HUN_{t-1}) + \phi log(HUN_t) + A^{-1}\Sigma_{y,t}^{0.5}\varepsilon_t \\ log(HUN_t) &= \delta_y(L)Y_{t-1} + \delta_h(L)log(HUN_{t-1}) + +\psi\Sigma_{y,t}^{0.5}\varepsilon_t + \mu_t \\ log(diag(\Sigma_{y,t})) &= \beta log(HUN_t) + log(h_t) \\ log(h_t) &= \alpha + \gamma log(h_{t-1}) + \eta_t \end{aligned}$$

where Y_t is a vector of macroeconomic variables (unemployment, inflation, and the short rate), A is lower triangular, HUN_t is the uncertainty measure, and h_t is the unobserved time-varying stochastic volatility process. Note that the parameters ϕ and ψ allow for the contemporaneous effect of uncertainty shocks on the macroeconomic variables as well as the contemporaneous effect of the other macroeconomic shocks to the uncertainty measure. Further the parameter β allows for the uncertainty shock to influence the variance of the other macroeconomic shocks. The model is estimated with three lags and follows the procedure described in Carriero et al. (2021). Figure A.11 reports impulse response functions to a household uncertainty shock.

Figure A.11: Impulse responses under time-varying volatility identification



The panels report impulse responses to a household uncertainty shock along with the 68 % confidence interval. DUNEMP is the change in the unemployment rate, INFLTN is the inflation rate, SHRATE is the short interest rate, and HUN is the household uncertainty measure.

Counterfactual VAR exercise on monetary policy response.

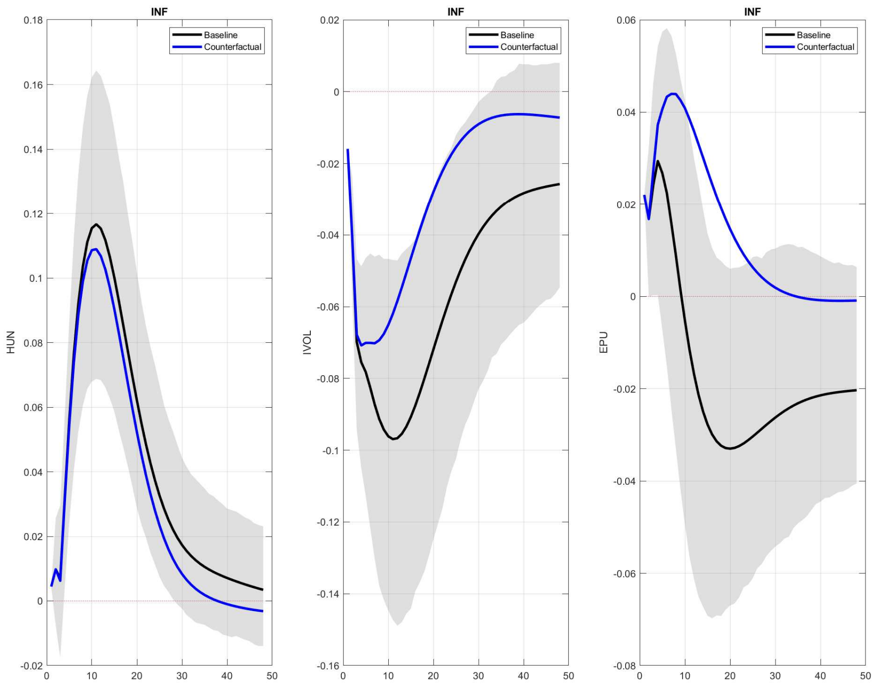
Following Bachmann and Sims (2012) and Kilian and Lewis (2011), the counterfactual impulse responses are produced by zeroing out the direct response of monetary policy to uncertainty shocks to evaluate the role of monetary policy in inducing inflationary uncertainty shocks. This is accomplished by first assuming that the equation in the VAR corresponding to the short rate is the monetary policy rule. One can then produce counterfactual impulse responses by taking the parameters from an estimated and recursively-identified VAR and zeroing out the parameters associated with the response of the monetary policy rule to contemporaneous and lagged uncertainty. For instance, in a four variable recursively-identified VAR with one lag and uncertainty ordered first while the policy rate is ordered last, the corresponding parameters are highlighted in red in equation A.1.

