Information Rigidity and State-Dependence of Inflation Expectations: New Evidence from the CESifo World Economic Survey*

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Abstract

We examine inflation forecasts in 16 high-income economies provided by the CESifo World Economic Survey (WES). In particular, we assess the degree of information rigidity in inflation expectations following an approach by Coibion and Gordonichenko (2012). We find evidence of informational rigidities with WES experts updating their information set every three to four months. However, the degree of information rigidity crucially depends on the forecast horizon. Moreover, based on a question on the importance of potential economic problems, we document state-dependence in WES inflation expectations. When the majority of experts assess the economic problem "inflation" as being highly important, the implied degree of information rigidity is smaller. That is, forecasters are more attentive when inflation concerns are prevailing. The same implication is obtained when trend inflation or past inflation are above a critical threshold value. Our empirical findings are supportive of models with noisy information (Woodford, 2002; Sims, 2003; Maćkowiak and Wiederholt, 2009) and state-dependent updating of information (Gorodnichenko, 2008; Woodford, 2009).

JEL classifications: C33, E31, E37
Keywords: inflation expectations; forecast errors; inattention; state-dependent updating

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1 Introduction

In forecast evaluation, a major theme is whether forecasters are rational. Information rigidities provide an explanation for often observed departures from forecast rationality in survey data.[1] Consequently, recent macroeconomic theory has started to account for informational rigidities based on models of imperfect information. Two key approaches are related to informational constraints either due to delayed ("sticky") information (Mankiw and Reis, 2002; Reis, 2006) or partial ("noisy") information (Woodford, 2001; Sims, 2003; Maćkowiak and Wiederholt, 2009).[2]

This study examines the process of inflation expectations formation in high-income countries. In particular, we assess the degree of information rigidity in inflation forecasts following an approach by Coibion and Gorodnichenko (2012), which is directly related to models of imperfect information. In contrast to previous tests of forecast rationality, their approach not only allows testing for the presence of informational rigidities but also provides the chance to determine the economic significance and mechanisms behind departures from full-information rational expectations (FIRE).

We use a unique dataset of inflation forecasts for 16 high-income countries provided by the CESifo World Economic Survey (WES). The WES is conducted quarterly by the Ifo Institute in Munich in co-operation with the International Chamber of Commerce (ICC) in Paris. To this date, about 1,200 national experts assess the general economic situation and indicate their expectations on macroeconomic indicators of their country, including the annual average rate of inflation. Two advantages arise with WES data. First, they provide fixed-event inflation forecasts, i.e., a sequence of forecasts related to the same event such as reported by Consensus Economics and the Survey of Professional Forecasters (SPF). This kind of forecast is well suited to evaluating the incorporation of new information. Second, the WES polls the experts' opinion on problems their economy is facing at present. Thereby, respondents are asked to assess the importance of a given variety of economic problems such as unemployment, insufficient demand, public deficits, and inflation. Focusing on the question related to inflation, we are able to identify periods where inflation is termed problematic. This allows us to analyze how changes in the importance assigned to inflation affect the process of forecasting inflation.

Our study is closely linked to literature that relates survey expectations to mod-

[1]See Pesaran and Weale (2006) for an overview of studies testing the rationality of survey expectations.
[2]Mankiw and Reis (2010) provide a thorough survey of literature since the last decade.

els of imperfect information, that is, to both sticky and noisy information. Andrade and Le Bihan (2010) analyze individual forecasts provided by the European Survey of Professional Forecasters. They find evidence of inattentive forecasters with characteristics implied by these two classes of models. However, their proposed model comprising both characteristics fails to describe the underlying expectations formation process well. Coibion and Gorodnichenko (2012) report informational rigidities in SPF and Consensus Economics forecasts that point to noisy-information models rather than models based on sticky information. Also focusing on professional forecasters, Dovern et al. (2013) document a higher degree of information rigidity for the consensus forecast than for individual forecasts. They infer from the individual updating frequencies that results are more in accordance with noisy-information models.

We contribute to this literature by testing whether inflation expectations can be characterized by sticky or noisy information. In addition, we address the more recent question of whether information updating is state-dependent. In that sense, Coibion and Gorodnichenko (2012) find that professional forecasters exhibit a state-dependent updating behavior in response to changes in macroeconomic volatility and large shocks such as recessions and the 9/11 attacks. Business cycle conditions are also shown to be an important trigger of aggregate and individual revisions of professional forecasts (Loungani et al., 2011; Dovern, 2013). Lamla and Sarferaz (2012) and Dräger and Lamla (2013) provide evidence on inflation-related news effects that drive the updating behavior of consumers' inflation expectations. An important feature of the present study is that it relies on a cross-country panel dataset which explicitly allows testing for state-dependence in inflation expectations. Besides their inflation forecast, WES experts also indicate how strong they rate inflation as a potential economic problem. We are therefore able to investigate whether different "states" concerning the importance of inflation influence the degree of information rigidity.

Our findings can be summarized in the following way. First, we find evidence of informational rigidities in inflation forecasts with WES experts updating their information set every three to four months. However, the degree of information rigidity crucially depends on the forecast horizon. Second, we document state-dependence in the process of forecasting inflation. When the majority of WES experts term inflation a major problem, the implied degree of information rigidity is smaller. That is, forecasters are more attentive when inflation concerns are prevailing. The same implication is obtained when expected trend inflation or past inflation is above a certain threshold. These empirical findings are supportive of models with noisy information (Woodford, 2001; Sims, 2003; Maćkowiak and Wiederholt, 2009) and state-dependent updating of information (Gorodnichenko, 2008; Woodford, 2009).

The remainder of this study is as follows. Section 2 illustrates models of imperfect information and the related test for informational rigidities. Section 3 describes the WES dataset and presents descriptive statistics. Our findings concerning the test for informational rigidities using WES inflation forecasts are reported in section 4. Consequently, we discuss the results of testing for state-dependence in the forecasting process in section 5. Section 6 provides conclusions.

2 Models of imperfect information

There is a large amount of empirical evidence that full-information rational expectations are not always given in practice.[3] Recent macroeconomic theory incorporates imperfect information in the modeling of the expectations formation process. Two key models are based on either sticky information (Mankiw and Reis, 2002) or noisy information (Sims, 2003).[4] Coibion and Gorodnichenko (2012) show that these two approaches have common implications concerning the implied degree of information rigidity and propose a test for the presence of informational rigidities. In the following, we present a short description of their test and the underlying models of imperfect information.[5]

In the sticky-information model, forecasters have rational expectations, yet they are inattentive and do not update their information set every period (Mankiw and Reis, 2002; Reis, 2006). Assuming that in each period only a fraction $(1-\lambda)$ of forecasters acquire new information, the average forecast F_t can therefore be expressed as a weighted average of the contemporaneous rational expectations forecast and the previous period's average forecast:

$$F_t \pi_{t+h} = (1-\lambda)(\pi_{t+h} + u_{t+h,t}) + \lambda F_{t-1} \pi_{t+h}, \tag{1}$$

where h denotes the forecast horizon and $u_{t+h,t}$ is a combination of shocks that take place from t to $t+h$ representing the rational expectations error. Based on equation (1),

[3]Concerning fixed-event forecasts, see, for example, evidence by Nordhaus (1987), Clements (1997), Isiklar et al. (2006), Clements et al. (2007), Ager et al. (2009), and Dovern and Weisser (2011).

[4]Mankiw and Reis (2010) also refer to these two types of models as the delayed and partial information model, respectively.

[5]See Coibion and Gorodnichenko (2012) for details and extensions of more general or specific cases.

the average ex-post forecast error is a function of the average forecast revision:

$$\pi_{t+h} - F_t\pi_{t+h} = \frac{\lambda}{(1-\lambda)}\left(F_t\pi_{t+h} - F_{t-1}\pi_{t+h}\right) + u_{t+h,t}, \tag{2}$$

where the effect of the forecast revision on the forecast error is directly related to the underlying degree of information rigidity λ. Subsequently, one can infer the average number of periods between information updates by the formula $1/(1-\lambda)$. Two implications arise from the sticky-information model. First, with $\lambda = 0$, forecasters have perfect information. Second, λ is a constant value which should hold irrespective of the forecast horizon.

