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Alexander Glas and Matthias Hartmann

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Alexander Glas* and Matthias Hartmann†

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Abstract

We analyze the determinants of average individual inflation uncertainty and disagreement based on data from the European Central Bank's Survey of Professional Forecasters. We empirically confirm the implication from a theoretical decomposition of inflation uncertainty that disagreement is an incomplete approximation to overall uncertainty. Both measures are associated with macroeconomic conditions and indicators of monetary policy, but the relations differ qualitatively. In particular, average individual inflation uncertainty is higher during periods of expansionary monetary policy, whereas disagreement rises during contractionary periods.

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*Corresponding author. Department of Economics, Heidelberg University, Bergheimer Straße 58, 69115 Heidelberg, Germany, email: alexander.glas@awi.uni-heidelberg.de; phone: +49 (0) 6221 54 2926.

†Department of Economics, Heidelberg University, Bergheimer Straße 58, 69115 Heidelberg, Germany, email: matthias.hartmann@awi.uni-heidelberg.de; phone: +49 (0) 6221 54 2908.

1 Introduction

Inflation uncertainty, as measured by the average across the individual variances of the cross section of density forecasts from the European Central Bank's Survey of Professional Forecasters, has considerably increased since at least the beginning of the recent financial crisis. The emergence of inflation uncertainty may reflect concerns about further rising inflation due to expansive monetary policy or fears of deflation as a result of a prolonged recession period (Drakos and Kouretas, 2015; Scharnagl and Stapf, 2015). Several theoretical arguments suggest that macroeconomic uncertainty has negative welfare effects (Fernández-Villaverde et al., 2011; Bloom et al., 2014). For example, inflation uncertainty may induce agents to postpone investment and savings decisions, reduce market efficiency due to an increase in the volatility of relative prices or increase risks regarding income streams from nominal financial and wage contracts (Friedman, 1977; Levi and Makin, 1979; Huizinga, 1993; Bloom, 2009). Empirical evidence for these arguments is documented by Grier and Perry (2000), Grier et al. (2000, 2004), Vitek (2002), Elder (2004) and Wright (2011). In contrast, the level of inflation and inflation expectations have been relatively low throughout the last decades and evolve in a rather stable way (Galí and Gambetti, 2009; Herrera and Pesavento, 2009; Conrad and Eife, 2012). This is often ascribed to successful monetary policy. However, the increase of inflation uncertainty questions these potential achievements.

Though survey-based measures of inflation uncertainty (henceforth: IU) such as the average variance from a cross-section of density forecasts (average individual IU) are often regarded as one of the most reliable ways to quantify uncertainty (Bachmann et al., 2013; Clements, 2014), many surveys do not elicit density forecasts. In such cases, the average variance of the point forecasts (disagreement) is often used as a proxy variable for IU. In addition, disagreement itself is often considered as a variable of interest, e.g. due to its potential influence on aggregate output (Mankiw and Reis, 2003). Giordani and Söderlind (2003) highlight the merits of using disagreement as a measure of IU. However, they also document that disagreement only accounts for approximately one half of the variation in average individual IU from the Survey of Professional Forecasters, leaving a considerable part of the latter unexplained. Using the same data, Rich and Tracy (2010) show that disagreement is weakly correlated with IU measures derived from density forecasts. Moreover, Zarnowitz and Lambros (1987) describe several cases in which disagreement and average individual IU deviate. These observations are rationalized in a model of forecast error components for deviations of inflation forecasts from realized inflation by Lahiri and Sheng (2010), who show that disagreement can be understood as one component of average individual IU.

This study provides a theory-guided empirical examination of the determinants of IU in the Eurozone. The latter is quantified by means of data from the European Central Bank's Survey of Professional Forecasters (ECB-SPF). Employing the forecast error component model of Davies and Lahiri (1995) and Lahiri and Sheng (2010), we conduct a variance decomposition which isolates disagreement as one of two components of average individual IU. The additional component is the variance of the shocks that occur during the period after forecasters report their predictions until the realization of the inflation rate. The model predicts that average individual IU and disagreement deviate more strongly for longer forecast horizons.

In order to analyze the determinants of IU, we employ a dynamic panel model, which is estimated by a generalized method of moments (GMM) approach as suggested by Arellano and Bover (1995). After investigating whether the predictions of the model of Lahiri and Sheng (2010) hold for the ECB-SPF data, the decomposition of average individual IU serves as a means to select a set of suitable instrumental variables. Moreover, we analyze to which extent the difference between average individual IU and disagreement evolves in a predictable way, i.e. if it can be explained by distinct indicators of macroeconomic conditions and monetary policy. If this is the case, disagreement should not be considered a reliable proxy of IU.

We find that the difference between average individual IU and disagreement increases with the forecast horizon. Moreover, dynamic panel estimates show that the influence of monetary policy indicators depends on which IU measure is considered as the dependent variable. Most importantly, average individual IU rises during periods when monetary policy is more expansive than what is prescribed by a Taylor rule (Taylor, 1993). In contrast, disagreement is primarily explained by contractionary monetary policy and stock market fluctuations. Hence, we do not only find that average individual IU and disagreement deviate more strongly for higher forecast horizons, but also that they are related to distinct indicators of monetary policy and the economic environment. Further analysis of the difference between average individual IU and disagreement, i.e. the variance of aggregate shocks, shows that this component increases during periods when monetary policy is expansive, whereas disagreement is not affected during such episodes. This suggests that an important reason for the steady increase in average individual IU since the beginning of the financial crisis is the sustained period of expansionary monetary policy. This influence is not detected if disagreement alone is used as an indicator of IU. Thus, assessments of the role of monetary policy for IU based on disagreement are incomplete. In contrast, both measures of IU are related to macroeconomic conditions such as the inflation rate and the growth rate of real GDP in a way that is consistent with findings from other empirical studies such as Lahiri et al. (1988) or Conrad et al. (2010).

The remainder of this paper is structured as follows. Section 2 presents the theoretical and empirical literature on the potential determinants of IU. Section 3 describes the IU measures that are employed in this study, whereas Section 4 introduces the econometric models. The data are introduced in Section 5. Subsequently, Section 6 presents and discusses the empirical results. In Section 7, we summarize and conclude.

2 Determinants of IU in the related literature

In the theoretical literature, relationships between several macroeconomic variables and IU have been identified. Friedman (1977) and Ball (1992) describe a positive influence of the level of inflation on IU. In addition, Friedman (1977) argues that IU is lower during periods of high economic growth. Schwert (1989) finds that IU is positively related to stock market volatility. Other studies identify links between IU and policy-related variables. Taylor (1993, 2007, 2008, 2012) argues that a predictable, i.e. rule-based, monetary policy reduces economic uncertainty. According to Taylor (2008), one of the causes of the financial crisis is that the interest rate set by the FED during the years after 2003 has been lower than the rate prescribed by a Taylor rule.

Empirically, the Friedman-Ball-hypothesis has been confirmed in several studies including Lahiri et al. (1988), Conrad and Karanasos (2005a), Conrad et al. (2010) and Hartmann and Herwartz (2012). Moreover, Mankiw et al. (2003) and Lamla and Maag (2012) find evidence for a positive relationship between disagreement and the inflation rate and a negative relationship between disagreement and GDP growth. Engle and Rangel (2008) and Conrad and Loch (2014) show that high volatility on global equity markets is associated with high IU. Dovern et al. (2012) highlight the particularly important role of monetary policy as a determinant of disagreement and document that disagreement in the G7 economies can be explained by the level of inflation, the output gap, the interest rate and an indicator of central bank independence. Ehrmann et al. (2012) show that higher transparency in central bank communication reduces disagreement due to a reduction in forecasters' cost of acquiring and processing new information. Wright (2011) finds that risk premia derived from yield curves as the difference between short- and long-term interest rates are positively related to IU. This implies that differences in horizons play an important role, which motivates our approach to distinguish between forecasting horizons. Conrad and Hartmann (2014) show that deteriorated macroeconomic conditions and discretionary monetary policy have a joint impact on IU and that it is particularly periods of expansionary monetary policy that are positively related to IU.

In the following, we contribute to this literature by providing a comparison between the determinants of average individual IU and disagreement. The comparative evaluation is based on the theoretical framwork of Davies and Lahiri (1995) and Lahiri and Sheng (2010), which is introduced in the next section.

3 Forecasting and uncertainty

In this section, we describe the *ex-ante* measures of IU that are based on survey data. The employed model of IU is borrowed from Davies and Lahiri (1995) and Lahiri and Sheng (2010), and is based on the h-step ahead inflation forecast errors, $e_{i,t+h|t}$, of individual survey participants $i = 1, ..., N$, defined as

$$e_{i,t+h|t} = \pi_{t+h} - \mu_{i,t+h|t}. \tag{1}$$

In (1), the inflation rate is denoted as π_{t+h} and $\mu_{i,t+h|h}$ represents an h-step ahead forecast. The quarterly survey periods are represented by the index $t = 1, ..., T$. Following Davies and Lahiri (1995) and Lahiri and Sheng (2010), the forecast error in (1) is decomposed into the sum of a common and an idiosyncratic component,

$$e_{i,t+h|t} = \lambda_{t+h|t} + \varepsilon_{i,t+h|t}, \tag{2}$$

where $\lambda_{t+h|t} = \sum_{j=1}^{h} u_{t+j}$ denotes the sum of all shocks u_{t+j} between survey period t and target period $t + h$ that are common to all forecasters. Individual characteristics such as differences in forecasters' information sets or their methods of processing new information are incorporated in $\varepsilon_{i,t+h|t}$.[1] We analyze fixed-horizon forecasts, characterized by a fixed forecast horizon and a rolling target period, whereas Davies and Lahiri (1995) and Lahiri and Sheng (2010) discuss fixed-event forecasts, characterized by a fixed target period and a rolling forecast horizon. Lahiri and Sheng (2010) make the following assumptions: First, $\mathbf{E}[u_{t+j}] = 0$ and $\mathbf{Var}[u_{t+j}] = \sigma^2_{u,t+j}$ for any t and j. Moreover, the shocks are uncorrelated at different points in time, so that $\mathbf{E}[u_{t+j}u_{t+j'}] = 0$ for any t and $j \neq j'$ and $\mathbf{E}[u_{t+j}u_{t'+j}] = 0$ for any j and $t \neq t'$. Second, $\mathbf{E}[\varepsilon_{i,t+h|t}] = 0$ and $\mathbf{Var}[\varepsilon_{i,t+h|t}] = \sigma^2_{\varepsilon,i,t+h|t}$ for any i, t and h and the individual shocks of different forecasters are uncorrelated with each other, so that $\mathbf{E}[\varepsilon_{i,t+h|t}\varepsilon_{i',t+h|t}] = 0$ for any t, h and $i \neq i'$. Third, the individual and aggregate shocks are uncorrelated: $\mathbf{E}[\varepsilon_{i,t+h|t}u_{t'+j}] = 0$ for any i, t, t', h and j. Given these assumptions, *ex ante* expected disagreement, i.e. the expectation of the cross-sectional variance of $\mu_{i,t+h|t}$, can be written as

$$S^2_{t+h|t} = \frac{1}{N-1}\sum_{i=1}^{N}\mathbf{E}\left[\left(\varepsilon_{i,t+h|t} - \frac{1}{N}\sum_{j=1}^{N}\varepsilon_{j,t+h|t}\right)^2\right] = \frac{1}{N}\sum_{i=1}^{N}\sigma^2_{\varepsilon,i,t+h|t}. \tag{3}$$

Moreover, individual IU, defined as the conditional variance of the errors in (2), is given by

$$\sigma^2_{i,t+h|t} = \sigma^2_{\lambda,t+h|t} + \sigma^2_{\varepsilon,i,t+h|t}, \tag{4}$$

where $\sigma^2_{\lambda,t+h|t} = \sum_{j=1}^{h}\sigma^2_{u,t+j}$ denotes the perceived uncertainty regarding future aggregate shocks under the assumptions stated above. Following Zarnowitz and Lambros (1987) and

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[1] Lahiri and Sheng (2010) argue that (2) can also include a third component, $\phi_{i,h}$, which might reflect an individual horizon-specific bias. However, the arguments in the theoretical model of Lahiri and Sheng (2010) are derived by disregarding $\phi_{i,h}$, since the estimates of this component are relatively small. Similarly, we find that estimates of $\phi_{i,h}$ for the ECB-SPF data are of negligible size for all forecast horizons. Therefore, we also disregard this component.