$$\begin{bmatrix} a_{1,1} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ a_{4,1} & \cdots & a_{4,4} \end{bmatrix} \begin{bmatrix} UNC_t \\ \vdots \\ MP_t \end{bmatrix} = \begin{bmatrix} b_{1,1} & \cdots & b_{1,4} \\ \vdots & \ddots & \vdots \\ b_{4,1} & \cdots & b_{4,4} \end{bmatrix} \begin{bmatrix} UNC_{t-1} \\ \vdots \\ MP_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{unc,t} \\ \vdots \\ \varepsilon_{mp,t} \end{bmatrix} \tag{A.1}$$

In the example illustrated in equation A.1, setting the estimated parameters $a_{4,1}$ and $b_{4,1}$ to zero would remove the response of monetary policy (MP) to contemporaneous and lagged fluctuations in uncertainty (UNC). Note that while we have ensured that the policy rate does not directly account for uncertainty, it may still indirectly respond to it when it reacts to fluctuations in unemployment and inflation. The exercise also assumes that the counterfactual is not siginificant enough to generate a change in the economic agents' behavior. Otherwise, the exercise would be subject to the *Lucas critique*.

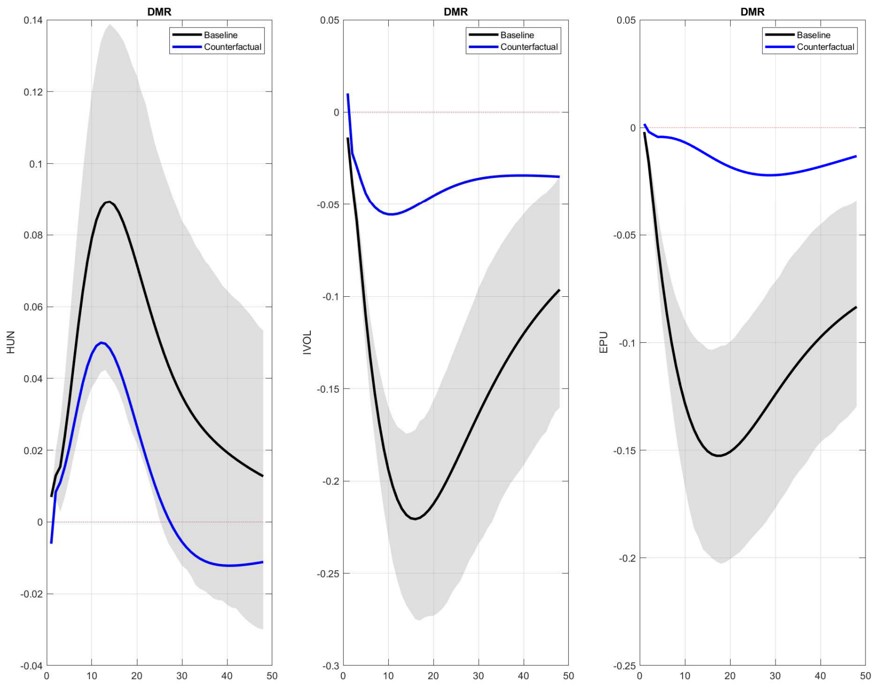
Figures A.12 and A.13 reports counterfactual impulse responses of inflation and the interest rate to uncertainty shocks (blue lines) in a recursively-identified VAR comprised of the following variables: uncertainty, unemployment, inflation, and the short rate. For comparison, the impulse responses from the unconstrained VAR are also plotted (black lines). The shaded areas reflect the 68% confidence sets around the unconstrained impulse responses. The impulse response of inflation to household uncertainty shocks (left panel) is slightly less inflationary in the counterfactual exercise. On the other hand, for the financial uncertainty (middle panel) and policy uncertainty (right panel) shock impulse responses, I find a shift towards more inflation (or less deflation). Consistent with these, I also find a shift towards relatively tighter monetary policy for the exercises concerning financial and policy uncertainty but a slight loosening of monetary policy in the counterfactual for household uncertainty.