A counterpart to the sticky-information model is based on the assumption of noisy information (Woodford, 2001; Sims, 2003). Within this framework, forecasters permanently observe inflation, but only obtain a noisy signal rather than full information about the true state of inflation. Let each forecaster i receive an individual signal of inflation:

$$s_{i,t} = \pi_t + \omega_{i,t}, \tag{3}$$

where $\omega_{i,t} \sim$ i.i.d. $N(0, \Sigma_\omega)$ is the individual noise of the signal. The forecasters solve this signal extraction problem by means of the Kalman filter:

$$F_{i,t}\pi_t = G\left(\pi_t + \omega_{i,t}\right) + (1-G)F_{i,t-1}\pi_t, \tag{4}$$

where $G \in (0,1)$ is the Kalman gain reflecting the relative weight on new information. Averaging over forecasters and iterating the expectations forward, the average ex-post forecast error can be expressed as:

$$\pi_{t+h} - F_t\pi_{t+h} = \frac{1-G}{G}\left(F_t\pi_{t+h} - F_{t-1}\pi_{t+h}\right) + u_{t+h,t}, \tag{5}$$

where the degree of information rigidity is now defined by $(1-G)$. In contrast to the sticky-information model, the extent to which new information is incorporated in the noisy-information model depends on the precision of the forecaster's underlying signal $s_{i,t}$. As pointed out by Coibion and Gorodnichenko (2012), the degree of information rigidity might differ with the strength of the signal and, thus, across forecast horizons.[6]

Although equation (2) of the sticky-information model and equation (5) of the noisy-

[6]Similarly, the Kalman gain in the noisy-information model is also determined by the persistence of the underlying times series and might consequently differ across macroeconomic variables.

information model are based on a different microfoundation, both have the same implication: in the presence of informational rigidities, the average ex-post forecast error is predictable by means of the average ex-ante forecast revision. Within a regression framework, Coibion and Gorodnichenko (2012) propose to test for informational rigidities in survey expectations by regressing the average forecast error on the preceding average forecast revision. The null of the test states that forecasters have full-information rational expectations.

3 The WES data

We analyze inflation forecasts provided by the CESifo World Economic Survey (WES). This survey is conducted jointly by the Ifo Institute in Munich and the International Chamber of Commerce (ICC) in Paris. National experts assess the general economic situation and indicate their expectations with respect to macroeconomic indicators of their country. As of October 2012, the WES comprises about 1,200 respondents in 124 countries. Economic experts are from different institutions such as international corporations, banks and insurance companies, academic and economic research institutes as well as chambers of commerce, embassies, and international organizations.[7]

The WES is carried out on a quarterly basis during January, April, July, and October of each year. Thereby, an emphasis is placed on the experts' qualitative expectations about key macroeconomic variables. In the present study, we analyze inflation forecasts based on the single quantitative question provided by the WES on a quarterly basis. Since 1996:Q1, participants are asked each quarter of a year:[8]

Question 4b:	The rate of inflation on average of this year will be	_______% (p.a.)

This question reflects short-term inflation expectations related to a fixed event where the forecast horizon h declines subsequently with each quarter from $h = 4$ in January to $h = 1$ in October of a given year.

Our sample comprises high-income countries classified according to the World Bank's annual World Development Report. We restrict our sample to countries with inflation

[7] See Stangl (2007) for a detailed description of the WES data.

[8] Before that time, the WES included a question on six-months-ahead inflation since 1990:Q3. However, the wording of this question changed a few times before 1996. See table A.1 in the appendix for a detailed description of the survey question on the inflation rate.

forecasts consistently available for the period 1996:Q1-2012:Q4 and with at least four forecasters per period, although the number of country experts has generally risen towards the end of the sample. Our final dataset consists of inflation forecasts for 16 high-income economies. Throughout our analysis, we consider the median inflation forecast as this measure is more robust to outliers than the mean.

Table 1 presents summary statistics of the WES inflation forecasts and realized inflation. Annual CPI inflation was obtained from the OECD database. For the UK, the inflation rate of the Retail Price Index provided by the UK Office for National Statistics was taken as the realized target variable until 2004:Q4 since this data is more closely related to the forecast series (see figure A.1 in the appendix).[9] Note that all countries in our panel are (de facto) inflation targeters.[10] On average, there are 19 inflation forecasts per country and per period available. The number of forecasts varies between 10 (Australia and New Zealand) and 51 forecasts (Germany). The cross-country average of actual inflation is less than 2% and reflects the low inflation rates of these high-income countries during the most recent two decades. The average forecast error is defined as realized inflation minus the median forecast and is negative in most countries. This suggests that forecasters have generally overestimated inflation. Yet, the magnitude of the average forecast error is below 0.2 percentage points in the majority of countries and is thus rather small. The average Root Mean Squared Error (RMSE) is reported in the last two columns of table 1. At the 4-quarter horizon, the smallest RMSE is found in the Netherlands (0.42) whereas the highest value is present for Sweden (1.17). Unsurprisingly, the RMSE declines with a reduction in the forecast horizon when more and more information about the target variable is revealed.

[9] In the present study, we do not use real-time data on CPI inflation. However, the CPI is generally subject to fewer and smaller revisions than real variables such as GDP growth (see, for instance, Giannone et al., 2012, for evidence on the euro area, Japan, and the US).

[10] Since early 2012, the US and Japan have also been communicating an official inflation target.

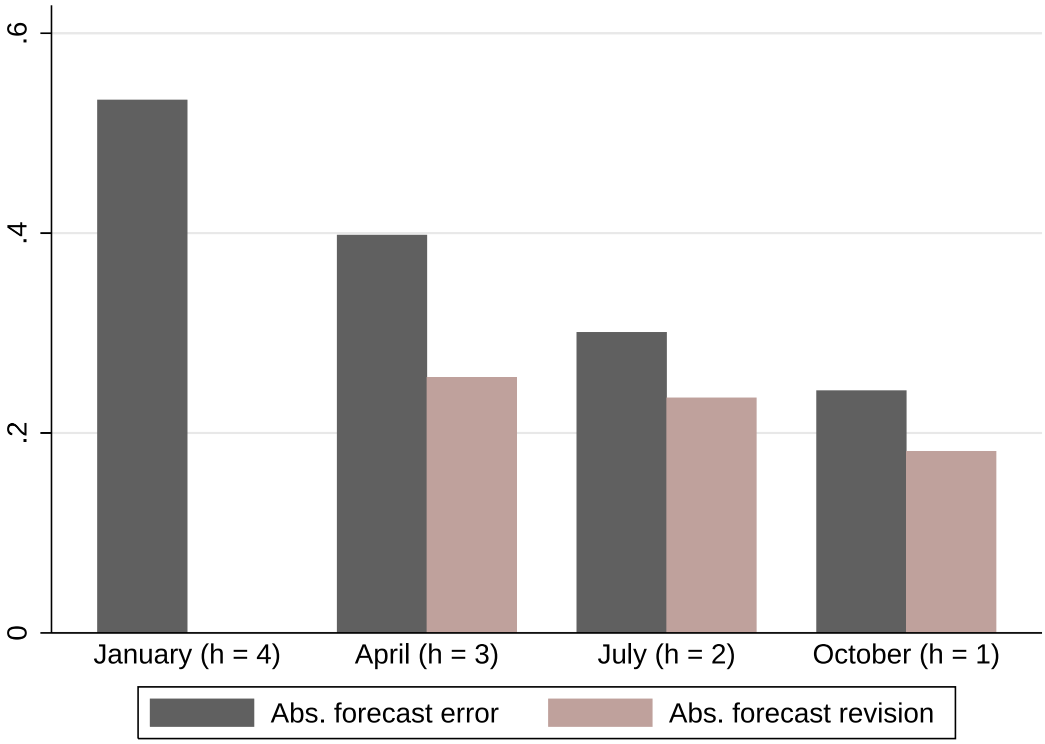
Table 1: Summary statistics of WES inflation forecasts and actual inflation