Lahiri and Sheng (2010), we obtain average individual IU as

$$\overline{\sigma^2_{t+h|t}} = \frac{1}{N}\sum_{i=1}^{N}\sigma^2_{i,t+h|t}. \tag{5}$$

This IU statistic can be interpreted as the uncertainty about the inflation forecast of a randomly drawn survey participant (Lahiri and Sheng, 2010). Given the assumptions stated above and relying on (2), Lahiri and Sheng (2010) decompose $\overline{\sigma^2_{t+h|t}}$ such that

$$\overline{\sigma^2_{t+h|t}} = \sigma^2_{\lambda,t+h|t} + S^2_{t+h|t}. \tag{6}$$

In (6), average individual IU is given by the sum of the variance of aggregate shocks and expected disagreement. Consequently, the variance of the aggregate shocks can be interpreted as the wedge between average individual IU and disagreement. Since $\sigma^2_{\lambda,t+h|t} = \sum_{j=1}^{h}\sigma^2_{u,t+j}$, this component increases with the forecast horizon h. The claim that the difference between average individual IU and disagreement increases with the forecast horizon is a direct consequence of the model specification. A large $\sigma^2_{\lambda,t+h|t}$ may also occur if forecasters are increasingly uncertain, e.g. during recession periods. Thus, the model suggests that the suitability of disagreement as a measure of IU may depend on both the forecast horizon and the state of the economy.

In this study, we use survey data to estimate the unobserved quantities in (6). Let $f_{i,t+h|t}$ denote a density forecast for the inflation rate, π_{t+h}, reported by individual forecaster i. Individual inflation expectations are expressed by the mean, $\mu_{i,t+h|t}$, of $f_{i,t+h|t}$. We quantify disagreement by

$$s^2_{t+h|t} = \frac{1}{N-1}\sum_{i=1}^{N}\left(\mu_{i,t+h|t} - \overline{\mu_{t+h|t}}\right)^2, \tag{7}$$

where $\overline{\mu_{t+h|t}} = (1/N)\sum_{i=1}^{N}\mu_{i,t+h|t}$.[2] Lahiri and Sheng (2010) show that, for sufficiently

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[2] Usually, disagreement is defined as the variance of point forecasts. We employ the means of the

large N, $s^2_{t+h|t}$ can be used to approximate $S^2_{t+h|t}$ in (3). Moreover, the variance of the individual density forecasts, $f_{i,t+h|t}$, delivers an estimate of individual IU, $\sigma^2_{i,t+h|t}$, from which $\overline{\sigma^2_{t+h|t}}$ is obtained using (5). Replacing $S^2_{t+h|t}$ in (6) with $s^2_{t+h|t}$, we obtain an estimate of the variance of aggregate shocks, $\sigma^2_{\lambda,t+h|t}$.

4 Modeling inflation uncertainty

This section introduces the empirical models that are employed to analyze the determinants of IU. We first examine how average individual IU and disagreement are related to each other. Departing from the model of Lahiri and Sheng (2010), we then analyze how average individual IU and disagreement are associated with various indicators of macroeconomic conditions and monetary policy that have been identified as drivers of IU in the related literature. In order to determine how the difference between both IU measures can be explained, we relate the variance of aggregate shocks to observable factors in a final step.

4.1 Explaining the variance of aggregate shocks

The decomposition of Lahiri and Sheng (2010) in equation (6) states that the variance of aggregate shocks equals the difference between average individual IU and disagreement. The model assumptions imply that $\sigma^2_{\lambda,t+h|t}$ increases with h. Moreover, the difference between $\overline{\sigma^2_{t+h|t}}$ and $s^2_{t+h|t}$ may also increase during recession periods. In order to evaluate empirically how much $\overline{\sigma^2_{t+h|t}}$ and $s^2_{t+h|t}$ deviate from each other, we estimate the following pooled model which includes observations for all forecast horizons $h = 1, ..., H$:

$$\sigma^2_{\lambda,t+h|t} = \zeta_1 D^{h=1} + ... + \zeta_H D^{h=H} + \gamma_1(t-1) + \gamma_2 D^{REC}_{t-1} + \nu_{t+h|t}, \tag{8}$$

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density forecasts instead. Clements (2012) provides a critical discussion.

where $\nu_{t+h|t} \sim (0, \sigma^2_{\nu,h})$ is the error term. The indicator variables $D^{h=1}, ..., D^{h=H}$ are defined such that, for example, $D^{h=1}$ is equal to unity for $h = 1$, and zero for all other horizons. Since the model of Lahiri and Sheng (2010) suggests that the variance of the aggregate shocks increases with the forecast horizon, it is expected that $\zeta_H > ... > \zeta_1 > 0$. To account for potential non-stationarity of $\sigma^2_{\lambda,t+h|t}$, a time trend, $t-1$, is included. The impact of recessions is captured by the indicator variable D^{REC}_{t-1}, which is equal to unity during recession periods, and zero in all other cases. Recessions are identified by the method of Bry and Boschan (1971) using the output gap, $\tilde{x}_{t-1} = 100 \times \left(x_{t-1} - x^{HP}_{t-1}\right)$ as an indicator of the business cycle with $x_{t-1} = \ln(X_{t-1})$ denoting the natural logarithm of the level of real GDP, X_{t-1}, and x^{HP}_{t-1} as the trend component of x_{t-1}, which is extracted by using the Hodrick-Prescott filter. Thereby, we identify the peaks and troughs of economics activity in the Eurozone. Following Chauvet and Hamilton (2005), a recession is defined as the period between a peak and a trough (excluding the former but including the latter). If the variance of aggregate shocks increases during recession periods, we would expect that $\gamma_2 > 0$.

4.2 Macroeconomic and policy influences on IU

The decomposition of Lahiri and Sheng (2010) implies that average individual IU and disagreement should be considered as distinct measures of IU. Thus, we evaluate them separately in the following. In order to control for forecaster-specific characteristics, we exploit the information from the panel of forecasters and set up the dynamic panel specification

$$y_{i,t+h|t} = \rho_h y_{i,t+h-1|t-1} + \boldsymbol{\alpha}'_h \boldsymbol{m}_{t-1} + \boldsymbol{\beta}'_h \boldsymbol{p}_{t-1} + \boldsymbol{\gamma}'_h \boldsymbol{d}_{t-1} + v_{i,t+h|t} \tag{9}$$

for $i = 1, ..., N$, where $y_{i,t+h|t} \in \{\sigma^2_{i,t+h|t}, \sigma^2_{\varepsilon,i,t+h|t}\}$ denotes either individual IU or the variance of individual shocks, $\boldsymbol{m}_{t-1}$ is a 3×1 vector of macroeconomic conditions, $\boldsymbol{p}_{t-1}$ is a 6×1 vector containing indicators of monetary policy, $\boldsymbol{d}_{t-1} = (1, t-1, D^{REC}_{t-1})'$ is a 3×1 vector of predetermined variables and $\boldsymbol{\alpha}_h, \boldsymbol{\beta}_h$ and $\boldsymbol{\gamma}_h$ denote the corresponding coefficient vectors. Moreover, $v_{i,t+h|t} = \eta_{i,h} + \nu_{i,t+h|t}$ represents the error term. The forecaster-specific fixed effects, $\eta_{i,h}$, capture unobserved heterogeneity with respect to individual IU. We estimate (9) using the approach of Arellano and Bover (1995) and include up to six-period lagged levels as well as the first differences of $y_{i,t+h-1|t-1}$ and the variables in $\boldsymbol{m}_{t-1}$ and $\boldsymbol{p}_{t-1}$ as instrumental variables. In addition, we include $\sigma^2_{\lambda,t+h-1|t-1}$, which is part of $\sigma^2_{i,t+h-1|t-1}$ according to the definition in (4). Hence, $\sigma^2_{\lambda,t+h-1|t-1}$ is likely to be a relevant instrument for $\sigma^2_{i,t+h-1|t-1}$. Moreover, past realizations of the IU measures, $\overline{\sigma^2_{t+1h-1|t-1}}$ and $s^2_{t+h-1|t-1}$, are readily available to forecasters when they report their predictions in period t and thus can be considered as part of their information sets. Thus, $\sigma^2_{\lambda,t+h-1|t-1}$ should also be exogeneous. To account for forecaster-specific heteroskedasticity and autocorrelation in $\nu_{i,t+h|t}$, we use robust standard errors and apply the adjustment by Windmeijer (2005). Unlike (8), the model in (9) is estimated separately for each forecast horizon h. For notational convenience, we do not differentiate between the coefficients for alternative choices of $y_{i,t+h|t}$ in (9). The variance of the individual shocks, $\sigma^2_{\varepsilon,i,t+h|t}$, is obtained using (4),

$$\sigma^2_{\varepsilon,i,t+h|t} = \sigma^2_{i,t+h|t} - \sigma^2_{\lambda,t+h|t}. \tag{10}$$

Inflation uncertainty may be related to the macroeconomic conditions as hypothesized by Friedman (1977) and Schwert (1989). Macroeconomic influences on IU are summarized in $\boldsymbol{m}_{t-1} = (\pi_{t-1}, \Delta x_{t-1}, RV_{t-1}(E))'$. According to Friedman (1977), two important covariates of IU are the level of inflation, which is defined as the year-on-year change of the quarterly Harmonised Index of Consumer Prices (HICP),

$$\pi_{t-1} = 100 \times \frac{HICP_{t-1} - HICP_{t-5}}{HICP_{t-5}}, \tag{11}$$

and output growth,

$$\Delta x_{t-1} = 100 \times \frac{X_{t-1} - X_{t-5}}{X_{t-5}}. \tag{12}$$

Empirical evidence regarding these relations has been documented by Conrad and Karanasos (2005b), Dovern et al. (2012) or Hartmann and Roestel (2013). Moreover, Engle and Rangel (2008) and Conrad and Loch (2014) document that IU is related to stock market volatility in the US. We measure stock market fluctuations by employing the intra-quarter variation of squared returns,

$$RV_{t-1}(E) = 100 \times \sqrt{\sum_{\ell \in t-1} r^2_{\ell,t-1}}, \tag{13}$$

with $r_{\ell,t-1} = \ln(P_{\ell,t-1}/P_{\ell-1,t-1})$ denoting the daily return of equity prices, $P_{\ell,t-1}$. Apart from macroeconomic conditions, IU might also be influenced by monetary policy. This hypotheses has been described, for example, in the widely-cited study of Ball (1992). Indicators of (monetary) policy are summarized in $\boldsymbol{p}_{t-1} = (\Delta EPU_{t-1}, \Delta AS_{t-1}, TD^+_{t-1}, |TD^-_{t-1}|, MPC_{t-1}, \Delta MM_{t-1})'$. IU might be affected by spillovers from uncertainty about economic and political conditions in general. To account for such influences, we consider the changes in the economic policy uncertainty indicator as denoted ΔEPU_{t-1} (cf. Baker and Bloom, 2013). A further source of IU might be the unconventional monetary policy measures adopted by the ECB such as the changes in the asset position of the central bank's balance sheet. The relation between IU and balance sheet adjustments, denoted ΔAS_{t-1}, might capture perceived increases in inflation risks due to the ECB's large-scale asset purchases since 2008. Moreover, a relation between deviations from rule-based monetary policy and uncertainty in general has been put forth in a series of articles by Taylor (2007, 2008, 2012). The degree to which the ECB might have deviated from a predictable monetary policy scheme such as the Taylor (1993) rule is expressed by the variables TD^+_{t-1} and $|TD^-_{t-1}|$. Deviations from the Taylor rule are defined as

$$TD_{t-1} = i_{t-1} - i^*_{t-1}, \tag{14}$$

where i_{t-1} is the interest rate set by the central bank and i^*_{t-1} is the optimal predicted Taylor rule interest rate specified as a function of the inflation rate and the output gap in line with the dynamic model proposed by Clarida et al. (1998),

$$i_{t-1} = \omega_0 + \omega_1 \pi_{t+3} + \omega_2 \tilde{x}_{t-1} + \xi_{t-1}. \tag{15}$$