Figure A.12: Counterfactual inflation impulse responses with non-responsive monetary policy



The panels report median impulse responses of inflation to one standard deviation shocks to uncertainty. Each column reports the responses of inflation in a VAR with the uncertainty shock indicated on the vertical axis labels. HUN is the measure of household uncertainty for the Euro area. IVOL 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 blue lines plot impulse responses from the counterfactual VAR which zeroes out the direct response of the short rate to uncertainty while the black lines plot responses from the unconstrained VAR. The shaded areas reflect the 68% confidence sets around the unconstrained impulse responses.

Figure A.13: Counterfactual interest rate impulse responses with non-responsive monetary policy



The panels report median impulse responses of the interest rate to one standard deviation shocks to uncertainty. Each column reports the responses of the interest rate in a VAR with the uncertainty shock indicated on the vertical axis labels. HUN is the measure of household uncertainty for the Euro area. IVOL 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 blue lines plot impulse responses from the counterfactual VAR which zeroes out the direct response of the short rate to uncertainty while the black lines plot responses from the unconstrained VAR. The shaded areas reflect the 68% confidence sets around the unconstrained impulse responses.

Cross-country heterogeneity of the effects of household uncertainty.

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. These country variables are 2002-2018 averages obtained from the World Bank World Development Indicators database. The right-most column reports the number of observations (countries) used to calculate the correlations. The full sample consists of 25 European countries (of which 17 are in the Euro area) and the Euro area as a whole.

Table A.6: Correlations of HUN with country characteristics

Variable	Correlation	Obs.
Ease of doing business	0.33276	25
Market Capitalization to GDP	-0.26924	23
Unemployment rate	0.16128	26
Real GDP per capita	-0.11533	26
Current Account to GDP	-0.10137	25
Share of Services to GDP	-0.093695	26
Labor Force Participation Rate	-0.080847	26
Share of vulnerable to total employment	-0.037591	26
GINI coefficient	-0.035716	25
Trade to GDP	0.034406	26
Legal Rights index	0.03169	26
Share of self-employed to total employment	-0.027177	26
Real GDP	0.0062896	26

The table reports Pearson correlation coefficients between the cumulated response of inflation to household uncertainty shocks over a 48-month horizon and average values of several variables (named in the first column) in the second column and the number of observations (countries) used to calculate correlations in the third column. These country variables are 2002-2018 averages obtained from the World Bank World Development Indicators database.

Table A.7 report the results of regessions of the inflationary response to household uncertainty shocks on average markups controlling for a host of economic variables.

Table A.7: Regression of cumulated impulse responses of inflation to household uncertainty shocks on markups II

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Markup	1.8610	1.6324	2.0227	2.4559	1.8696	1.6302	1.6772
	(1.1496)	(1.1001)	(1.0455)	(1.6341)	(1.1653)	(1.1717)	(1.0822)
NonEA	-0.0031	0.1983	0.0884	-0.6302	-0.0970	0.4263	0.6196
	(0.8565)	(0.7878)	(0.7250)	(1.2370)	(0.8334)	(1.0600)	(0.9536)
Periph	0.3430						
	(0.7260)						
South		0.8533					
		(0.7090)					
Control			UNEMP	LFPR	VULNEMP	EASEBUS	LEGALRIGHTS
R-squared	0.2528	0.3404	0.3785	0.2520	0.2407	0.2866	0.3510
Obs.	13	13	13	13	13	13	13

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 years 2002-2016 and taken from De Loecker and Eeckhout (2020). The omitted country group category in column 1 is the core group of Euro area countries. The omitted country group category in column 2 is the Northern group of Euro area countries. The omitted country group category in columns 3 to 7 are the Euro area countries. UNEMP is the unemployment rate. LFPR is the labor force participation rate. VULNEMP is the share of vulnerable to total employment. EASEBUS is the World Bank ease of doing business index. LEGALRIGHTS is the World Bank strength of legal rights index. Country characteristics are averages over the period 2002-2018.