Country	Avg. # fore-casters	Avg. forecast (median)	Avg. actual inflation	Avg. forecast error	Avg. RMSE ($h = 4$)	Avg. RMSE ($h = 1$)
Australia	10	2.9	2.6	−0.24	0.91	0.55
Austria	12	1.8	1.9	0.06	0.73	0.17
Belgium	14	2.0	2.1	0.07	0.75	0.22
Canada	11	2.0	2.0	−0.08	0.48	0.28
Finland	17	1.8	1.7	−0.13	0.82	0.28
France	16	1.7	1.6	−0.12	0.57	0.24
Germany	51	1.7	1.5	−0.16	0.45	0.28
Italy	21	2.3	2.3	−0.01	0.61	0.17
Japan	30	0.1	-0.1	−0.16	0.54	0.30
Netherlands	15	2.2	2.1	−0.05	0.42	0.22
New Zealand	10	2.5	2.3	−0.17	0.69	0.58
Spain	23	2.7	2.7	0.02	0.76	0.24
Sweden	14	1.7	1.2	−0.44	1.17	0.55
Switzerland	14	1.0	0.7	−0.26	0.66	0.20
United Kingdom	17	2.6	2.7	0.13	0.63	0.37
United States	25	2.5	2.4	−0.05	0.69	0.57
Average	19	2.0	1.9	−0.10	0.68	0.33

Note: Sample averages refer to the period 1996:Q1-2012:Q4.

Figure 1 shows the size of forecast errors and revisions by different forecast horizons. On average, the absolute forecast error is the highest in the January survey of a target year and declines with the forecast horizon. With $h = 1$, the size of the forecast error has more than halved. As the calculation of forecast revisions requires one preceding forecast, the first revision is available in April of a target year. The size of forecast revisions exhibits a similar downward trend across horizons, although the difference between subsequent quarters is smaller.

Figure 1: Size of forecast errors and revisions by forecast horizons



The WES also polls the experts' opinion on prevailing economic problems in their country. The wording of the question is:

Question 9: Please try to assess the **importance** of the following **problems** the economy of your country is facing **at present:**

	most important	important	not so important
- Lack of confidence in the government's economic policy	☐	☐	☐
- Insufficient demand	☐	☐	☐
- Unemployment	☐	☐	☐
- Inflation	☐	☐	☐
- Lack of international competitiveness	☐	☐	☐
- Trade barriers to exports	☐	☐	☐
- Lack of skilled labour	☐	☐	☐
- Public deficits	☐	☐	☐
- Foreign debts	☐	☐	☐
- Capital shortage	☐	☐	☐

To this date, the question concerning current economic problems is posed bi-annually in the WES questionnaire (April and October of a given year). It provides three qualitative answers: "most important", "important", and "not so important". At the country level, the qualitative answers can be summarized by averaging across experts where the answers "most important" receive a value of 1, "important" a value of 0 and "not so important" a value of -1. If the resulting balance statistic lies within the range 0 to 1, the majority of experts evaluate a particular economic problem as being highly important. In contrast, a balance statistic within the range of -1 to 0 suggests that the economic problem is predominantly assessed as being of minor importance. On average, each economic problem was evaluated by 20 respondents, which is similar to the average number of inflation forecasts.[11] Overall, the qualitative question on economic problems allows for the identification of periods where inflation concerns are prevailing.

[11] See appendix A.1 for a detailed description of the WES question on economic problems. Summary statistics of the number of respondents are reported in table A.3 in the appendix.

4 Testing the inflation expectations process of WES forecasters

We examine the process of WES inflation expectations by applying the framework by Coibion and Gorodnichenko (2012). To test for the presence of informational rigidities, we estimate the following equation:

$$\pi_{i,t+h} - F_t\pi_{i,t+h} = \beta_0 + \beta_1 \Delta F_t \pi_{i,t+h} + \nu_{i,h,t}, \tag{6}$$

where i denotes the country index, h is the forecast horizon, and $\nu_{i,h,t}$ represents the rational expectations error. The forecast revision $\Delta F_t\pi_{i,t+h}$ is the difference between two subsequent forecasts of current-year inflation $(F_t\pi_{i,t+h} - F_{t-1}\pi_{i,t+h})$. In the presence of informational rigidities, β_1 is expected to be significantly positive. One advantage arises when using WES data for the above test. The forecasts of the WES economic experts are published only at the aggregate country level. Consequently, their forecast revisions should not be strategical as in the case of professional forecasters who might have reputational or contest objectives (Marinovic et al., 2013). As WES participants are anonymous, the estimate of β_1 should fully reflect the underlying degree of information rigidity.

The relationship between the forecast error and forecast revision is derived by averaging across agents and might not hold when using individual data. This is why we perform the analysis at the aggregate country level. In total, we have 17 forecast events related to annual average inflation for the period 1996-2012. Due to this short time dimension, we apply a fixed-effects panel estimator. Provided that CPI inflation is to a large extent driven by energy and commodity prices and therefore includes a global component, it is reasonable to assume that forecast errors and revisions are possibly correlated across countries. This might, in turn, violate the central assumption of the fixed-effects model that innovations are cross-sectionally independent. Table 2 shows the Pesaran (2004) Cross-section Dependence (CD) test statistic. The hypothesis that residuals of the fixed-effects model are uncorrelated across countries can be rejected at all conventional significance levels. The average absolute correlation between the innovations amounts to 0.30 at the longest forecast horizon $h = 3$. Therefore, we estimate the fixed-effects model with Driscoll and Kraay (1998) standard errors which are robust to cross-sectional correlation across countries as well as to heteroskedasticity and autocorrelation.[12]

Table 2: Testing for cross-sectional independence

	All	Separate horizons		
	$h = 1, 2, 3$	$h = 1$ (Oct.)	$h = 2$ (July)	$h = 3$ (April)
Pesaran's CD test statistic	15.10***	4.73***	5.32***	9.10***
Average abs. correlation of residuals	0.25	0.25	0.23	0.30

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Based on a fixed effects (within) estimation of the following model: $\pi_{i,t+h} - F_t\pi_{i,t+h} = \beta_0 + \beta_1 \Delta F_t \pi_{i,t+h} + \nu_{i,h,t}$.

The regression results of the test for informational rigidities are reported in table 3. Concerning equation (6), the coefficient on the forecast revision is $\hat{\beta}_1 = 0.12$ when pooling across forecast horizons. According to the sticky-information model, the degree of information rigidity is $\lambda = \frac{\beta_1}{1+\beta_1} = 0.11$. Hence, the average number of periods between information updates is $\frac{1}{(1-\lambda)} = 1.12$, implying that forecasters acquire new information approximately every quarter. In the context of the noisy-information model, this signifies a weight $G = 0.89$ on new information relative to the previous forecast. Turning to the separate forecast horizons, results differ considerably. At horizons 1 and 2, we do not find evidence of information rigidity as the coefficient on the forecast revision is insignificant. That is, the null of full-information rational expectation cannot be rejected at very short forecast horizons. In contrast, at $h = 3$, the estimated coefficient is 0.40 and statistically different from zero at the 1% significance level. This suggests information updating every four months (1.4 quarters) in the sticky-information model or a weight of 0.7 on new information relative to the previous period's forecast in the noisy-information set-up.[13]

[12]Estimation is based on the Stata modules `xtcsd` by De Hoyos and Sarafidis (2006) and `xtscc` by Hoechle (2006). For all following regression models in the present study, outliers were identified and removed according to Cook's distance to obtain more precise estimates. Including the outliers does not change the results in a qualitative way.

[13]Following Coibion and Gorodnichenko (2012), we split the forecast revision in equation (6) into the present and lagged forecast and tested whether both coefficients are of equal magnitude. Again, results are consistent with predictions from the sticky- or noisy-information model only at $h = 3$.

Taken together, the message from table 3 is twofold. First, we find evidence of a moderate degree of information rigidity in inflation forecasts of three to four months. This updating frequency is higher than found by Coibion and Gorodnichenko (2012) for the US (six to seven months). However, the authors report a smaller degree of information rigidity when using cross-country data and notably when results are solely based on Consensus Economics inflation forecasts. Moreover, evidence on micro price changes also suggests an average updating frequency of about 4 months (Klenow and Malin, 2010).