Since the regressors in (15) are endogenous, the model is estimated by means of GMM using up to four-period lags of i_{t-1}, π_{t-1} and $\tilde{x}_{t-1}$ as instrumental variables. Based on (14) and (15), we define $TD^+_{t-1} = TD_{t-1} \times \mathbb{1}(TD_{t-1} > 0)$, where $\mathbb{1}(TD_{t-1} > 0)$ equals unity if $TD_{t-1} > 0$, and zero else. Similarly, $|TD^-_{t-1}| = |TD_{t-1}| \times \mathbb{1}(TD_{t-1} < 0)$, where $\mathbb{1}(TD_{t-1} < 0)$ equals unity if $TD_{t-1} < 0$, and zero else. Furthermore, the role of central bank communication for the emergence or containment of uncertainty is frequently discussed in the literature. Morris and Shin (2002) develop a theoretical models to show that policymakers can maximize social welfare by providing as much public information as possible in the absence of private information. Empirically, Ehrmann et al. (2012) show that higher central bank communication reduces disagreement. In order to account for these findings, we consider the Monetary Policy Communicator, MPC_{t-1}, which quantifies the ECB's communication of risks regarding future price stability. Finally, IU might emerge from large-scale increases in monetary aggregates. We acknowledge this potential transmission channel by consideration of ΔMM_{t-1}, which denotes changes of the so-called money multiplier,

$$MM_{t-1} = \frac{M3_{t-1}}{M0_{t-1}}, \tag{16}$$

with $M3_{t-1}$ denoting an indicator for the broad money supply and $M0_{t-1}$ denoting the more narrow definition of base money. Holland (1995) argues that monetary policy may be tempted to stimulate output growth via monetary surprises if such shocks are less observable to consumers during turbulent times. This creates higher uncertainty about both money growth and inflation. To summarize, $\boldsymbol{p}_{t-1}$ comprises indicators of the monetary policy stance that are based on interest rates but also takes more traditional, money-based indicators into account.

In each survey period, the SPF contains a certain number of missing values. In order to determine whether the estimation of the model in (9) is influenced by the presence of missing values, we relate the *aggregated* measures of IU to the same observable factors as before. This is based on the argument of Lahiri and Sheng (2010) that average individual IU can be interpreted as the uncertainty of the average forecaster. Since $\overline{\sigma^2_{t+h|t}} = (1/N)\sum_{i=1}^{N}\sigma^2_{i,t+h|t}$ and $s^2_{t+h|t} = (1/N)\sum_{i=1}^{N}\sigma^2_{\epsilon,i,t+h|t}$, it follows from (9) that

$$y_{t+h|t} = \rho_h y_{t+h-1|t-1} + \boldsymbol{\alpha}'_h \boldsymbol{m}_{t-1} + \boldsymbol{\beta}'_h \boldsymbol{p}_{t-1} + \boldsymbol{\gamma}'_h \boldsymbol{d}_{t-1} + \overline{v_{t+h|t}}, \tag{17}$$

where $y_{t+h|t} \in \{\overline{\sigma^2_{t+h|t}}, s^2_{t+h|t}\}$ denotes either average individual IU or disagreement and $\overline{v_{t+h|t}} = \overline{\eta_h} + \overline{\nu_{t+h|t}}$ with $\overline{\eta_h} = (1/N)\sum_{i=1}^{N}\eta_{i,h}$ and $\overline{\nu_{t+h|t}} = (1/N)\sum_{i=1}^{N}\nu_{i,t+h|t}$. Comparing equations (9) and (17) shows that the impact of the macroeconomic and policy variables on individual and aggregate measures of IU is identical. Consequently, the empirical evidence from equation (9) can be directly compared to the findings for average individual IU and disagreement.

4.3 Decomposing the influences on IU

So far we have argued that it is necessary to evaluate average individual IU and disagreement separately and set up two models in (17),[3]

$$\overline{\sigma^2_{t+h|t}} = \boldsymbol{\alpha}'_{1,h}\boldsymbol{m}_{t-1} + \boldsymbol{\beta}'_{1,h}\boldsymbol{p}_{t-1} + \boldsymbol{\gamma}'_{1,h}\boldsymbol{d}_{t-1} + \overline{v_{1,t+h|t}} \tag{18}$$

and

$$s^2_{t+h|t} = \boldsymbol{\alpha}'_{2,h}\boldsymbol{m}_{t-1} + \boldsymbol{\beta}'_{2,h}\boldsymbol{p}_{t-1} + \boldsymbol{\gamma}'_{2,h}\boldsymbol{d}_{t-1} + \overline{v_{2,t+h|t}}. \tag{19}$$

According to the decomposition of Lahiri and Sheng (2010), $s^2_{t+h|t}$ is a component of $\overline{\sigma^2_{t+h|t}}$. If the impact of the covariates on both measures differs, this must be due to a systematic influence of $\boldsymbol{m}_{t-1}$ and $\boldsymbol{p}_{t-1}$ on on the second component of IU, $\sigma^2_{\lambda,t+h|t}$. Thus, we also analyze the determinants of the variance of aggregate shocks by means of

$$\sigma^2_{\lambda,t+h|t} = \boldsymbol{\alpha}'_{3,h}\boldsymbol{m}_{t-1} + \boldsymbol{\beta}'_{3,h}\boldsymbol{p}_{t-1} + \boldsymbol{\gamma}'_{3,h}\boldsymbol{d}_{t-1} + \nu_{3,t+h|t}, \tag{20}$$

where $\nu_{3,t+h|t}$ is the horizon-specific error term. Inserting (19) and (20) into the decomposition in (6), we obtain

$$\overline{\sigma^2_{t+h|t}} = (\boldsymbol{\alpha}'_{2,h} + \boldsymbol{\alpha}'_{3,h})\boldsymbol{m}_{t-1} + (\boldsymbol{\beta}'_{2,h} + \boldsymbol{\beta}'_{3,h})\boldsymbol{p}_{t-1} + (\boldsymbol{\gamma}'_{2,h} + \boldsymbol{\gamma}'_{3,h})\boldsymbol{d}_{t-1} + \overline{v_{2,t+h|t}} + \nu_{3,t+h|t}. \tag{21}$$

By comparing (18) and (21) it can be seen that the impact of the macroeconomic conditions and policy indicators on overall IU is given by their aggregate impact on the two components of IU since $\boldsymbol{\alpha}'_{1,h} = \boldsymbol{\alpha}'_{2,h} + \boldsymbol{\alpha}'_{3,h}$ and $\boldsymbol{\beta}'_{1,h} = \boldsymbol{\beta}'_{2,h} + \boldsymbol{\beta}'_{3,h}$. If, for example,

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[3] In this subsection, we deviate from our previous approach and explicitly account for the fact that the coefficients vary for different dependent variables. Here, subscripts 1, 2 and 3 denote coefficients when the dependent variable is $\overline{\sigma^2_{t+h|t}}$, $s^2_{t+h|t}$ or $\sigma^2_{\lambda,t+h|t}$, respectively. We also exclude the lagged dependet variable from all models because otherwise the effect of the covarites on average individual IU cannot be decomposed in the way presented in this subsection.

expansionary monetary policy, as measured by $|TD^{-}_{t-1}|$, has no effect on $s^2_{t+h|t}$ but increases $\sigma^2_{\lambda,t+h|t}$, the net effect of such a policy on $\overline{\sigma^2_{t+h|t}}$ may be positive. Looking only at disagreement as a proxy for overall IU, however, one would mistakingly conclude that expansionary monetary policy does not increase IU in this scenario. This example illustrates why the decomposition of Lahiri and Sheng (2010) has important implications for the analysis of the determinants of IU. It is necessary to check whether there are observable factors which increase the difference between $\overline{\sigma^2_{t+h|t}}$ and $s^2_{t+h|t}$ in a systematic way. If this is the case, disagreement does not capture all relevant influences on IU and should thus not be considered as a reliable proxy of IU.

5 Data

Forecast data is provided by the Survey of Professional Forecasters, which has been conducted by the European Central Bank during successive quarters since 1999Q1. We employ density forecasts, $f_{i,t+h|t}$, regarding future HICP inflation in the Eurozone, π_{t+h}. As can be seen in Table 1, the intervals employed in the SPF questionnaire have changed on some occasions.

[TABLE 1 HERE]

The sample contains fixed-horizon forecasts from the surveys conducted between 1999Q1 and 2013Q2, so that $T = 58$, for $h \in \{4, 8, 20\}$, denoting forecast horizons of one-year-, two-years- and five-years-ahead, respectively. The time series for $h = 20$ is only available starting in 2001Q1. We exclude forecasters from our analysis whenever they do not report an appropriate density forecast, e.g. if reported subjective probabilities do not sum to one. The remaining cross-section comprises predictions from $N = 98$ anonymous forecasters. Figure 1 depicts the participation of these forecasters in the SPF surveys for different forecast horizons. Evidently, the panel is unbalanced. However, the number of missing observations is lower than for the US-SPF, for which Lahiri et al. (2014) document a substantial fraction of missing observations.

[FIGURE 1 HERE]

We follow Engelberg et al. (2009) and fit a generalized beta distribution to the individual histograms if forecasters attach non-zero probabilities to at least three different intervals.[4]

Figure 2 depicts individual and average inflation expectations as well as aggregate IU measures over the survey period t for $h \in \{4, 8, 20\}$. The graphs for $\mu_{i,t,h}$ show that long-term expectations are scattered around the ECB's target of an inflation rate ,,below, but close to, 2%“ (ECB, 2014) without any visible up or down tendency. For all h, the $\overline{\sigma^2_{t+h|t}}$ measures evolve fairly constant between 1999 and 2007 but show an upward trend from 2007 until the end of the sample period. The $s^2_{t+h|t}$ statistics show considerable increases during the years 2008 and 2009. However, for all h, $s^2_{t+h|t}$ reverts to its pre-crisis level after a short period of time. This is in line with the argument of Lahiri and Sheng (2010) that the trajectory of $s^2_{t+h|t}$ may differ from the one of $\overline{\sigma^2_{t+h|t}}$, depending on the perceived variation of forthcoming aggregate shocks, $\sigma^2_{\lambda,t+h|t}$. In addition, the plots show that, on average, $\overline{\sigma^2_{t+h|t}}$ and $\sigma^2_{\lambda,t+h|t}$ increase with h, whereas there are little deviations between the $s^2_{t+h|t}$ statistics, except for the peak in 2009, which is smaller for larger h.

[FIGURE 2 HERE]

Rich et al. (2012) also construct IU measures from the ECB-SPF data set, though they use an alternative approach, which is based on rolling-horizon forecasts. Distinguishing between the variance of the aggregate density forecast and average individual IU, Rich et al. (2012) find that IU evolves in a relatively stable way through the second quarter of 2007 and increases steadily afterwards. This in line with the evidence depicted in Figure 2. The findings of Rich et al. (2012) with respect to the disagreement statistic are also in line with the ones reported here.

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[4] Triangular distributions are fitted when less than three intervals are used. For details see Engelberg et al. (2009).

Table 2 reports correlations across IU measures. In line with the decomposition in (6), average individual IU is positively correlated with both disagreement and the variance of aggregate shocks. The strength of the relation between $\overline{\sigma^2_{t+h|t}}$ and $s^2_{t+h|t}$ seems to be relatively high but declines with h from a correlation coefficient of 0.5 for $h = 4$ to less than 0.4 for $h = 20$. The correlation statistics between $s^2_{t+h|t}$ and $\sigma^2_{\lambda,t+h|t}$ also decline (in absolute terms) for larger forecast horizons. These findings are indicated by correlation statistics which are marked in boldface. In addition, correlations between the $\overline{\sigma^2_{t+h|t}}$ measures are higher than correlations between $s^2_{t+h|t}$ or $\sigma^2_{\lambda,t+h|t}$ measures for different h.