New Keynesian model appendix.

Table A.8: Calibrated parameters

Parameter		Symbol	Value	Target
	Discount factor	β	0.99	Annual real rate of 4%
	Habits	θ	0.75	Following Fernandez-Villaverde et al. (2015)
	Risk aversion	σ	2	Following Fernandez-Villaverde et al. (2015)
	Inverse labor elasticity	κ	1	Following Fernandez-Villaverde et al. (2015)
	Demand elasticity	η	3.13	Euro area average markups
			1.84-8.82	Range of country markups (PT to IT)
	Price rigidity	δ	28..80	Equivalent to average Calvo price duration of 4.27 quarters
			9.33-91.67	Equivalent to average Calvo price duration of 2.87 to 7.29 quarters
Monetary policy				
	Persistence	ρ_r	0.70	Following Fernandez-Villaverde et al. (2015)
	Inflation coefficient	α_π	1.5	Conventional values
	Output coefficient	α_y	0.1	Conventional values
	Supply uncertainty coefficient	α_v	0.00	Baseline
	Demand uncertainty coefficient	α_{vb}	0.00	Baseline
			2.1e-4;3.9e-4	Demand uncertainty inflation response of 0 and -1.1
	Inflation target	π^*	1.0047	Annualized value of 1.9%
Productivity				
	Mean	$\bar{A}$	exp(4.36)	Steady state labor (h) of 0.33
	Persistence	ρ_A	0.96	Fernald (2014)
	Volatility	$\bar{\sigma}_A$	0.008	Fernald (2014)
Preference				
	Mean	$\bar{b}$	2	Steady state discount factor is β
	Persistence	ρ_b	0.96	Matched to productivity shock persistence
	Volatility	$\bar{\sigma}_b$	0.15	Variance decomposition of output is roughly equal between preference and productivity shocks

Notes: Monetary policy parameters are slightly skewed towards inflation relative to output when compared to Fernandez-Villaverde et al. (2015) to better match the Euro area. For the same reason, the inflation target is set to close but below 2%.

Supply-side uncertainty 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 expectations on productivity growth. That is, in responding to a hypothetical survey, I assume that the 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 $\varepsilon_{a,t+1} \sim i.i.d.\, \mathscr{N}(0,1)$ and shocks to $\sigma_{A,t+1}$ represent supply-side uncertainty. Conditional on information available to the households at time t, the growth forecast is a Normally-distributed random variable.

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

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 i will choose to answer the option *Don't know* when the expected forecast error variance exceeds their threshold.

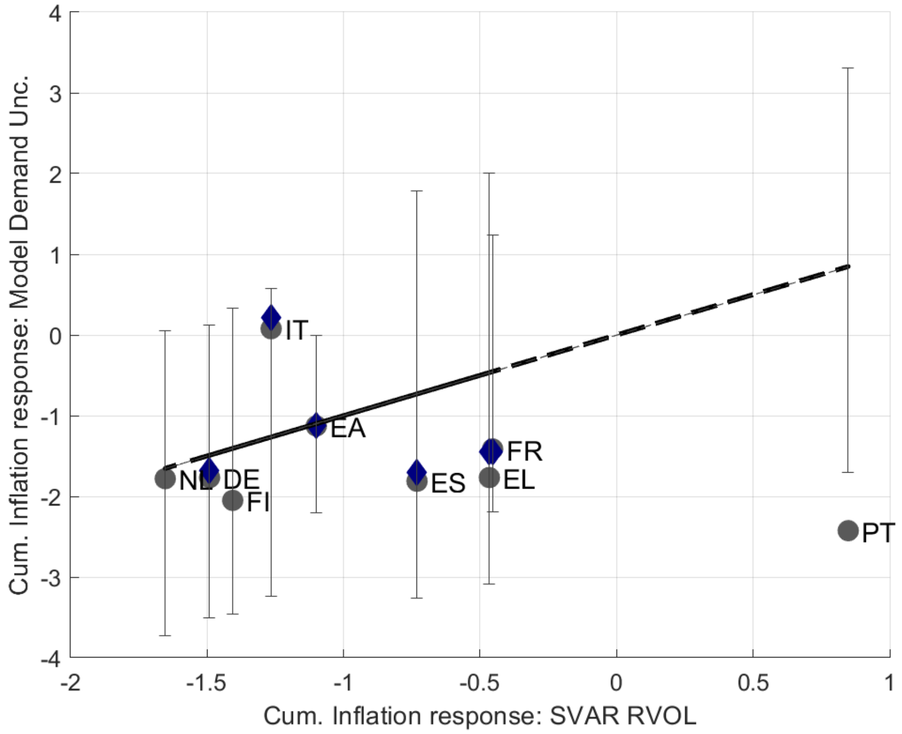
Suppose this threshold is log-normally distributed with mean $\bar{s}$ and variance v^2, $log(s_i^2) \sim \mathcal{N}(\bar{s}, v^2)$ in the cross-section of households. Then, the fraction of households who choose the option *Don't know* - the household uncertainty index (HUN_t) - is given by,