Second, we find that the degree of information rigidity in WES inflation forecasts differs across forecast horizons. As laid out in section 2, this is in contrast to the prediction of the sticky-information model where λ should hold irrespective of the time distance to the forecasting variable. Divergent results across forecast horizons are rather supportive of noisy-information models. Since WES experts forecast the annual average rate of inflation, they have little information available at the January survey of a given year. With the end of the target year approaching, they obtain increasingly more information to predict annual average inflation. In the context of the noisy-information model, this implies that the forecasters' signal about the true state of annual average inflation is revealed more precisely with each subsequent quarter of a target year. Conversely, the degree of information rigidity increases with the forecast horizon of a target year. This feature of noisy-information models is reflected by WES forecasts. A higher degree of information rigidity at longer forecast horizons is also documented for Consensus Economics survey data which consists in year-on-year growth rates or annual average growth rates (Coibion and Gorodnichenko, 2012; Loungani et al., 2011).

In general, our sample period is characterized by lower macroeconomic volatility in light of the "Great Moderation" and by the introduction of inflation targeting practices in most countries. Therefore, it is also of interest to see whether the degree of information rigidity was rather stable or changing during the period 1996-2012. Recent contributions emphasize that the degree of inattention in inflation expectations is time-varying (Coibion and Gorodnichenko, 2012; Lamla and Sarferaz, 2012; Dräger and Lamla, 2012). We follow the former and estimate equation (6) for each point in time by Pooled Ordinary Least Squares. The smoothed coefficient $\beta_{1,t}$ is shown in figure 2. Evidently, the underlying degree of information rigidity is not constant over time. The coefficient on the forecast revision is on average higher during the first half of the sample with a significant increase during the mid-2000s. It exhibits a sharp significant drop during the recent Global Financial Crisis. Note that our estimation is based on a rather

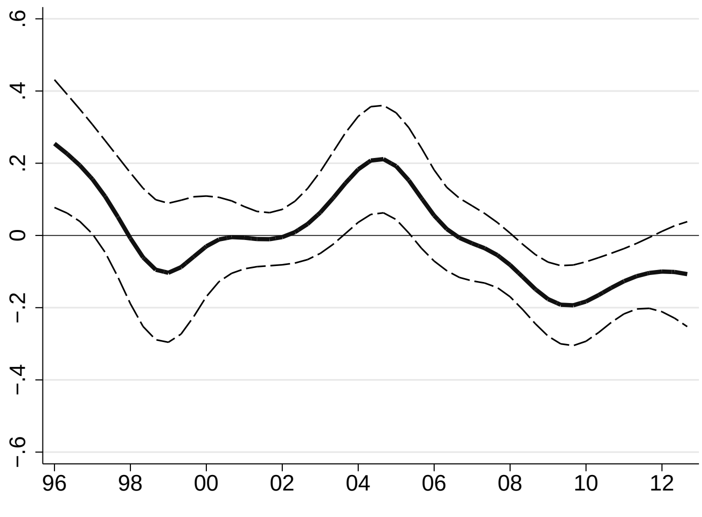
Table 3: Testing for the presence of informational rigidities

	All	Separate horizons		
Dependent variable: $\pi_{t+h} - F_t\pi_{t+h}$	$h = 1, 2, 3$	$h = 1$ (Oct.)	$h = 2$ (July)	$h = 3$ (April)
$\Delta F_t \pi_{t+h}$	0.12**	−0.10	0.05	0.40***
	(0.06)	(0.06)	(0.07)	(0.11)
R-squared	0.18	0.30	0.19	0.20
# observations	768	260	260	256

Driscoll-Kraay standard errors in parentheses. Each specification includes country-fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

small sample resulting in a higher parameter uncertainty. Nevertheless, figure 2 suggests that there are changes in the underlying degree of information rigidity. Notably, the extent to which forecasters are inattentive might change with the economic stance.

Figure 2: Time-varying estimate of information rigidity



Note: The figure shows the coefficient on the forecast revision based on a Gaussian kernel smoother with a bandwidth of three quarters (solid line) together with ±1 standard error (dashed lines).

5 Testing for state-dependence in inflation expectations

The previous section showed that the degree of information rigidity in WES inflation forecasts varies over time. In the context of imperfect information models, it can be optimal for agents to be inattentive given lower macroeconomic volatility or to focus more on idiosyncratic rather than aggregate conditions (Sims, 2003; Branch et al., 2009; Maćkowiak and Wiederholt, 2009). Likewise, recent contributions combine state-dependent characteristics of updating or pricing behavior with informational rigidities (Gorodnichenko, 2008; Knotek, 2010; Woodford, 2009).[14] In this section, we analyze whether the degree of information rigidity in inflation forecasts is endogenously determined by the extent to which inflation might be perceived as being problematic. We consider two approaches. First, we investigate whether the degree of information rigidity varies when the economic problem "inflation" is assessed as being highly important by WES experts. Second, we analyze in this vein whether forecasters are more attentive when realized inflation is above a certain threshold. In our application, both approaches suggest that the process of inflation expectations formation is state-dependent.

5.1 Subjective assessment of the economic problem "inflation"

The WES asks participants to evaluate the importance of a given choice of economic problems. Consequently, we are able to investigate whether different "states" of the importance assigned to inflation influence the expectations formation process. Figure 3 shows the balance statistic of the problem "inflation" (left axis) together with annual average inflation (right axis). The balance statistic ranges between -1 and 1 whereas actual inflation is centered roughly around its mean value. The latter is not known before January of the following year whereas the last forecast is made in October of a given year. Although the balance statistic has predominantly remained negative, there are periods where inflation is termed a major problem. In these periods, the respective balance statistic is close to zero ("important") or even positive ("most important"). This increase in the balance statistic is generally accompanied by an increase in inflation. Both variables are strongly linked with a correlation coefficient of 0.66. That is, the balance statistic is a good predictor of whether annual average inflation will be (subjectively) high. An increase in the balance statistic can be observed in most countries during the early 2000s, the oil price hike in 2008 and in the aftermath of the Great Recession with a pickup of inflation rates in 2011. The lowest maximum balance statistic over

[14] See Mankiw and Reis (2010), chapter 7.1, for an overview of this strand of literature.

time is found in Japan (-0.32), which reflects the prolonged deflation era of this country. In Spain, experts generally assigned a high importance to inflation from the end of the 1990s onwards until 2008. During this period, Spain also experienced on average the highest inflation rate of all countries in our sample.

Alternatively, we can assess to which extent WES experts perceive inflation as being important in comparison to other economic problems mentioned in the questionnaire. To obtain a ranking, the balance statistics of the ten potential economic problems are sorted from the highest to lowest value for each country and period. Accordingly, a rank of 1 indicates the most important problem, and 10 the least important. Figure 4 displays the rank of the economic problem "inflation" over time. The co-movement with actual inflation is inverse to the previous figure. Peaks of annual average inflation generally coincide with a high ranking of the economic problem "inflation" and thus a low value of the rank. The ranking exhibits a strong negative correlation with actual inflation and the balance statistic shown in figure 3; the correlation coefficient is -0.55 and -0.82, respectively. Overall, the rank of the problem "inflation" is on average not ranked highest of the ten economic problems. This is similar to findings by Ehrmann and Tzamourani (2012) who document that respondents from the World Values Survey do not assign the highest importance to "fighting rising prices" from a given choice of policy priorities. Nevertheless, the ranking of the economic problem "inflation" presented here is far from being time-invariant, as it indicates periods with higher inflation concerns. Since the WES survey provides a direct measures of the (subjective) importance of inflation, we would expect that forecasters are more attentive during these periods.