[TABLE 2 HERE]

Inflation rates, π_t, and real GDP growth rates, Δx_t, are drawn from the Statistical Data Warehouse (SDW) database of the ECB. This data source provides real-time data, which are most closely related to the information available to forecasters at the time when predictions are reported. Using the GDP data, we calculate the output gap, $\tilde{x}_t$, from which three periods of economic recessions are identified for our sample period: 2001Q1 to 2005Q3, 2008Q2 to 2009Q2 and 2011Q4 to 2013Q2. Quarterly realized stock market volatility, $RV_t(E)$, is calculated using Eurostoxx bluechip net returns for the Eurozone.[5] To measure changes in the quarterly economic policy uncertainty, ΔEPU_t, we use the monthly EU Economic Policy Uncertainty Index of Baker et al. (2013), which is defined as the weighted sum of three components: Newspaper coverage of policy-related economic uncertainty with a weight of 0.5, forecaster disagreement about federal government budget balances with a weight of 0.25 and inflation disagreement with a weight of 0.25. The newspaper component is defined as the normalized coverage of policy-related economic uncertainty by ten influential newspapers from major EU countries and measured by the number of newspapers containing at least one term from each of the three sets ,,un-

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[5] `http://www.stoxx.com/data/historical/historical_bluechip.html`

certain/uncertainty“, ,,economic/economy“ and ,,policy/tax/spending/regulation/central bank/budget deficit“.[6] The index ΔEPU_t as we use it does not include inflation disagreement. We remove this component and rescale the remaining index by dividing it by 100. Changes in the ECB's balance sheet, ΔAS_t, are measured using data on the quarterly total assets/liabilities in the Euro area in trillions of Euros. The data series is drawn from the SDW database, which also provides data on interest rates used in the construction of both TD_t^+ and $|TD_t^-|$.[7] To quantify ECB communication regarding forthcoming threats to price stability, we include MPC_t, which is defined as the quarterly average of the monthly Monetary Policy Communicator, which is published by the KOF (cf. Conrad and Lamla, 2010). This indicator translates the ECB president's statements on price stability during the monthly ECB press conferences into numerical values, such that $MPC_t \in [-1, +1]$ with positive (negative) values indicating upside (downside) risks to price stability.[8] Measures of money supply used in the construction of ΔMM_t are also drawn from the SDW. Figure 3 plots the macroeconomic variables and indicators of monetary policy.

[FIGURE 3 HERE]

The graphs show that the levels of EPU_t, AS_t and MM_t might be non-stationary. Hence, we consider their first differences, $\Delta EPU_t, \Delta AS_t$ and ΔMM_t, in the empirical models instead of their levels.[9]

6 Results

In this section, empirical results for the models introduced in Section 4 are summarized and discussed. We first examine how the variance of aggregate shocks depends on the forecast horizon and whether it changes during recession periods. In order to analyze the

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[6] `http://www.policyuncertainty.com/europe_monthly.html`

[7] `http://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=123.ILM.W.U2.C.T000.Z5.Z01`

[8] `https://www.kof.ethz.ch/de/indikatoren/monetary-policy-communicator/`

[9] In addition to the graphical evidence in Figure 3, the results from augmented Dickey-Fuller (ADF) tests suggest non-stationarity in most cases. Results are provided by the authors upon request.

determinants of IU, distinct measures of IU are then related to indicators of macroeconomic conditions and monetary policy. Third, we examine which observable factors can explain the difference between average individual IU and disagreement.

6.1 Explaining the variance of aggregate shocks

Table 3 contains the estimates of equation (8) for a sample including time series for all forecast horizons $h = 4, 8, 20$.

[TABLE 3 HERE]

The results for the horizon-specific indicator variables, $D^{h=4}$, $D^{h=8}$ and $D^{h=20}$, show that the variance of aggregate shocks significantly increases with h and, thus, underscore the claim of the model of Lahiri and Sheng (2010) that the difference between average individual IU and disagreement increases with the forecast horizon. This means that horizon-specific considerations explain a considerable fraction of this difference. Hence, $\overline{\sigma^2_{t+h|t}}$ and $s^2_{t+h|t}$ provide distinct assessments of IU. In contrast, the coefficient on D^{REC}_{t-1} is insignificant, which means that the difference between average individual IU and disagreement does not increase during recessions, although the coefficient of D^{REC}_{t-1} has the expected positive sign.

6.2 Dynamic panel estimates for individual IU measures

In this section, we discuss how different IU statistics can be explained by macroeconomic and policy variables. Table 4 presents the dynamic panel estimates of equation (9). To highlight the effect of variables which quantify macroeconomic conditions as described in prominent theoretical discussions such as Friedman (1977) and Schwert (1989), the models in (9) are first estimated leaving aside the indicators of monetary policy in $\boldsymbol{p}_{t-1}$. In a second step, the models with all explanatory variables are estimated.

[TABLE 4 HERE]

From Table 4 it can be seen that the inflation rate, π_{t-1}, is positively, but weakly, related to $\sigma^2_{i,t+h|t}$. This is in line with the theoretical arguments by Friedman (1977) and Ball (1992). The insignificant coefficients in the even-numbered columns may be partly explained by the fact that π_{t-1} is positively correlated with both TD^+_{t-1} and $|TD^-_{t-1}|$ due to the inclusion of the inflation rate as a covariate in (15). In addition, π_{t-1} is positively correlated with ΔMPC_{t-1}, reflecting the fact that higher values of the Monetary Policy Communicator suggest that the central bank communicates inflation risks. In line with the arguments of Friedman (1977) that higher economic growth reduces IU, the results indicate a significant negative relationship between $\sigma^2_{i,t+h|t}$ and Δx_{t-1}. The impact of stock market volatility is insignificant for all horizons, althouhg the estimated coefficients have the expected positive sign for $h = 4$ and 8.

In the even-numbered columns, we report findings regarding the relationship between IU and indicators of monetary policy. The results show that during periods of expansionary monetary policy such as the years following the beginning of the crisis, (average) individual IU also tends to be high. This is expressed by the positive relationship between negative deviations from the Taylor rule, $|TD^-_{t-1}|$, and $\sigma^2_{i,t+h|t}$ for all h. This highlights the important role of monetary policy for the emergence of IU. As can be seen in Figure 2, the $\overline{\sigma^2_{t+h|t}}$ statistics increase from an initial level of around 0.2 before the beginning of the crisis to approximately 0.4 afterwards. The interest rate policy of the ECB during the crisis is characterized by sustained periods of negative deviations from the optimal Taylor rule of up to three percent, which can be seen in Figure 3. The estimated coefficients on $|TD^-_{t-1}|$ in columns (2), (4) and (6) suggest that a one percent deviation of the interest rate from the optimal Taylor rule increases (average) individual IU by approximately 0.04 units. This a relatively large effect and suggests that expansionary monetary policy accounts for more than 50 percent of the increase in average individual IU since the beginning of the crisis for all horizons. In contrast, positive deviations from the Taylor rule, TD^+_{t-1}, are only related to short-term IU, $\sigma^2_{i,t+4|t}$, although the estimated effect is also relatively large.

In columns (7) to (12) we present the estimates when the variance of individual shocks, $\sigma^2_{\varepsilon,i,t+h|t}$, is used as the dependent variable. The relationship between macroeconomic conditions and $\sigma^2_{\varepsilon,i,t+h|t}$ is similar to the evidence for $\sigma^2_{i,t+h|t}$. However, in line with Engle and Rangel (2008) and Conrad and Loch (2014), realized stock market volatility, $RV_{t-1}(E)$ is positively related to the variance of individual shocks for $h = 4$ and 8.

With respect to the importance of monetary policy, we find that $\sigma^2_{\varepsilon,i,t+h|t}$ is positively associated with TD^+_{t-1} for $h = 4$ and 8. The estimated effects are quantitatively large. This implies that disagreement rises during periods of restrictive interest rate policy. This is in contrast to the findings for $\sigma^2_{i,t+h|t}$, which suggest that individual IU is more closely related to expansionary monetary policy. In addition, periods of contractionary monetary policy are expected to lead to a decline in the inflation rate, which should reduce disagreement based on the positive relationship between π_{t-1} and $\sigma^2_{\varepsilon,i,t+h|t}$. However, the positive impact of TD^+_{t-1} suggests that the decision of the central bank to deviate from a rule-based monetary policy increases disagreement in a way that outweighs the potential reduction that results from the policy-induced reduction of the inflation rate. Since disagreement is a component of average individual IU and since contractionary monetary policy is not related to IU in columns (1) to (6), this suggests that the the overall effect of such deviations on IU should be small, despite its relationship with disagreement. Rather, it is periods of expansionary interest rate policy that are related to increases in IU. In addition, $\sigma^2_{\varepsilon,i,t+4|t}$ is also positively related to ΔAS_{t-1} and ΔMM_{t-1}, which implies that forecasters disagree about the implications of large changes in the ECB's balance sheet and monetary aggregates for future inflation.

Table 4 also reports p-values for the Hansen test of overidentifying restrictions. We cannot reject the null hypothesis that the overidentification restrictions are valid in all model specifications for $\sigma^2_{i,t,h}$ and almost all cases for the variance of individual shocks, $\sigma^2_{\varepsilon,i,t+h|t}$. This supports the robustness of the employed dynamic panel specification. The number of instruments used in each specification is fairly large due to the weak relevance in columns (7) to (12), but is smaller than the number of forecasters.

To summarize, individual IU and the variance of individual shocks are related to distinct indicators of monetary policy. This has important implications in terms of evaluating whether unpredictable changes in monetary policy may be associated with increases in the level of IU or not. Given the results in Table 4 for the variance of individual shocks as the dependent variable, it appears that positive deviations from a rule-based interest rate policy are associated with higher IU. However, it is negative deviations that are most important for the explanation of the increase in (average) individual IU across all forecast horizons.

6.3 The determinants of the variance of aggregate shocks

The results in the previous section reveal that different measures of IU are related to distinct indicators of monetary policy. In particular, (average) individual IU rises during periods of expansionary monetary policy, while disagreement does not. In order to examine the distinction between average individual IU and disagreement, we relate their difference, i.e. the variance of aggregate shocks, to macroeconomic conditions and policy indicators for different forecast horizons. Equation (**??**) is estimated using the same indicators of macroeconomic conditions and monetary policy used in sections 6.2 for the anticipation horizons $h \in \{4, 8, 20\}$. The results are reported in Table 5.

[TABLE 5 HERE]

We find that $\sigma^2_{\lambda,t+h|t}$ is positively related to the inflation rate, π_{t-1}, and the deviation variable $|TD^-_{t-1}|$. This means that periods of expansionary monetary policy increase the variance of the forthcoming aggregate shocks. In addition, we find that $\sigma^2_{\lambda,t+h|t}$ is negatively related to the real GDP growth rate, Δx_{t-1}, stock market volatility, $RV_{t-1}(E)$, changes in the central bank's asset position, ΔAS_{t-1}, positive deviations from the Taylor rule, TD^{+}_{t-1}, and changes in the money multiplier, ΔMM_{t-1}. Thus, it appears that, with the exception of $|TD^{-}_{t-1}|$, most indicators of monetary policy reduce the variance of future aggregate shocks. This helps to explain the previous findings regarding the determinants of individual IU from Table 4. In particular, positive deviations from the Taylor rule increase disagreement but systematically reduce the perceived variance of aggregate shocks. If these effects offset each other, (average) individual IU may not appear to be significantly related to TD^{+}_{t-1}. In contrast, negative deviations from the Taylor rule increase the perceived variance of aggregate shocks but seem to have little impact on the variance of individual shocks and, therefore, disagreement. Hence, the overall effect on individual IU is positive. In other words, $|TD^{-}_{t-1}|$ appears to contribute to the difference between $\overline{\sigma^2_{t+h|t}}$ and $s^2_{t+h|t}$, i.e. expansionary monetary policy increases the variance of aggregate shocks common to all individual forecasters unambiguously, and, thereby, increases (average) individual IU. To summarize, policy evaluations based on disagreement as a proxy for IU are potentially incomplete and misleading.