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

where $\Phi()$ is the standard normal cumulative density function and HUN_t is an increasing function of supply-side uncertainty shocks. 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).

A comparison of the responses of inflation to demand-side uncertainty from the calibrated model against the responses of inflation to financial uncertainty from vector auto-regressions.

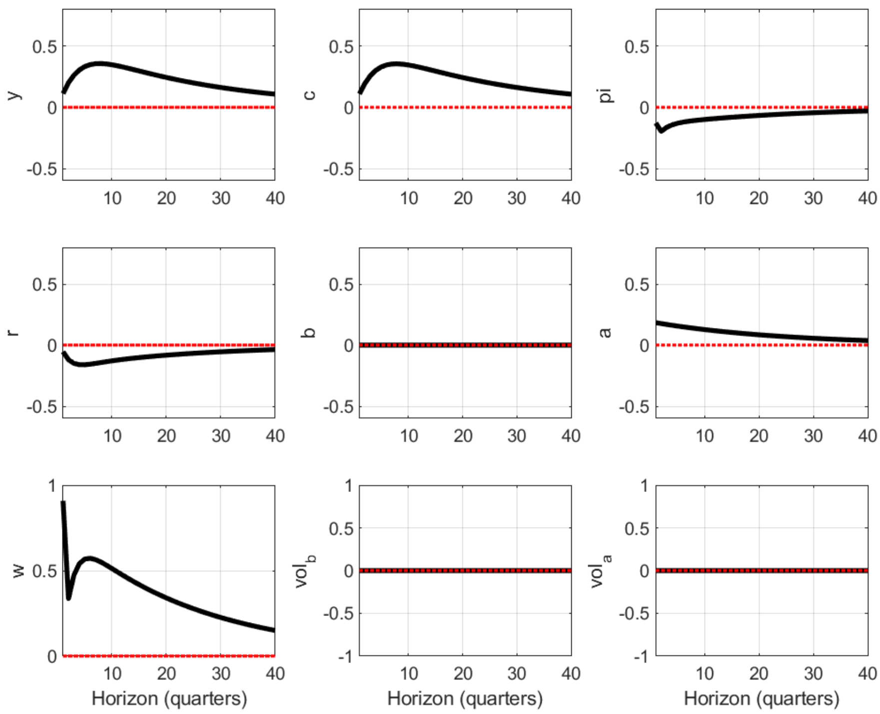
Figure A.14: Inflation IRFs to financial uncertainty: Model vs. SVAR