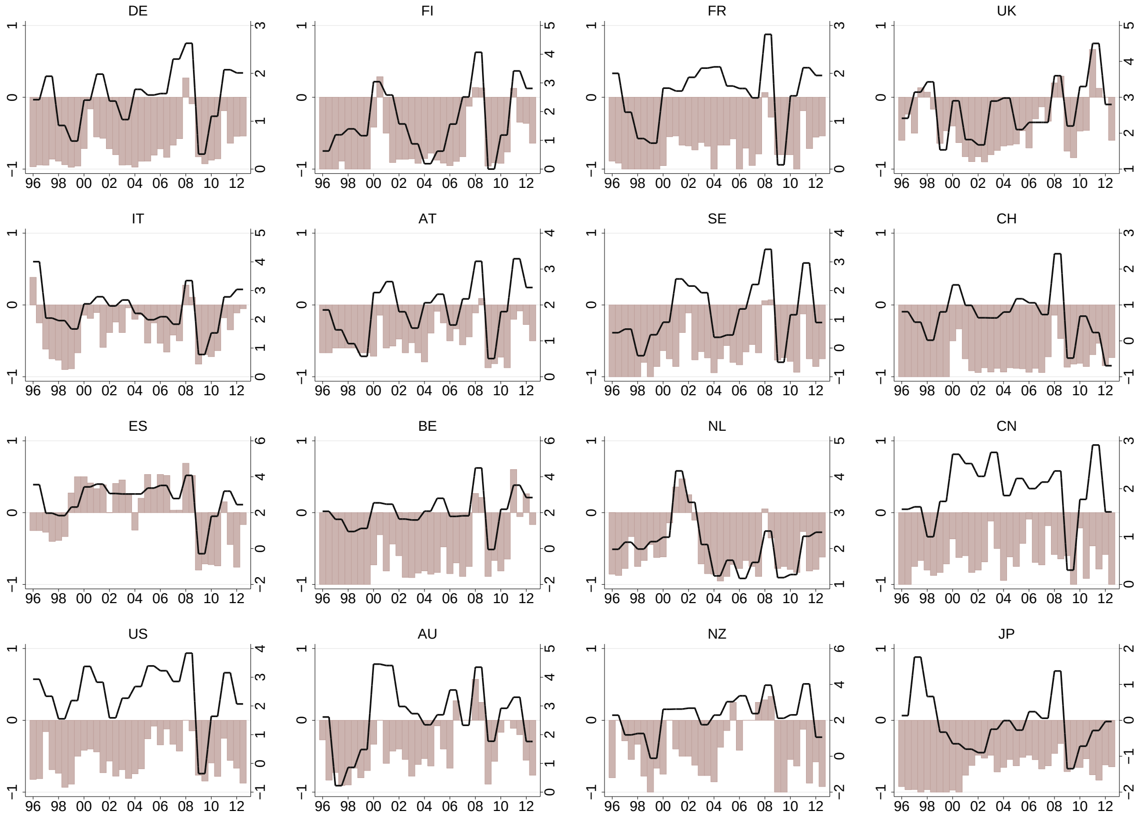
In the following, we test for state-dependence in WES inflation expectations by augmenting equation (6) with interaction variables referring to states when inflation is deemed an important economic problem. Since our regression results in section 4 revealed that informational rigidities are mainly prevailing at the longest forecast horizon, we perform the subsequent analysis at $h = 3$ only and estimate the following equation:[15]

$$\pi_{t+3} - F_t\pi_{t+3} = \beta_0 + \beta_1\Delta F_t\pi_{t+3} + \beta_2 D_t^{Pr.\pi} + \beta_3\Delta F_t\pi_{t+3} \times D_t^{Pr.\pi} + \nu_t, \qquad (7)$$

where $D_t^{Pr.\pi}$ is an indicator variable for periods when the economic problem "inflation" is predominantly assessed as being highly important. We consider three alternative indicators. First, the indicator $D_t^{Pr.\pi}$ equals one when the balance statistic of the problem

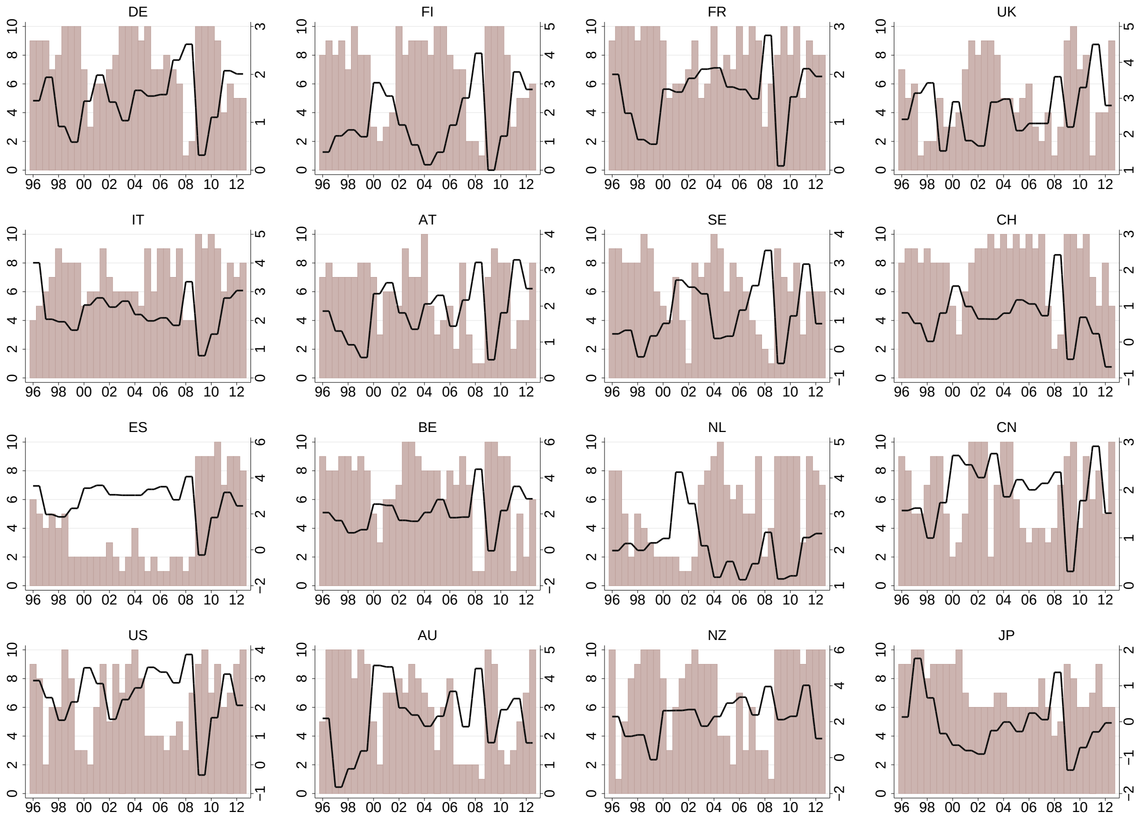
[15]To simplify the notation, we drop the country subscript from the subsequent equations.

Figure 3: Importance of the economic problem "inflation" and actual inflation



Note: This figure shows the WES balance statistic of the economic problem "inflation" (bar chart, left axis) together with annual average inflation (black line, right axis) of a respective year. In calculating the balance statistic, answers indicating "most important" receive a value of 1, "important" a value of 0 and "not so important" a value of -1.

Figure 4: Rank of the economic problem "inflation" and actual inflation



Note: This figure shows the WES ranking of the economic problem "inflation" (bar chart, left axis) together with annual average inflation (solid line, right axis) of a respective year. The rank is ranging from 1 (highest value of the balance statistic out of 10 given economic problems) to 10 (lowest value).

"inflation" is positive; otherwise, the indicator equals zero. Second, we consider an alternative balance statistic where both the answers "most important" and "important" receive a value of 1 and "not so important" a value of 0. Based on this alternative balance statistic, we then define a continuous indicator $D_t^{Pr.\pi}$ which varies between 0 and 1. Third, we focus on the rank of inflation among the ten possible economic problems. In particular, $D_t^{Pr.\pi}$ equals one when inflation is among the three most important economic problems during this period, and zero otherwise. In all cases, β_3 reflects the difference in the effect of the forecast revision (that is, the underlying degree of information rigidity) in periods of a subjective higher importance of inflation in contrast to periods where respondents attach minor importance to inflation. In case of FIRE, the sum of the coefficient on the forecast revision and the interaction with the indicator variable should equal zero.