6.4 Estimates for aggregate IU measures

The results from the dynamic panel model may be affected by both the presence of missing values in our sample and the choice of instruments. As a robustness check, we report the estimates for the determinants of the aggregate IU measures, $\overline{\sigma^2_{t+h|t}}$ and $s^2_{t+h|t}$, as defined in (17). By the same argument as in Section 6.2, we distinguish between average individual IU and disagreement to highlight how individual findings might deviate regarding the influences on IU. Table 6 contains the estimates of equation (17).

[TABLE 6 HERE]

The results for the impact of the macroeconomic conditions are broadly in line with the findings from Table 4 in Section 6.2. The relationship between the inflation rate, π_{t-1}, and both $\overline{\sigma^2_{t+h|t}}$ and $s^2_{t+h|t}$ is insignificant, whereas the real GDP growth rate, Δx_{t-1}, is negatively related to average individual IU, $\overline{\sigma^2_{t+h|t}}$. In addition, both $\overline{\sigma^2_{t+h|t}}$ and $s^2_{t+h|t}$ are positively related to stock market volatility, $RV_{t-1}(E)$, for $h = 4$ and 8, even though the impact on disagreement is quantitatively larger.

With respect to the indicators of monetary policy, we find that $\overline{\sigma^2_{t+h|t}}$ is related to $|TD^-_{t-1}|$, while $s^2_{t+h|t}$ is more strongly associated with TD^+_{t-1}. This is in line with the previous evidence and suggests that average individual IU is higher during periods of expansionary monetary policy, whereas disagreement is higher when monetary polciy is contractionary. The estimated size of these effects is similar to ones from Table (4). In addition, the estimated coefficient on $|TD^-_{t-1}|$ is positive and significant for $h = 20$ but smaller than the corresponding coefficient for $\overline{\sigma^2_{t+20|t}}$ in column (7). The explanatory power of the models for $\overline{\sigma^2_{t+h|t}}$ is markedly higher than for $s^2_{t+h|t}$ in 6.

Overall, the results from Table 6 support the main findings from Table 4 and highlight the importance of the decomposition of Lahiri and Sheng (2010) in that disagreement is an incomplete approximation of IU and is related to different variables than measures of IU derived from density forecasts. The presence of missing values in the SPF panel does not appear to have a strong impact on the estimates from the dynamic panel model.

7 Conclusion

We analyze average individual IU and disagreement as two distinct measures of IU. The estimation sample covers the period before and after the beginning of the recent financial crisis in the Eurozone. While disagreement reverts to its pre-crisis level after a short period of time, average individual IU continues to rise. In line with the decomposition proposed by Lahiri and Sheng (2010), which shows that average individual IU can be regarded as the sum of disagreement and the variance of aggregate shocks, the empirical evidence shows that the difference between average individual IU and disagreement increases with the forecast horizon. Based on the empirical confirmation of the decomposition, we relate different measures of IU to a number of macroeconomic and policy variables that have been proposed as being related to IU in both the theoretical and empirical literature. Exploiting the full information contained in the cross-section of forecasters, we find that the relationship between individual IU and macroeconomic conditions is in line with the typical findings in the literature. However, the employed measures of IU are related to fundamentally different indicators of monetary policy. What is most striking is that average individual IU is primarily associated with expansionary monetary policy, whereas disagreement is more strongly associated with contractionary episodes. Moreover, we find that the difference between these measures systematically increases when monetary policy is unduly expansive. We conclude that disagreement is a misleading measure of IU for the purpose of assessing the risks associated with the European Central Bank's management of the financial and sovereign debt crisis.

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9 References

Arellano, M., Bover, O., 1995. Another look at the instrumental variables estimation of error-component models. *Journal of Econometrics* 68, 29-51.

Bachmann, R., Elstner, S., Sims, E. R., 2013. Uncertainty and economic activity: Evidence from business survey data. *American Economic Journal: Macroeconomics* 5, 217-249.

Baker, S.R., Bloom, N., Davis, S.J., 2013. Measuring economic policy uncertainty. *Chicago Booth Research Paper* 13-02, 1-29.

Ball, L., 1992. Why does high inflation raise inflation uncertainty? *Journal of Monetary Economics* 29, 371-388.

Bloom, N., 2009. The impact of uncertainty shocks. *Econometrica* 77, 623-685.

Bloom, N., Fernández-Villaverde, J., Schneider, M., 2014. The macroeconomics of uncertainty and volatility. *Journal of Economic Literature*, forthcoming.

Boero, G., Smith, J., Wallis, K.F., 2008. Uncertainty and disagreement in economic prediction: The Bank of England Survey of External Forecasters. *Economic Journal* 118, 1107-1127.

Bomberger, W.A., Frazer, W.J., 1981. Interest rates, uncertainty, and the Livingston data. *Journal of Finance* 36, 661-675.

Bry, G., Boschan, C., 1971. Cyclical analysis of time series: selected procedures and computer programs. New York, NBER.

Chauvet, M., Hamilton, J.D., 2005. Dating business cycles turning points. *NBER Working Paper* 11422, 1-59.

Clarida, R., Galí, J., Gertler, M., 1998. Monetary policy rules in practice: Some international evidence. *European Economic Review* 42, 1033-1067.

Clements, M.P., 2012. Probability distributions or point predictions? Survey forecasts of US output growth and inflation. *Warwick Economic Research Papers* 976, 1-36.

Clements, M.P., 2014. Forecast uncertainty - Ex ante and ex post: US Inflation and output growth. *Journal of Business and Economic Statistics* 32, 206-216.

Conrad, C., Eife, T.A., 2012. Explaining inflation-gap persistence by a time-varying Taylor rule. *Journal of Macroeconomics* 34, 419-428.

Conrad, C., Karanasos, M., 2005a. Dual long memory in inflation dynamics across countries of the Euro area and the link between inflation uncertainty and macroeconomic performance. *Studies in Nonlinear Dynamics and Econometrics* 9, Article 5.

Conrad, C., Karanasos, M., 2005b. On the inflation-uncertainty hypothesis in the USA, Japan and the UK: A dual long memory approach. *Japan and the World Economy* 17, 327-343.

Conrad, C., Karanasos, M., Zeng, N., 2010. The link between macroeconomic performance and variability in the UK. *Economics Letters* 106, 154-157.

Conrad, C., Lamla, M.J., 2010. The high-frequency response of the EUR-US-dollar exchange rate to ECB monetary policy announcements. *Journal of Money, Credit and Banking*, 42, 1391-1417.

Conrad, C., Loch, K., 2014. Anticipating long-term stock market volatility. *Journal of Applied Econometrics*, forthcoming.

Conrad, C., Hartmann, M., 2014. Cross-sectional evidence on the relation between monetary policy, macroeconomic conditions and low-frequency inflation uncertainty. *University of Heidelberg Discussion Paper* No. 574, 1-43.

Cukierman, A., 1992. Central bank strategy: Credibility and independence. Cambridge: MIT Press.

Cukierman, A., Meltzer, A.H., 1986. A theory of ambiguity, credibility, and inflation under discretion and asymmetric information. *Econometrica* 54, 1099-1128.

Davies, A., Lahiri, K., 1995. A new framework for analyzing survey forecasts using three-dimensional panel data. *Journal of Econometrics* 68, 205-227.

Dovern, J., Fritsche, U., Slacalek, J., 2012. Disagreement among forecasters in G7 countries. *Review of Economics and Statistics* 94, 1081-1096.

Drakos, A.A., Kouretas, G.P., 2015. The conduct of monetary policy in the Eurozone before and after the financial crisis. *Economic Modelling* 48, 83-92.

Ehrmann, M., Eijffinger, S., Fratzscher, M., 2012. The role of central bank transparency for guiding private sector forecasts. *Scandinavian Journal of Economics* 114, 1018-1052.

Elder, J., 2004. Another perspective on the effects of inflation uncertainty. *Journal of Money, Credit and Banking* 36, 911-928.

Engelberg, J., Manski, C.F., Williams, J., 2009. Comparing the point predictions and subjective probability distributions of professional forecasters. *Journal of Business and Economic Statistics* 27, 30-41.

Engle, R.F., Rangel, J.G., 2008. The spline-GARCH model for low-frequency volatility and its global macroeconomic causes. *Review of Financial Studies* 21, 1187-1222.

European Central Bank, 2014. *ECB Monthly Bulletin* November 2014, 1-97.

Fernández-Villaverde, J., Guerrón-Quintana, P., Rubio-Ramírez, J.F., 2011. Risk matters: The real effects of volatility shocks. *American Economic Review* 101, 2530-2561.

Friedman, M., 1977. Inflation and unemployment. *Journal of Political Economy* 85, 451-472.

Galí, J., Gambetti, L., 2009. On the sources of the Great Moderation. *American Economic Journal: Macroeconomics* 1, 26-57.

Giordani, P., Söderlind, P., 2003. Inflation forecast uncertainty. *European Economic Review* 47, 1037-1059.

Grier, K.B., Perry, M.J., 2000. The effects of real and nominal uncertainty on inflation and output growth. *Journal of Applied Econometrics* 15, 45-58.

Grier, K.B., Henry, O.T., Olekalns, N., Shields, K., 2004. The asymmetric effects of uncertainty on inflation and output growth. *Journal of Applied Econometrics* 19, 551-565.

Hartmann, M., Herwartz, H., 2012. Causal relations between inflation and inflation uncertainty - Cross-sectional evidence in favor of the Friedman-Ball hypothesis. *Economics Letters* 115, 144-147.

Hartmann, M., Roestel, J., 2013. Inflation, output and uncertainty in the era of inflation targeting - A multi-economy view on causal linkages. *Journal of International Money and Finance* 37, 98-112.

Herrera, A.-M., Pesavento, E., 2009. Oil price shocks, systematic monetary policy, and the Great Moderation. *Macroeconomic Dynamics* 13, 107-137.

Holland, A.S., 1995. Inflation and uncertainty-tests for temporal ordering. *Journal of Money, Credit and Banking* 27, 827-837.

Huizinga, J., 1993. Inflation uncertainty, relative price uncertainty, and investment in U.S. manufacturing. *Journal of Money, Credit and Banking* 25, 521-549.

Lahiri, K., Liu, F., 2005. ARCH models for multi-period forecast uncertainty: A reality check using a panel of density forecasts. In: *Econometric Analysis of Financial and Economic Time Series Part A*, Terrell, D., Fomby, T. (Eds.), Elsevier, North Holland.

Lahiri, K., Peng, H., Zhao, Y., 2014. On-line learning and forecast combination in unbalanced panels. *Econometric Reviews*, forthcoming.

Lahiri, K., Sheng, X., 2008. Evolution of forecast disagreement in a Bayesian learning model. *Journal of Econometrics* 144, 325-340.

Lahiri, K., Sheng, X., 2010. Measuring forecast uncertainty by disagreement: The missing link. *Journal of Applied Econometrics* 25, 514-538.

Lahiri, K., Teigland, C., Zaporowski, M., 1988. Interest rates and the subjective probability distribution of inflation forecasts. *Journal of Money, Credit and Banking* 20, 233-248.

Lamla, M.I., Maag, T., 2012. The role of media for inflation forecast disagreement of households and professional forecasters. *Journal of Money, Credit and Banking* 44, 1325-1350.

Levi, M.D., Makin, J.H., 1979. Fisher, Phillips, Friedman and the measured impact of inflation on interest. *Journal of Finance* 34, 35-52.

Mankiw, N.G., Reis, R., Wolfers, J., 2003. Disagreement about inflation expectations. *NBER Working Paper* 9796, 209-248.