The gray dots represent simulated cumulated impulse responses of inflation to a demand-side uncertainty shock from calibrations of the model to match average markups for 9 regions in the Euro area against estimated cumulated impulse responses of inflation to financial uncertainty shocks (realized volatilty of stock market indices) from vector auto-regressions. The monetary policy rule in the model is calibrated to respond to demand-side uncertainty shocks such that the response of inflation to demand-side uncertainty for the Euro area calibration matches the cumulated impulse response of inflation to financial uncertainty in the vector auto-regression also for the Euro area. The blue diamonds represent simulated cumulated impulse responses of inflation to a demand-side uncertainty shock from calibrations of the model to match average markups and degrees of price rigidity for 5 regions in the Euro area against estimated cumulated impulse responses of inflation to financial uncertainty shocks from vector auto-regressions. The vertical axes indicate the model-simulated cumulated impulse response, over a 4-year horizon, of inflation to demand-side uncertainty shocks. The horizontal axis reports the cumulated impulse response, over a 4-year horizon, of inflation to household uncertainty shocks from vector auto-regressions. The 45 degree black line is also indicated for reference. The vertical lines, each centered on the 45 degree diagonal line, represent the 68% confidence band around the vector auto-regression cumulated impulse responses.

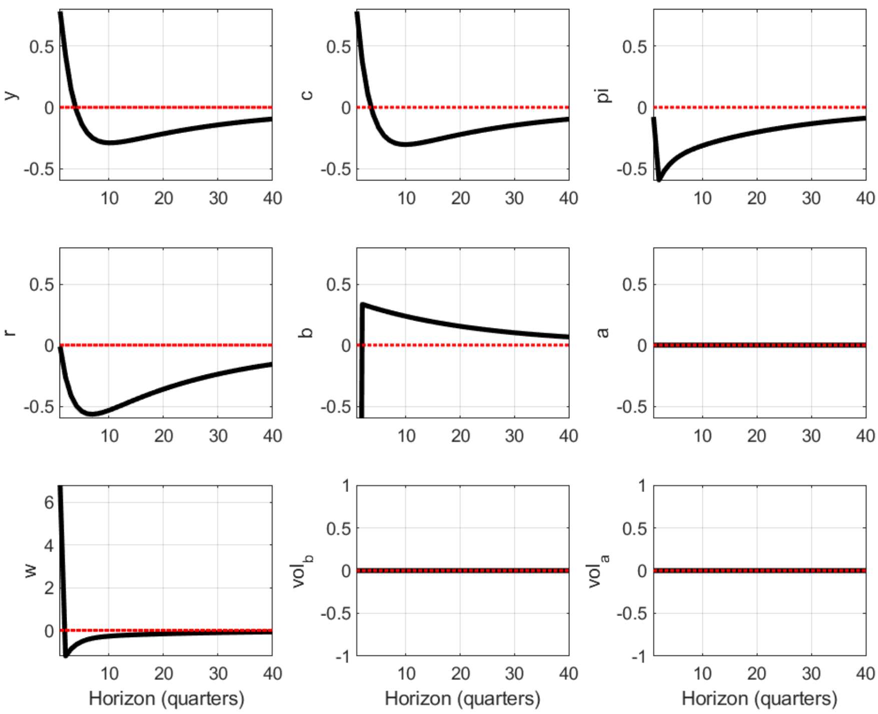
Impulse responses to all model shocks.

Figure A.15: Model-implied responses to a technology shock



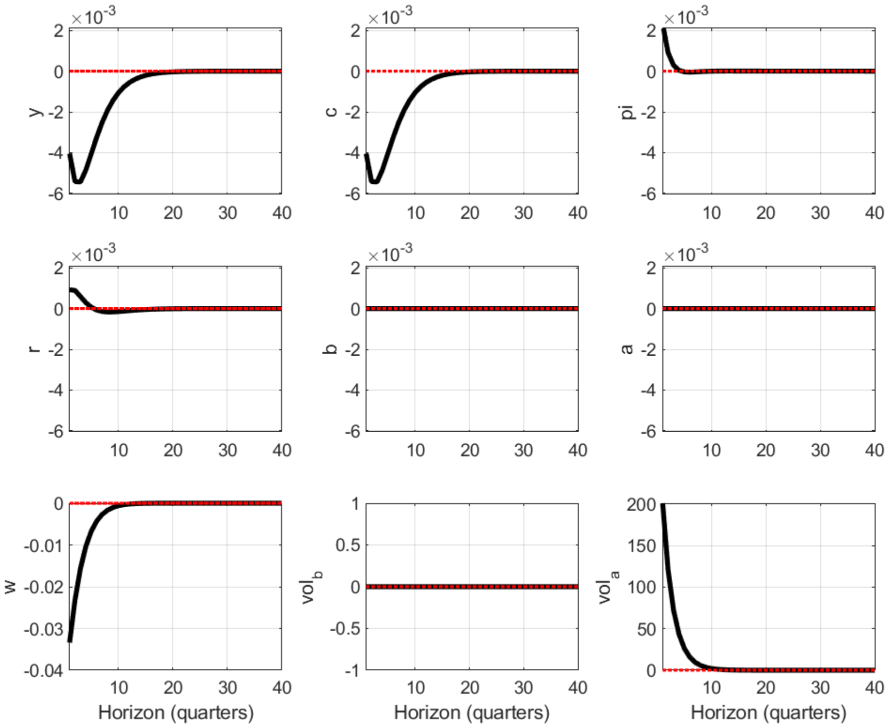
The black lines represents simulated impulse responses of model variables to a technology shock (A_t). All impulse responses except for the endogenous volatilities vol_a and vol_b are in percent deviations from their stochastic steady state values.