Regression results are summarized in table 4. The first regression model is based on the indicator equal to one when the majority of experts evaluate the problem "inflation" as highly important. The coefficient on the interaction term between the indicator variable and the forecast revision is significantly negative. Thus, the degree of information rigidity is lower when inflation concerns are prevailing. Regression (2) displays the specification based on the alternative balance statistic. We also find a significantly negative interaction term between the indicator variable and the forecast revision. When the fraction of experts indicating "most important" or "important" increases, the associated degree of information rigidity in inflation forecasts is lower. A similar result is obtained with regression (3). When inflation is among the top 3 economic problems as listed in the WES questionnaire, the degree of inattention declines. The Wald test on whether both coefficients related to the forecast revision add up to zero is displayed in the lower part of table 4. In regressions (2) and (3), we cannot reject the null hypothesis that forecasters have FIRE. In the case of regression (1), the null that β_1 and β_3 are equal in magnitude can be rejected at all conventional significance levels. Inasmuch as the estimated coefficient on the interaction term is absolutely larger than the coefficient on the forecast revision, this finding does not suggest a rejection of FIRE but rather overshooting expectations concerning future inflation (Coibion and Gorodnichenko, 2012). Note that the coefficient on all indicator variables is positive and significant at the 1% level. This implies that the forecast error is significantly different in periods of a higher importance of inflation. However, a constant term of a specific event is not informative about departures from FIRE. Rather, it indicates whether all forecasts made within this event have the same bias (Bakhshi et al., 2005). Here, in times of a higher importance of inflation, forecast errors generally have an upward bias. Taken together, the above findings point to state-dependence in the forecasting process with information being acquired and processed more quickly when inflation is regarded as being an important problem.

Table 4: Testing for state-dependence in inflation expectations given the importance of the economic problem "inflation"

Dependent variable: $\pi_{t+3} - F_t\pi_{t+3}$	$D_t^{Pr.\pi} = 1$ if balance statistic > 0 (1)	$D_t^{Pr.\pi} \in [0,1]$ (alt. balance statistic) (2)	$D_t^{Pr.\pi} = 1$ if rank $\leqslant 3$ (out of 10) (3)
$\Delta F_t\pi_{t+3}$	0.47***	0.44***	0.44***
	(0.09)	(0.08)	(0.08)
$D_t^{Pr.\pi}$	0.38***	0.57***	0.42***
	(0.12)	(0.16)	(0.10)
$\Delta F_t\pi_{t+3} \times D_t^{Pr.\pi}$	−0.67***	−0.55***	−0.56***
	(0.14)	(0.17)	(0.15)
p-value ($\beta_1 + \beta_3 = 0$)	0.00	0.39	0.32
R-squared	0.26	0.28	0.31
# observations	257	258	258

Driscoll-Kraay standard errors in parentheses. Each specification includes country-fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Likewise, large changes in the subjective importance of inflation might have an effect on the degree of information rigidity. To this end, we estimate the following model:

$$\pi_{t+3} - F_t\pi_{t+3} = \beta_0 + \beta_1 \Delta F_t\pi_{t+3} + \beta_2 D_t^{\Delta Pr.\pi} + \beta_3 \Delta F_t\pi_{t+3} \times D_t^{\Delta Pr.\pi} + \nu_t, \qquad (8)$$

where $D_t^{\Delta Pr.\pi}$ equals one in case of large changes in the balance statistic of the economic problem "inflation" and zero otherwise. Large changes are defined as being in the upper 90^{th} percentile of the non-negative distribution of changes and can be interpreted as "inflation surprises". Estimation results are reported in table 5. The indicator in regression (1) is based on changes in the balance statistic (which ranges between −1 and 1). The related interaction term with the forecast revision is significantly negative and larger in magnitude than the coefficient on the forecast revision. Once more, forecasters seem to have overshooting expectations; the null that both coefficients add up to zero is rejected at the 1% level. A significantly lower degree of information rigidity is also found when the analysis is based on the alternative balance statistic (ranging between 0 and 1). Here, we cannot reject the null that the coefficients are equal in absolute value. In both specifications, the intercept of the indicator variable is again significantly different from periods with no large changes in the importance of inflation. Our findings suggest that information updating speeds up when inflation has gained a lot of importance. This confirms a state-dependent updating of inflation expectations.

Table 5: Testing for state-dependence in inflation expectations given changes in the importance of the economic problem "inflation"

Dependent variable: $\pi_{t+3} - F_t\pi_{t+3}$	Change in balance stat. of problem "inflation" (1)	Change in alt. balance stat. of problem "inflation" (2)
$\Delta F_t\pi_{t+3}$	0.37***	0.38***
	(0.11)	(0.11)
$D_t^{\Delta Pr.\pi}$	0.55***	0.42*
	(0.12)	(0.21)
$\Delta F_t\pi_{t+3} \times D_t^{\Delta Pr.\pi}$	−0.85***	−0.72**
	(0.13)	(0.27)
p-value ($\beta_1 + \beta_3 = 0$)	0.00	0.22
R-squared	0.22	0.20
# observations	242	243

Driscoll-Kraay standard errors in parentheses. Each specification includes country-fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.2 Level of expected trend inflation and past inflation

As documented in the previous section, forecasters are on average more attentive when they term inflation an important economic problem. In a similar vein, we would expect a lower degree of information rigidity when the level of inflation is high. Most countries in our sample have adopted an inflation targeting framework or central elements of inflation targeting policies with generally an announced band of inflation within the range 1-3% (Roger, 2010). This raises the question of whether the degree of inattention changes when inflation is higher than the announced target. For this purpose, we define high-inflation states by means of two alternative measures. First, we derive a measure of trend inflation from an Unobserved Components-Stochastic Volatility (UC-SV) model. The estimation is performed recursively with data from 1991:Q1 onwards through each forecast quarter t. This yields a one-sided estimate of the trend component of inflation, which can be seen as a measure of long-term inflation expectations (Stock and Watson, 2010). Second, we also compare past levels of the annualized quarterly rate of inflation.[16] Since the WES is queried within January, April, July, and October of a given year, we assume that the previous quarter's (trend) inflation is in the information set of WES experts.

As before, we test for state-dependence by augmenting equation (6) with indicator variables for high-inflation (HI) states:

$$\pi_{t+3} - F_t\pi_{t+3} = \beta_0 + \beta_1 \Delta F_t \pi_{t+3} + \beta_2 D_t^{HI} + \beta_3 \Delta F_t \pi_{t+3} \times D_t^{HI} + \nu_t, \quad (9)$$

where D_t^{HI} equals one during periods when (trend) inflation is above a certain threshold value and zero otherwise.

Table 6 reports the regression results concerning different threshold values of inflation. Regressions (1) to (3) are based on trend inflation. Whenever our measure of trend inflation is above a threshold of 2.5 percentage points, the implied degree of information rigidity is significantly smaller. This effect is amplified when the threshold value is set to 3 percentage points or to the 90th percentile of the distribution of inflation rates, as indicated by the increasing magnitude of the coefficient on the interaction term. In all cases, we cannot reject the null that the sum of coefficients is zero. Regressions (4) to (6) are related to the annualized quarterly rate of inflation. When the value of past inflation is above 2.5 percentage points, we do not document a significant change in the expectations formation process. In contrast, there is a significant decrease in the underlying degree of information rigidity for states with inflation above a value of 3 percentage points or within the 90th percentile. Concerning the Wald test displayed in the lower part of table 6, there is again evidence of FIRE or overshooting expectations. The results based on threshold values of expected trend inflation and past inflation emphasize our previous findings that state-dependence is inherent in the process of inflation expectations formation.

[16] See appendix A.4 for a description of inflation data and the estimation of the UC-SV model.