Morris, S., Shin, H.S., 2002. Social value of public information. *American Economic Review* 92, 1521-1534.

Okun, A.M., 1971. The mirage of steady inflation. *Brookings Papers on Economic Activity* 2, 485-498.

Rich, R., Tracy, J., 2010. The relationships among expected inflation, disagreement, and uncertainty: Evidence from matched point and density forecasts. *Review of Economics and Statistics* 92, 200-207.

Rich, R., Song, J., Tracy, J., 2012. The measurement and behavior of uncertainty: Evidence from the ECB Survey of Professional Forecasters. *Federal Reserve Bank of New York Staff Reports* 588, 1-47.

Scharnagl, M., Stapf, J., 2015. Inflation, deflation, and uncertainty: What drives euro-area option-implied inflation expectations, and are they still anchored in the sovereign debt crisis? *Economic Modelling* 48, 248-269.

Schwert, G.W., 1989. Why does stock market volatility change over time? *Journal of Finance* 44, 1115-1153.

Taylor, J.B., 1993. Discretion versus policy rules in practice. *Carnegie Rochester Conference Series on Public Policy* 39, 195-214.

Taylor, J.B., 2007. Housing and monetary policy. *Proceedings of FRB of Kansas City Symposium, Jackson Hole, NY.*

Taylor, J.B., 2008. The financial crisis and the policy responses: An empirical analysis of what went wrong. In: *A Festschrift in Honour of David Dodge's Contributions to Canadian Public Policy*, Ottawa, Bank of Canada.

Taylor, J.B., 2012. Monetary policy rules work and discretion doesn't: A tale of two eras.

Journal of Money, Credit and Banking 44, 1017-1032.

Vitek, F., 2002. An empirical analysis of dynamic interrelationships among inflation, inflation uncertainty, relative price dispersion, and output growth. *Bank of Canada Working Paper* 2002-39, 1-35.

Windmeijer, F. 2005. A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics* 126, 25-51.

Wright, J.H., 2011. Term premia and inflation uncertainty: Empirical evidence from an international panel dataset. *American Economic Review* 101, 1514-1534.

Zarnowitz, V., Lambros, L.A., 1987. Consensus and uncertainty in economic prediction. *Journal of Political Economy* 95, 591-621.

Tables and Figures

Table 1: Intervals used in the Survey of Professional Forecasters questionnaire

$f_{i,t+h\|t}$							
1999Q1-2000Q3			$(-\infty;-0.1]$	$\ldots[0.5(k-1);0.5k-0.1]$,	$k=1,\ldots,7\ldots$	$[3.5;+\infty)$	
2000Q4			$(-\infty;-0.1]$	$\ldots[0.5(k-1);0.5k-0.1]$,	$k=1,\ldots,8\ldots$		$[4.0;+\infty)$
2001Q1-2008Q2			$(-\infty;-0.1]$	$\ldots[0.5(k-1);0.5k-0.1]$,	$k=1,\ldots,7\ldots$	$[3.5;+\infty)$	
2008Q3-2009Q1			$(-\infty;-0.1]$	$\ldots[0.5(k-1);0.5k-0.1]$,	$k=1,\ldots,8\ldots$		$[4.0;+\infty)$
2009Q2-2009Q4	$(-\infty;-2.1]$			$\ldots[0.5(k-1);0.5k-0.1]$,	$k=-3,\ldots,8\ldots$		$[4.0;+\infty)$
2010Q1-present		$(-\infty;-1.1]$		$\ldots[0.5(k-1);0.5k-0.1]$,	$k=-1,\ldots,8\ldots$		$[4.0;+\infty)$

Notes: The table illustrates changes to the range of SPF density forecasts, $f_{i,t+h|t}$, in the questionnaire of the ECB. Density forecasts are issued by forecasters $i=1,...,98$ in sample period $t=1,...,58$, representing time instances between 1999Q1 and 2013Q2, with forecast horizon $h\in\{4,8,20\}$. Each row depicts the upper and lower intervals whereas k indicates the intermediate intervals.

Table 2: Correlations across aggregate IU measures

	$\overline{\sigma^2_{t+4\|t}}$	$\overline{\sigma^2_{t+8\|t}}$	$\overline{\sigma^2_{t+20\|t}}$	$s^2_{t+4\|t}$	$s^2_{t+8\|t}$	$s^2_{t+20\|t}$	$\sigma^2_{\lambda,t+4\|t}$	$\sigma^2_{\lambda,t+8\|t}$	$\sigma^2_{\lambda,t+20\|t}$
$\overline{\sigma^2_{t+4\|t}}$	1.00								
$\overline{\sigma^2_{t+8\|t}}$	0.98	1.00							
$\overline{\sigma^2_{t+20\|t}}$	0.92	0.94	1.00						
$s^2_{t+4\|t}$	**0.50**	0.50	0.28	1.00					
$s^2_{t+8\|t}$	0.47	**0.47**	0.32	0.73	1.00				
$s^2_{t+20\|t}$	0.44	0.47	**0.38**	0.43	0.63	1.00			
$\sigma^2_{\lambda,t+4\|t}$	**0.70**	0.68	0.80	**-0.26**	-0.08	0.14	1.00		
$\sigma^2_{\lambda,t+8\|t}$	0.84	**0.85**	0.88	0.14	**-0.06**	0.16	0.82	1.00	
$\sigma^2_{\lambda,t+20\|t}$	0.84	0.84	**0.94**	0.14	0.11	**0.05**	0.82	0.89	1.00

Notes: The sample period $t=1,...,58$ represents time instances between 1999Q1 and 2013Q2. The IU measures $\overline{\sigma^2_{t+h|t}}$, $s^2_{t+h|t}$ and $\sigma^2_{\lambda,t+h|t}$ refer to average individual IU, disagreement and the variance of aggregate shocks from equations (5), (7) and (6) at forecast horizons $h\in\{4,8,20\}$, respectively. Correlations which highlight the relationship between distinct measures of IU for different forecast horizons are marked in boldface.

Table 3: Estimates of the horizon effects on the variance of aggregate shocks

		Variance of aggregate shocks $\sigma^2_{\lambda,t+h\|t}$ $h = 4, 8, 20$
$D^{h=4}$	Indicator variable for $h = 4$	1.57
		(0.81)
$D^{h=8}$	Indicator variable for $h = 8$	9.33*
		(0.85)
$D^{h=20}$	Indicator variable for $h = 20$	15.06*
		(1.13)
$t - 1$	Time trend	0.37*
		(0.02)
D^{REC}_{t-1}	Recession indicator variable	1.26
		(0.74)
	Adj. R^2	0.96
	No. of observations	164

Notes: This table reports the estimates of equation (8). The sample period $t = 1, ..., 58$ represents time instances between 1999Q1 and 2013Q2. Coefficients are estimated with OLS. Heteroskedasticity-robust standard errors in parentheses. The reported coefficients and standard errors are the estimated ones times 100. Asterisks ("*") indicate significance at the 5% critical level.

Table 4: Dynamic panel estimates of the relationship between individual IU measures and their potential determinants

		Individual IU $\sigma^2_{i,t+h\|t}$						Variance of individual shocks $\sigma^2_{\varepsilon,i,t+h\|t}$					
		$h=4$		$h=8$		$h=20$		$h=4$		$h=8$		$h=20$	
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\sigma^2_{i,t+h-1\|t-1}$	Individual IU	38.29*	36.52*	40.88*	38.04*	54.53*	47.31*						
		(7.47)	(6.00)	(8.59)	(7.65)	(9.60)	(8.70)						
$\sigma^2_{\varepsilon,i,t+h-1\|t-1}$	Variance of individual shocks							41.09*	40.10*	32.29*	39.82*	38.98*	40.91*
								(7.87)	(6.52)	(10.31)	(8.25)	(10.10)	(8.49)
π_{t-1}	Inflation rate	1.86	0.58	2.54*	0.54	1.82	0.67	3.90*	0.28	2.31	-0.96	1.85	-0.09
		(1.01)	(0.61)	(1.05)	(0.76)	(1.24)	(1.12)	(1.19)	(0.69)	(1.19)	(0.95)	(1.66)	(1.08)
Δx_{t-1}	Real GDP growth rate	-1.42*	-1.62*	-1.54*	-1.65*	-1.43*	-1.88*	-1.84*	-1.11*	-2.48*	-1.01	-2.18*	-1.21*
		(0.69)	(0.47)	(0.60)	(0.51)	(0.71)	(0.62)	(0.81)	(0.53)	(0.68)	(0.53)	(0.85)	(0.59)
$RV_{t-1}(E)$	Stock price volatility	5.06	7.00	1.95	5.64	-8.34	-10.60	32.05*	39.51*	4.22	25.26*	8.89	7.36
		(7.01)	(8.14)	(5.66)	(8.49)	(8.45)	(10.77)	(8.86)	(9.31)	(6.81)	(9.98)	(9.68)	(11.26)
ΔEPU_{t-1}	Economic Policy Uncertainty		-0.16		-0.18		-0.36		-0.54		-3.44		-1.01
			(1.63)		(1.90)		(2.40)		(1.95)		(2.35)		(2.28)
ΔAS_{t-1}	ECB assets		-4.18		-5.54		1.02		10.21*		-2.46		-3.38
			(4.05)		(4.54)		(4.68)		(4.60)		(5.31)		(5.04)
TD^+_{t-1}	Positive Taylor deviations		3.01*		1.52		-2.72		5.61*		4.67*		-2.38
			(1.26)		(1.62)		(2.12)		(1.39)		(2.05)		(2.19)
$\|TD^-_{t-1}\|$	Negative Taylor deviations		3.96*		4.47*		3.72*		0.71		0.92		1.06
			(0.95)		(1.31)		(1.12)		(1.01)		(1.42)		(1.13)
MPC_{t-1}	Monetary Policy Communicator		2.25		0.90		2.21		3.00		0.37		2.63
			(2.48)		(2.48)		(3.85)		(3.15)		(2.99)		(3.85)
ΔMM_{t-1}	Money multiplier		-0.27		-0.92		0.16		2.69*		0.99		-1.26
			(1.00)		(1.05)		(1.19)		(1.15)		(1.26)		(1.28)
	Constant	6.81*	9.26*	8.44*	13.40*	9.96*	19.26*	-1.35	-0.68	7.60*	3.61	5.24	6.21
		(2.05)	(2.28)	(2.93)	(3.40)	(4.12)	(4.45)	(2.26)	(2.36)	(3.28)	(3.32)	(5.17)	(4.93)
$t-1$	Time trend	0.12*	0.05	0.14*	0.01	0.13	-0.05	-0.02	0.04	-0.09	-0.00	-0.09	-0.08
		(0.05)	(0.06)	(0.06)	(0.08)	(0.08)	(0.08)	(0.06)	(0.06)	(0.06)	(0.09)	(0.10)	(0.09)
D^{REC}_{t-1}	Recession indicator variable	-1.51	-0.32	-1.71	-0.01	-0.87	-1.12	-3.79	-0.15	-4.81*	-0.34	-4.12	-1.60
		(1.81)	(1.06)	(1.76)	(1.23)	(1.96)	(1.44)	(2.16)	(1.15)	(2.07)	(1.45)	(2.60)	(1.56)
	No. of observations	2,206	2,157	1,928	1,880	1,533	1,533	2,206	2,157	1,928	1,880	1,533	1,533
	No. of forecasters	88	87	87	86	75	75	88	87	87	86	75	75
	No. of instruments	32	74	32	74	32	68	32	74	32	74	32	68
	Hansen p-value	0.09	0.42	0.17	0.79	0.12	0.37	0.00	0.14	0.13	0.33	0.04	0.39

Notes: This table reports the estimates of equation (9). Cross-sectional units $i = 1, ..., 98$ denote individual forecasters and sample period $t = 1, ..., 58$ represents time instances between 1999Q1 and 2013Q2. Coefficients are estimated with the two-step system GMM estimator by Arellano and Bover (1995). Within-forecaster heteroskedasticity- and autocorrelation-robust standard errors using the adjustment proposed by Windmeijer (2005) are reported in parentheses. The reported coefficients and standard errors are the estimated ones times 100. Asterisks ("*") indicate significance at the 5% critical level.