Figure A.16: Model-implied responses to a preference shock



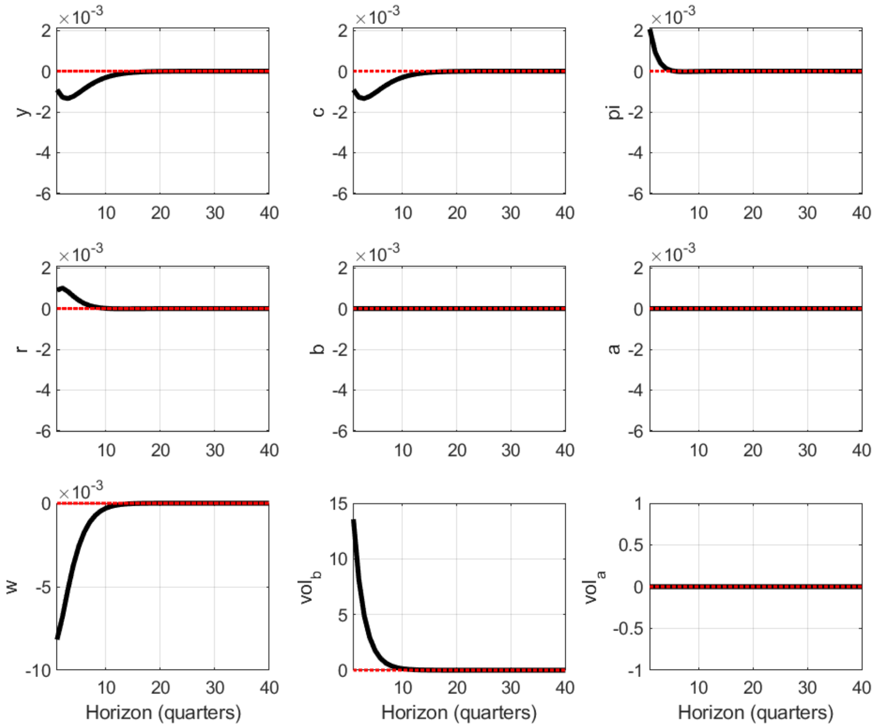
The black lines represents simulated impulse responses of model variables to a preference shock (b_t). All impulse responses except for the endogenous volatilities vol_a and vol_b are in percent deviations from their stochastic steady state values.

Figure A.17: Model-implied responses to a supply-side uncertainty shock



The black lines represents simulated impulse responses of model variables to a supply-side uncertainty shock ($vol_{A,t}$). All impulse responses except for the endogenous volatilities vol_a and vol_b are in percent deviations from their stochastic steady state values.

Figure A.18: Model-implied responses to a demand-side uncertainty shock



The black lines represents simulated impulse responses of model variables to a demand-side uncertainty shock ($vol_{b,t}$). All impulse responses except for the endogenous volatilities vol_a and vol_b are in percent deviations from their stochastic steady state values.