Table 6: Testing for state-dependence in inflation expectations given the level of actual inflation

Dependent variable: $\pi_{t+3} - F_t\pi_{t+3}$	$D_t^{HI} = 1$ if			$D_t^{HI} = 1$ if		
	Trend inflation > 2.5 (1)	Trend inflation > 3 (2)	Trend inflation $\in 90^{th}$ percentile (3)	QoQ inflation > 2.5 (4)	QoQ inflation > 3 (5)	QoQ inflation $\in 90^{th}$ percentile (6)
$\Delta F_t\pi_{t+3}$	0.48***	0.48***	0.49***	0.30*	0.41***	0.46***
	(0.09)	(0.07)	(0.08)	(0.14)	(0.09)	(0.09)
D_t^{HI}	0.39***	0.30***	0.25**	0.41***	0.42***	0.59***
	(0.07)	(0.08)	(0.11)	(0.09)	(0.10)	(0.18)
$\Delta F_t\pi_{t+3} \times D_t^{HI}$	−0.44***	−0.63***	−0.66***	−0.31	−0.62***	−0.96***
	(0.10)	(0.19)	(0.12)	(0.19)	(0.15)	(0.24)
p-value ($\beta_1 + \beta_3 = 0$)	0.80	0.43	0.18	0.91	0.12	0.03
R-squared	0.30	0.28	0.26	0.30	0.30	0.29
# observations	255	256	256	258	259	258

Driscoll-Kraay standard errors in parentheses. Each specification includes country-fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6 Concluding remarks

The focus of this paper was to analyze inflation expectations in high-income countries. Specifically, we assess the degree of information rigidity in inflation forecasts following an approach by Coibion and Gorodnichenko (2012). Their test is directly based on models of imperfect information and therefore allows to quantify the extent and sources of informational rigidities. We apply their approach to a unique dataset provided by the CESifo World Economic Survey. Our sample comprises inflation forecasts for 16 high-income countries from 1996 to 2012. Since WES participants are also asked to evaluate the importance of the economic problem "inflation", we can identify periods where inflation concerns among respondents are prevailing. Consequently, we analyze to what extent the level and changes in the importance assigned to inflation influence the underlying expectations formation process.

Our main results can be summarized as follows. First, we provide evidence of information rigidity with WES experts updating their information set every three to four months. However, the degree of information rigidity crucially depends on the forecast horizon. Second, we document state-dependence in the process of forecasting inflation. When the majority of WES experts assess inflation as being an important economic problem, the implied degree of information rigidity is lower. We actually find that forecasters can be characterized by having full-information rational expectations during periods of higher inflation concerns. This conclusion seems robust when considering the level of expected trend inflation and past inflation. Whenever the value of (trend) inflation is above a critical threshold, forecasters are on average more attentive.

For economic modeling, two implications arise from our empirical findings. Since the degree of information rigidity varies across forecast horizons, this validates noisy-information models (Woodford, 2001; Sims, 2003; Maćkowiak and Wiederholt, 2009) rather than sticky-information models which assume a constant updating frequency. A more prominent role of noisy information in the expectations formation process of forecasters is also consistent with findings by Coibion and Gorodnichenko (2012) and Dovern et al. (2013). Moreover, we document that WES experts seem to be more attentive when they judge inflation to be a major economic problem. This finding suggests a state-dependent rule of information updating, as recently addressed in theoretical models by Gorodnichenko (2008) and Woodford (2009).

Appendix

A.1 Wording of WES questions

Table A.1: Wording of WES question on inflation rate

from 07/1990 to 04/1991 (except in 10/1990)
The rate of inflation will be: ____%*
from 07/1991 to 07/1994 and in 04/1995
The rate of inflation by the end of the next 6 months will be: ____% (p.a.)
from 10/1994 to present (except in 04/1995)
The rate of inflation on average of this year will be: ____% (p.a.)**

* Expected tendency of consumer prices within the next 6 to 12 months.
** The remark "(compared to average of previous year)" was used from 10/1994 to 10/1998, in 10/1999 and 10/2000. The number of the year was used instead of "this year" in every January survey of each year from 2002 onwards, as well as in all 2004 surveys, 10/2005, 07/2006, 10/2006, and from 07/2011 onwards.

Table A.2: Wording of WES question on economic problems

from 03/1983 to 04/1991

The most important problems for the economy in this country are at present:

- Inflation	☐

from 07/1991 to 10/2003

Please try to assess the **importance** of the following **problems** the economy of your country is facing **at present:**

	most important	also very important	not so important/ not relevant*
- Inflation	☐	☐	☐

from 04/2004 to present

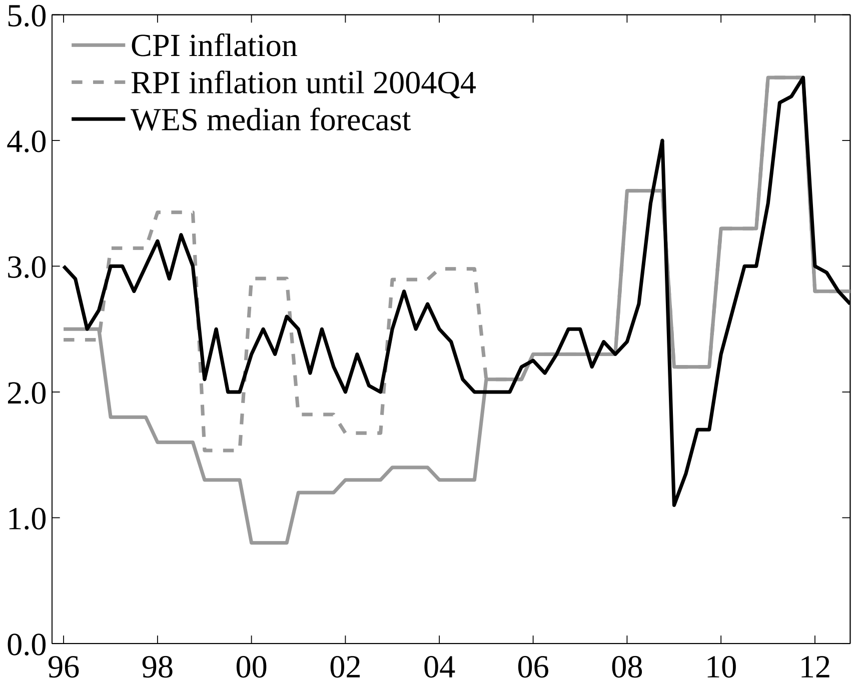
Please try to assess the **importance** of the following **problems** the economy of your country is facing **at present:**

	most important	important	not so important
- Inflation	☐	☐	☐

* The word "so" was omitted in 04/1998 and 07/1998; "not relevant" was omitted in 04/2002, 10/2002, and 10/2003.
In 04/2003, "very important" was used instead of "most important" and "important" was used instead of "also very important".
The questions were included in the WES with a periodicity as follows. In 1983: March, August. From 1984 to 1988: March, June, October. From 1989 to 01/2002: January, April, July, October. From 04/2002 to present: April, October.

A.2 Comparison of WES forecasts to CPI and RPI inflation for the UK

Figure A.1: Comparison of WES forecasts to CPI and RPI inflation for the UK



A.3 Descriptive statistics on economic problems

Table A.3: Average number of assessments per economic problem

Country	**Pr. 01**	**Pr. 02**	**Pr. 03**	**Pr. 04**	**Pr. 05**	**Pr. 06**	**Pr. 07**	**Pr. 08**	**Pr. 09**	**Pr. 10**
Australia	10	10	10	10	10	10	10	10	10	10
Austria	13	13	14	14	14	14	14	14	14	14
Belgium	15	15	16	16	16	16	16	16	16	15
Canada	11	11	11	12	11	11	12	11	11	11
Finland	19	19	19	19	19	19	19	19	19	19
France	18	18	18	18	18	18	18	18	18	18
Germany	54	53	54	54	54	54	54	54	54	53
Italy	23	23	23	23	23	23	23	23	23	23
Japan	32	32	32	32	32	32	32	32	32	31
Netherlands	16	16	16	16	15	15	16	16	16	15
New Zealand	10	10	10	10	10	11	10	10	10	10
Spain	25	25	25	25	25	25	25	25	25	24
Sweden	15	15	15	15	15	15	15	15	15	14
Switzerland	13	14	13	13	13	13	14	13	13	13
United Kingdom	18	18	18	18	18	18	18	18	18	18
United States	29	29	29	29	29	29	29	29	29	29
Average	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**

Note: Sample average is referring to questionnaires conducted in April and October of a respective year (1996:Q2-2012:Q4). Legend: Pr. 01: Lack of confidence in the government's economic policy. Pr. 02: Insufficient demand. Pr. 03: Unemployment. Pr. 04: Inflation. Pr. 05: Lack of international competitiveness. Pr. 06: Trade barriers to exports. Pr. 07: Lack of skilled labour. Pr. 08: Public deficits. Pr. 09: Foreign debts. Pr. 10: Capital shortage.