Table 5: Estimates of the determinants of the variance of aggregate shocks

		Variance of aggregate shocks $\sigma^2_{\lambda,t+h\|t}$		
		$h = 4$	$h = 8$	$h = 20$
		(1)	(2)	(3)
π_{t-1}	Inflation rate	1.99	3.75*	3.27*
		(1.26)	(1.13)	(0.93)
Δx_{t-1}	Real GDP growth rate	-0.65	-1.34*	-1.45*
		(0.40)	(0.59)	(0.47)
$RV_{t-1}(E)$	Stock price volatility	-49.66	-24.41	-34.91
		(29.72)	(19.98)	(22.78)
ΔEPU_{t-1}	Economic Policy Uncertainty	5.62	4.47	4.53
		(4.13)	(3.75)	(4.01)
ΔAS_{t-1}	ECB assets	-25.48*	-9.66	-6.42
		(10.48)	(8.55)	(12.03)
TD^{+}_{t-1}	Positive Taylor deviations	-3.81	-4.12	-6.98*
		(2.45)	(2.42)	(2.64)
$\|TD^{-}_{t-1}\|$	Negative Taylor deviations	4.87*	5.71*	4.13*
		(1.59)	(0.97)	(1.07)
MPC_{t-1}	Monetary Policy Communicator	-4.81	0.07	-7.07*
		(3.60)	(2.40)	(2.79)
ΔMM_{t-1}	Money multiplier	-4.86*	-3.62*	-1.67
		(1.59)	(1.26)	(2.41)
	Constant	12.23*	12.87*	20.64*
		(3.55)	(2.80)	(3.75)
$t-1$	Time trend	0.06	0.07	0.14*
		(0.09)	(0.06)	(0.07)
D^{REC}_{t-1}	Recession indicator variable	-0.90	0.17	-0.95
		(1.62)	(1.41)	(1.64)
	R^2	0.66	0.81	0.73
	No. of observations	56	56	50

Notes: This table reports the estimates of equation (20). The sample period $t = 1, ..., 58$ represents time instances between 1999Q1 and 2013Q2. Coefficients are estimated with OLS. Newey-West standard errors accounting for fourth-order autocorrelation in parentheses. The reported coefficients and standard errors are the estimated ones times 100. Asterisks ("*") indicate significance at the 5% critical level.

Table 6: Estimates of the relationship between aggregate IU measures and their potential determinants

		Average individual IU $\overline{\sigma^2_{t+h\|t}}$						Disagreement $s^2_{t+h\|t}$					
		$h=4$		$h=8$		$h=20$		$h=4$		$h=8$		$h=20$	
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$\overline{\sigma^2_{t+h-1\|t-1}}$	Average individual IU	66.43*	43.76*	65.79*	36.05*	65.26*	36.72						
		(10.15)	(6.56)	(9.26)	(8.18)	(8.00)	(22.34)						
$s^2_{t+h-1\|t-1}$	Disagreement							68.70*	64.89*	47.49*	32.06	16.21	-31.25
								(15.67)	(17.34)	(12.84)	(17.12)	(24.85)	(17.38)
π_{t-1}	Inflation rate	0.22	0.15	-0.07	0.21	0.58	1.56	1.10	0.21	-0.37	-1.88*	0.28	-0.18
		(0.62)	(0.51)	(0.69)	(0.67)	(0.71)	(1.09)	(0.72)	(0.97)	(0.54)	(0.75)	(0.69)	(0.69)
Δx_{t-1}	Real GDP growth rate	-0.57	-1.09*	-0.54	-1.28*	-1.01*	-1.41*	0.06	-0.07	-0.65	-0.41	-0.69	-0.65
		(0.30)	(0.35)	(0.37)	(0.48)	(0.38)	(0.44)	(0.38)	(0.41)	(0.40)	(0.42)	(0.47)	(0.43)
$RV_{t-1}(E)$	Stock price volatility	14.89*	15.30*	20.95*	16.99*	0.84	-8.76	31.13*	34.26*	22.36*	31.36*	7.29	8.55
		(3.83)	(5.16)	(3.64)	(6.90)	(6.47)	(11.57)	(12.36)	(15.88)	(6.64)	(12.90)	(5.43)	(6.96)
ΔEPU_{t-1}	Economic Policy Uncertainty		-1.29		-1.60		-1.94		1.25		-2.86		-2.22
			(2.05)		(2.47)		(2.49)		(3.30)		(3.08)		(2.05)
ΔAS_{t-1}	ECB assets		-2.02		-1.70		-1.33		6.99		3.92		-5.91
			(4.80)		(4.70)		(10.35)		(6.51)		(4.36)		(7.37)
TD^+_{t-1}	Positive Taylor deviations		1.71*		2.27		0.39		1.87		4.59*		5.33*
			(0.84)		(1.21)		(2.07)		(1.54)		(1.95)		(2.44)
$\|TD^-_{t-1}\|$	Negative Taylor deviations		2.69*		3.79*		3.95*		-0.58		-0.49		2.77*
			(0.48)		(0.59)		(1.32)		(1.07)		(0.54)		(0.51)
MPC_{t-1}	Monetary Policy Communicator		2.52		0.62		-4.28		2.99		-0.91		-2.19
			(1.40)		(1.56)		(4.13)		(2.07)		(2.22)		(2.70)
ΔMM_{t-1}	Money multiplier		0.17		-0.05		0.36		2.18		1.72		0.11
			(1.09)		(1.05)		(2.58)		(2.09)		(0.92)		(0.70)
	Constant	3.00	7.27*	4.72	12.19*	8.40*	16.44*	-4.31*	-3.77	3.32	3.35	3.42	5.62*
		(1.55)	(1.56)	(2.43)	(2.72)	(2.18)	(4.89)	(2.13)	(2.83)	(2.18)	(2.07)	(1.92)	(2.60)
$t-1$	Time trend	0.12*	0.09*	0.12*	0.07	0.11*	0.05	0.04	0.07	-0.01	0.05	0.01	-0.06
		(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.02)	(0.06)	(0.02)	(0.05)	(0.03)	(0.05)
D^{REC}_{t-1}	Recession indicator variable	-0.45	0.11	-0.13	0.42	-0.27	-0.28	0.10	0.71	-0.58	0.24	0.08	1.53
		(0.66)	(0.73)	(0.84)	(0.95)	(1.07)	(1.11)	(1.23)	(1.47)	(0.87)	(0.66)	(0.93)	(1.17)
	Adj. R^2	0.93	0.94	0.91	0.94	0.83	0.87	0.69	0.68	0.65	0.66	0.26	0.41
	No. of observations	57	56	57	56	49	49	57	56	57	56	49	49

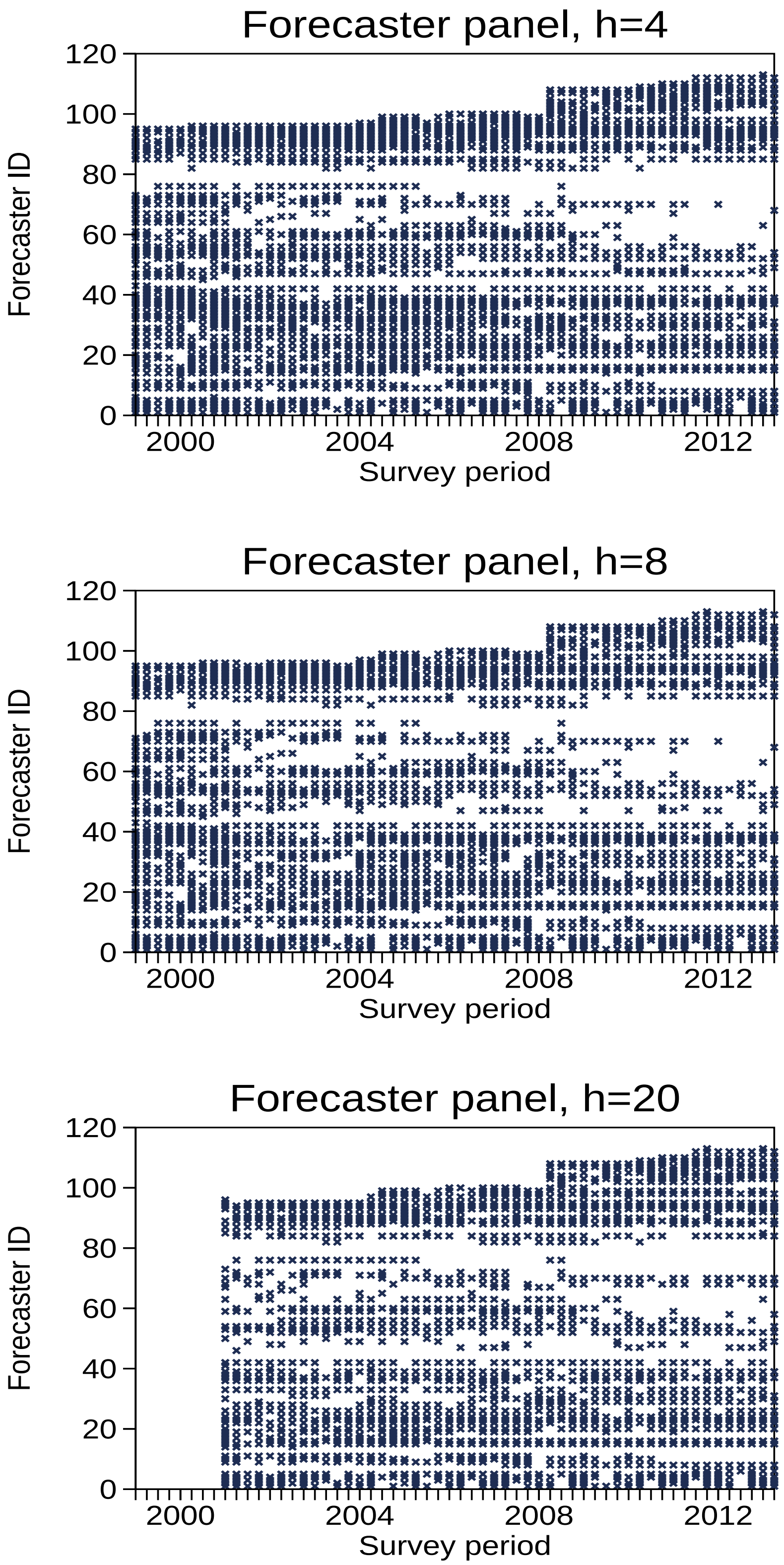
Notes: This table reports the estimates of equation (17). The sample period $t = 1, ..., 58$ represents time instances between 1999Q1 and 2013Q2. Coefficients are estimated with OLS. Newey-West standard errors accounting for fourth-order autocorrelation in parentheses. The reported coefficients and standard errors are the estimated ones times 100. Asterisks ("*") indicate significance at the 5% critical level.