A.4 Description of inflation data and the UC-SV model

Inflation is measured as the annualized quarterly percent change in the Consumer Price Index (CPI) defined by $400 \times \log(CPI_t/CPI_{t-1})$. For the UK, the inflation rate of the Retail Price Index is taken until 2004:Q4 and the inflation rate of the CPI thereafter. All inflation series are seasonally adjusted. Moreover, we tracked and replaced outliers in the data beforehand as reported in table A.4. Thereby, we detect observations that deviate more than four times the interquartile range from the median (Stock and Watson, 2003). These outliers are marked with an asterisk in table A.4 and were replaced with the median over a symmetric window of six observations. Furthermore, we replaced five outliers either due to major VAT rate changes (in Japan, the Netherlands, and Sweden) or exceptional observations such as the German reunification in 1991.

Table A.4: Detection of outliers in quarterly CPI inflation rate

Country	**Dates of replaced outliers**		
Australia	2000:Q3*		
Canada	1991:Q1*		
Germany	1991:Q3	1991:Q4	1993:Q1*
Japan	1997:Q2		
Netherlands	2001:Q1		
New Zealand	2010:Q4*		
Sweden	1991:Q1*	1992:Q1	1993:Q1*
United States	2008:Q4*		

To measure trend inflation, we estimate an unobserved components model with stochastic volatility (UC-SV) as proposed by Stock and Watson (2007). The underlying state-space model decomposes inflation into a stochastic trend and a transitory component. The UC-SV model is defined as:

$$\pi_t = \bar{\pi}_t + \eta_t \qquad \eta_t \sim N(0, \sigma^2_{\eta,t}) \tag{A.1}$$

$$\bar{\pi}_{t+1} = \bar{\pi}_t + \epsilon_t \qquad \epsilon_t \sim N(0, \sigma^2_{\epsilon,t}) \tag{A.2}$$

$$\log \sigma^2_{\eta,t+1} = \log \sigma^2_{\eta,t} + \nu_{1,t} \tag{A.3}$$

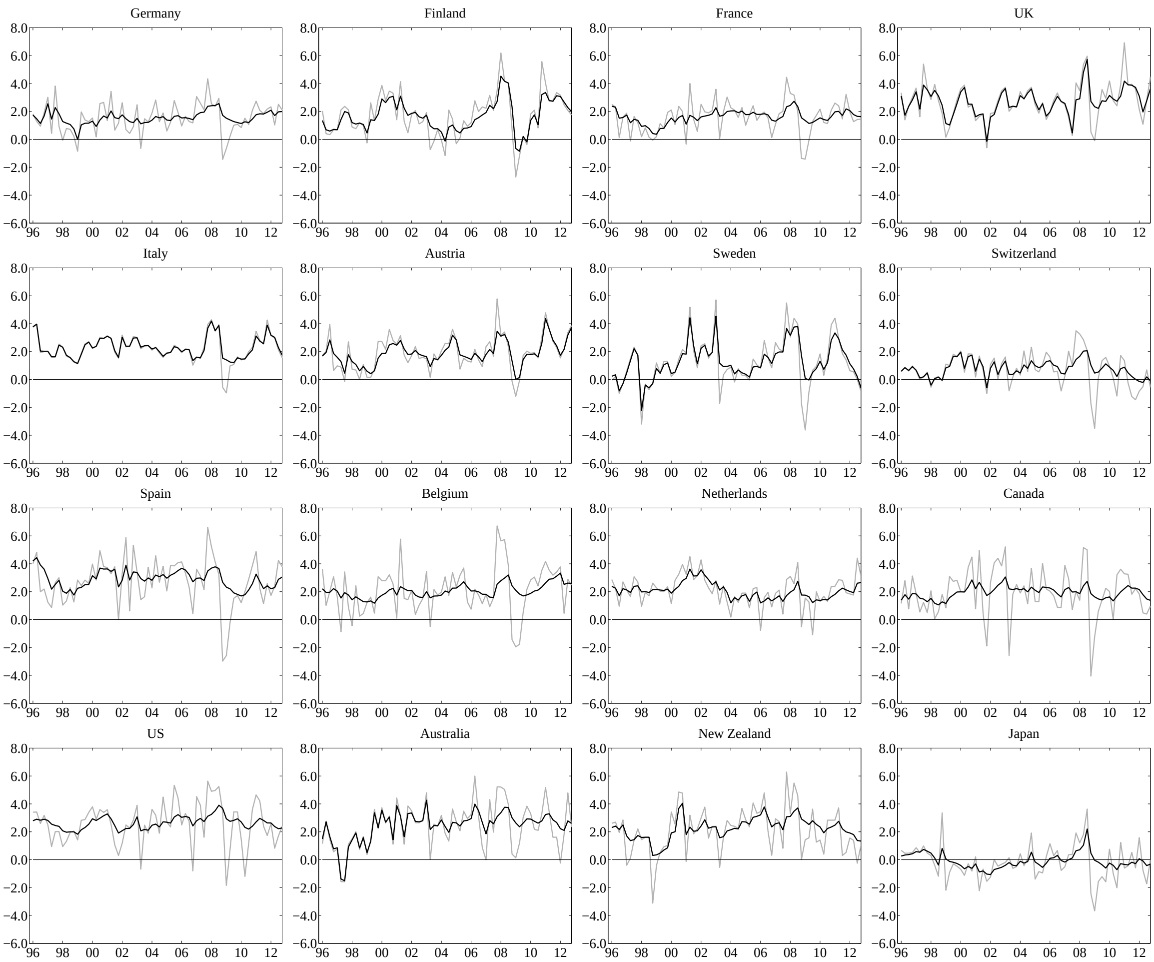
$$\log \sigma^2_{\epsilon,t+1} = \log \sigma^2_{\epsilon,t} + \nu_{2,t} \tag{A.4}$$

$$\begin{pmatrix} \nu_{1,t} \\ \nu_{2,t} \end{pmatrix} \sim N(0, \gamma I_2) \tag{A.5}$$

The trend component is denoted by $\bar{\pi}_t$ whereas the transitory component is modeled as the innovation process η_t. The variances of the trend and transitory innovations are allowed to vary over time by following a geometric random walk. This, in turn, leads to a time-varying estimate of trend inflation. The model includes only one scalar parameter γ which affects the time variation of the shock variances. Following Stock and Watson (2007), we compute the UC-SV model with $\gamma = 0.20$ for quarterly inflation. Estimation is carried out with the Gibbs sampler.

For the purpose of our analysis, we want to obtain a real-time measure of trend inflation. To this end, estimation of the UC-SV model is performed recursively with the same starting point in 1991:Q1 for all countries and an increasing data window from 1996:Q1 through 2012:Q4. Using only inflation data available up to t yields a one-sided estimate of the trend component of inflation $\bar{\pi}_{t|t}$. Note that, according to equation (A.1), the model's unbiased forecast of inflation is the trend component of inflation, irrespective of the forecast horizon. As suggested by Stock and Watson (2010), the estimate of $\bar{\pi}_{t|t}$ provides a proxy of long-term inflation expectations at time t. Figure A.2 displays the resulting trend measure together with the annualized quarterly rate of inflation.

Figure A.2: Recursive estimates of the trend component of inflation



Note: The gray line represents actual annualized quarterly inflation. The dark line represents the estimate of trend inflation.

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