Table 7: Estimates of the relationship between aggregate IU measures and their potential determinants

			$h=4$			$h=8$			$h=20$	
		$\overline{\sigma^2_{t+4\|t}}$ (1)	$s^2_{t+4\|t}$ (2)	$\sigma^2_{\lambda,t+4\|t}$ (3)	$\overline{\sigma^2_{t+8\|t}}$ (4)	$s^2_{t+8\|t}$ (5)	$\sigma^2_{\lambda,t+8\|t}$ (6)	$\overline{\sigma^2_{t+20\|t}}$ (7)	$s^2_{t+20\|t}$ (8)	$\sigma^2_{\lambda,t+20\|t}$ (9)
π_{t-1}	Inflation rate	0.78	-1.21	1.99	1.12	-2.63*	3.75*	3.35*	0.08	3.27*
		(0.75)	(1.32)	(1.26)	(0.87)	(0.70)	(1.13)	(0.83)	(0.89)	(0.93)
Δx_{t-1}	Real GDP growth rate	-1.89*	-1.23*	-0.65	-2.17*	-0.83*	-1.34*	-1.94*	-0.48	-1.45*
		(0.36)	(0.40)	(0.40)	(0.39)	(0.40)	(0.59)	(0.35)	(0.37)	(0.47)
$RV_{t-1}(E)$	Stock price volatility	10.75	60.42*	-49.66	10.13	34.54*	-24.41	-25.33	9.58	-34.91
		(7.52)	(24.46)	(29.72)	(8.50)	(13.24)	(19.98)	(16.64)	(7.34)	(22.78)
ΔEPU_{t-1}	Economic Policy Uncertainty	0.60	-5.01	5.62	0.24	-4.22	4.47	1.83	-2.70	4.53
		(2.28)	(3.73)	(4.13)	(2.58)	(2.88)	(3.75)	(3.02)	(2.20)	(4.01)
ΔAS_{t-1}	ECB assets	-7.72	17.75*	-25.48*	-5.92	4.04	-9.96	-11.07	-4.64	-6.42
		(5.30)	(7.28)	(10.48)	(6.07)	(4.43)	(8.55)	(7.68)	(7.25)	(12.03)
TD^+_{t-1}	Positive Taylor deviations	1.97	5.78*	-3.81	2.06	6.19*	-4.12	-2.78	4.20*	-6.98*
		(1.00)	(2.01)	(2.45)	(1.29)	(1.83)	(2.42)	(1.95)	(1.62)	(2.64)
$\|TD^-_{t-1}\|$	Negative Taylor deviations	4.72*	-0.16	4.87*	5.78*	0.08	5.71*	6.02*	1.89*	4.13*
		(0.67)	(1.59)	(1.59)	(0.66)	(0.87)	(0.97)	(0.61)	(0.57)	(1.07)
MPC_{t-1}	Monetary Policy Communicator	1.66	6.47	-4.81	-0.76	-0.83	0.07	-9.73*	-2.65	-7.07*
		(2.37)	(3.65)	(3.60)	(2.14)	(2.74)	(2.40)	(3.39)	(2.29)	(2.79)
ΔMM_{t-1}	Money multiplier	-1.21	3.65*	-4.86*	-1.26	2.35*	-3.62*	-1.91	-0.24	-1.67
		(1.04)	(1.60)	(1.59)	(1.02)	(0.85)	(1.26)	(1.60)	(1.11)	(2.41)
	Constant	14.13*	1.90	12.23*	20.56*	7.69*	12.87*	24.20*	3.57	20.64*
		(1.87)	(3.40)	(3.55)	(2.28)	(1.99)	(2.80)	(1.96)	(2.82)	(3.75)
$t-1$	Time trend	0.14*	0.08	0.06	0.09	0.02	0.07	0.10*	-0.04	0.14*
		(0.05)	(0.10)	(0.09)	(0.05)	(0.06)	(0.06)	(0.05)	(0.05)	(0.07)
D^{REC}_{t-1}	Recession indicator variable	-0.13	0.77	-0.90	-0.01	-0.18	0.17	-0.18	0.77	-0.95
		(1.11)	(1.70)	(1.62)	(1.11)	(0.82)	(1.41)	(1.24)	(0.97)	(1.64)
	Adj. R^2	0.94	0.68	0.66	0.94	0.66	0.81	0.87	0.41	0.73
	No. of observations	56	56	56	56	56	56	50	50	50

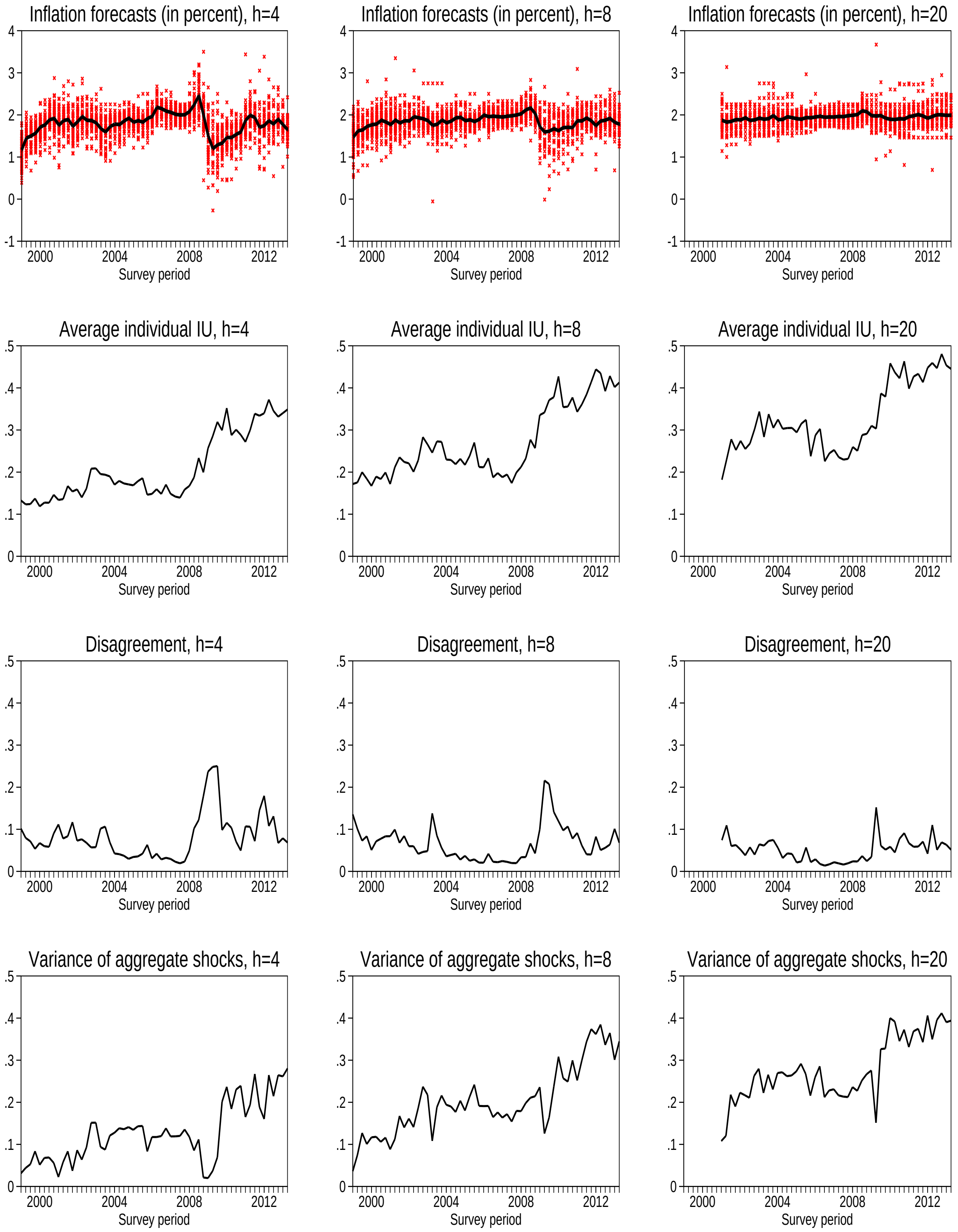
Notes: This table reports the estimates of equation (17). The sample period $t = 1, ..., 58$ represents time instances between 1999Q1 and 2013Q2. Coefficients are estimated with OLS. Newey-West standard errors accounting for fourth-order autocorrelation in parentheses. The reported coefficients and standard errors are the estimated ones times 100. Asterisks ("*") indicate significance at the 5% critical level.

Figure 1: SPF forecaster panel



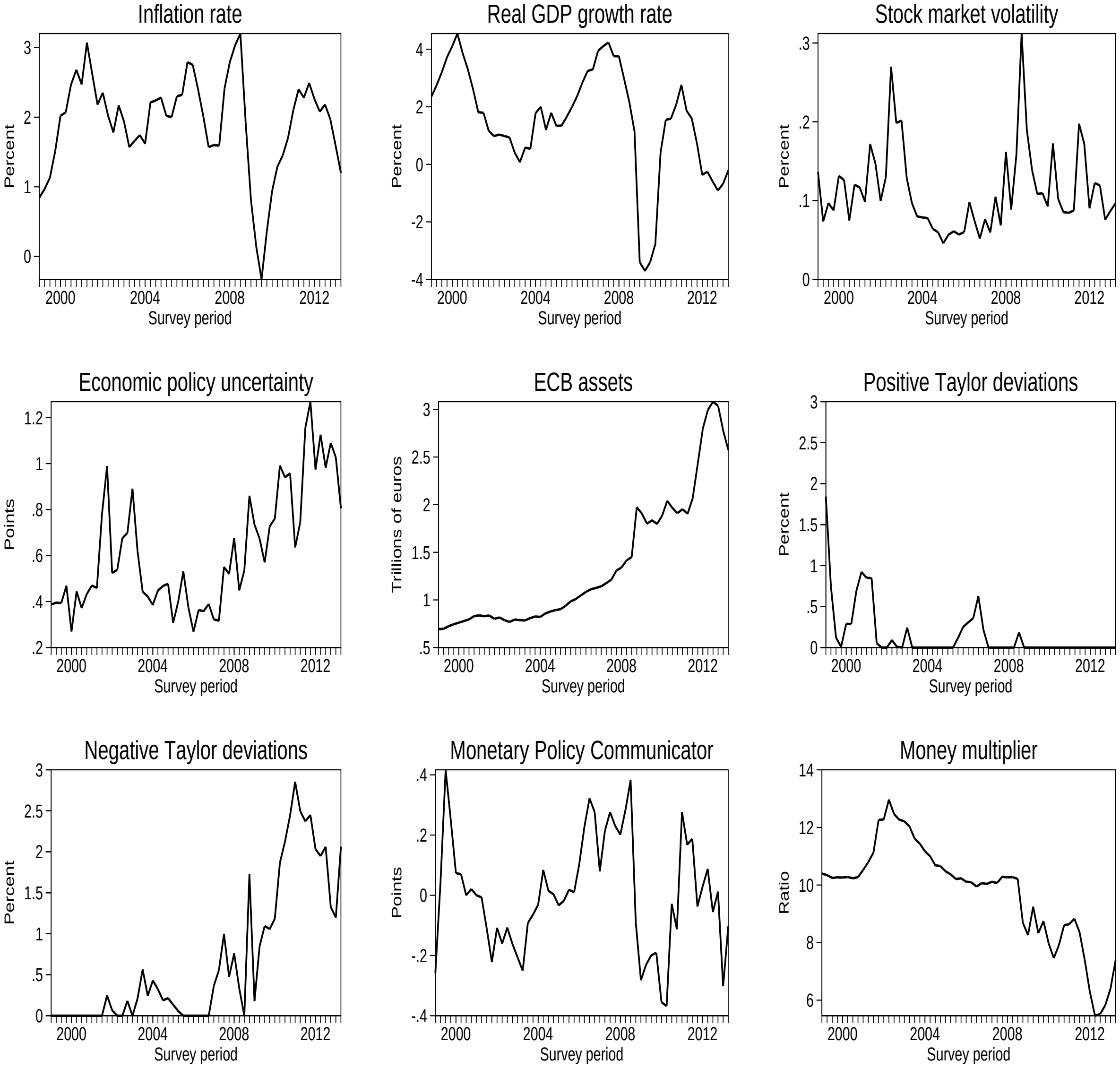
Notes: Graphs depict forecaster participation in SPF surveys between 1999Q1 and 2013Q2 for forecast horizons $h \in \{4, 8, 20\}$. Each cross indicates that a density forecast is reported by a survey participant.

Figure 2: Inflation expectations and uncertainty measures



Notes: Graphs depict inflation expectations and inflation uncertainty measures for forecast horizons $h \in \{4, 8, 20\}$ from left to right. The horizontal axis denotes the periods during which surveys are delivered. The solid black lines in the plots in the first row are the cross-sectional means of the individual expectations.

Figure 3: Macroeconomic and policy variables



Notes: Graphs depict variables measuring macroeconomic conditions and indicators of monetary policy.