How do Euro Area Inflation Expectations Evolve Over Time?*

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Abstract

Numerous event studies have documented that financial asset prices react very little to aggregated inflation releases in the euro area. The standard explanation for this non-response is that most of the national price data are already publicly available at the time of the final release. Contrary to the conventional wisdom, this paper shows that asset prices are indeed influenced by euro area inflation data releases. The responses are however limited to regional inflation outcomes published early in the monthly release cycle. On the basis of this finding, the paper proposes a Bayesian updating framework which suggests how investors go about when filtering out the news component in regional and national price releases. The model provides timely measures of aggregated inflation expectations for Germany and the euro area. The measures can hopefully serve as complements to standard survey-based expectations collected weeks ahead of the actual publication.

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1 Introduction

Every day a myriad of macro economic announcements across all major markets are published. For each release, investors need to filter out the news component contained in the release and revise their future macro economic outlook accordingly. This filtering process is particularly complex for early releases within certain broad data categories. For instance, ahead of the final estimate of the euro area harmonised consumer price index (HICP), investors must evaluate the impact a number of national and regional consumer price data may have on the aggregated data. If investors are rational, any early release that deviates from expectations should induce an update of investors' view about aggregated euro area inflation.

The main purpose of this paper is to suggest a model that specifies a consistent procedure for such a continious updating, applied on both pan-German and aggregated euro area inflation expectations. To this end, we start from the well known observation that aggregated euro area inflation releases do not move financial markets, see for instance Andersson, Hansen, and Sebestyén (2006). The standard explanation for this non-response is that most of the national price data are already publicly available at the time of the final release. Put it differently, if investors correctly update their inflation expectations subsequently to early national and regional publications, the aggregated final release should contain very little news.

This in turn suggests that there can be scope for some market movements for inflation data published ahead of the final release. In the euro area, consumer price data of six German federal states (Laender) are usually released first in the monthly price data cycle. Using intraday data for the German long-term bond markets, we find that the surprise component of German Laender releases indeed have a significant impact on financial markets. The significant impact these early euro area releases exert on financial asset prices provides evidence that investors, on a daily basis, do update their view about inflation dynamics in the euro area.

As a next step we introduce a Bayesian updating framework which describes how investors could go about filtering out the news component contained in early releases. This general model rests on the observation that macroeconomic announcements can be grouped into broad categories, in our case "price developments" indicators. Within each category, there is a host of different announcements, which can be regarded as noisy measurements of the same underlying phenomena. For each national or regional release, the proposed update procedure depends on three main factors. First the size of the surprise component of the individual release affects the update. Thus, the larger the surprise component is, the more investors update aggregated inflation expectations, everything else held equal. Second, the update also depends on the perceived correlation between the inflation developments in the regional or national areas of the releases and the inflation developments for the aggragate. The higher the perceived correlations are, the stronger is the update. Third, the quality of the regional or national releases should also be taken into account in the update process. If the individual releases are being perceived as relatively noisy, little update takes place.

Using the proposed theoretical updating model, the paper provides empirical estimates of how pan-German and euro area inflation expectations vary over time following the releases of a large number of regional and national price indicators. We find that the magnitudes of the updates gradually declines as the information set widens, which also is in line with anecdotal evidence provided by market intelligence.

The paper contributes to the existing literature in two main aspects. First, the exploration of the information content of early inflation data releases in the euro area is new in the event study literature. The finding that these early releases significantly move financial asset prices helps to solve the puzzle why aggregated German and euro area price releases do not move financial markets. Second, the proposed Bayesian updating framework, which provides timely estimates of how investors update their beliefs about broad macroeconomic indicators, is also novel. The model can serve as useful cross-check to survey-based expectations, usually collected weeks before the actual announcements.

2 Financial market reactions to German price announcements

A number of papers have examined to what extent euro area financial market prices are influenced by price data releases. Applied on money market rates, Ehrmann and Fratzscher (2003) examine the influence of a wide range of macro announcements. They find that, in the 1993 to 2002 period, German CPI exerts little impact on daily money market rates in the euro area. Similarly, Andersson, Hansen, and Sebestyén (2006) examine a wide range of euro area price indicators (flash HICP, final HICP, Producer Price index and M3). They conclude that these announcements have no significant intraday impact on German long-term bonds over the 1999 to 2005 period.

The overwhelming evidences that euro area financial markets respond little to price data releases may appear puzzling given the ECB price stability objective, laid out in the Maastricht Treaty. One may argue that if asset prices are forward-looking, price data releases that deviate from expectations should increase the likelihood of future policy actions on the side of the ECB. These revisions in monetary policy expectations should result in some asset price adjustments. However, the aggregated euro area price releases are normally published after most regional and national price data have become available. As a result, the news component in these aggregated releases can be deemed as being limited. Thus, it cannot be ruled out that investors do react to euro area inflation data but that the market responses take place during the national or regional releases and not at the time of the final release.

To examine this issue in some details, we evaluate the intraday asset price reactions to the first released euro area inflation data - the six German Laender which are released ahead of the pan-German estimate. There is in general no pre-announced publication calendar for the preliminary German CPI data, neither at the state nor at the federal level. However, market participants are informed that the data will mostly likely be published in an interval ranging between the 22nd and the 24th of the reference month.

On the asset price side, data on futures prices for ten-year maturity German bonds between 1999 and 2006 are used. Given the rather small and relatively stable spread between government bond yields within the euro area since 1999, German bond prices can be regarded as providing a fairly sound illustration of long-term interest rate developments for the euro area as a whole. To gauge the asset price responses as accurate as possible, intraday bond prices (sampled every ten-minutes) are employed. The data have been collected and purchased from Tick data, a private data provider.

The most standard approach to evaluate how asset prices, on average, are influenced by macroeconomic releases is to regress the percentage price change of the asset over a very short interval on a constant and the surprise component of the announcements:

$$R_t = \alpha_t + \beta_{i,t} S_{i,t} + \theta C + \varepsilon_{i,t} \tag{1}$$

where R_t is a vector of German bond returns surrounding the release i and $S_{i,t}$ is the standardised surprise component. The statistical significance of the β coefficient then determines if a release can be deemed as significantly impacting the financial asset price or not. A negative (positive) significant beta coefficient means that a higher (lower) than expected price release exerts upward (downward) pressure on euro area bond yields. Other important macro economic releases released at the same time are also included in the regressions (the vector C) to increase the estimation efficiency and minimise omitted variable bias. Unfortunately, one cannot calculate the surprise component of the Laender releases in a consistent way, as they are not included in standard market surveys (such as Bloomberg estimates). In order quantify the incremental information embodied in the release, a forecast for the individual Laender data was derived using autoregressive linear regression models (see the technical annex for more details). Overall the forecasts have shows good explanatory power and when the derived forecasts are aggregated they mimick the pan-German consensus expectations. It should however be noted that the forecasts can only be considered a very rough approximation of the market expectations.

Table 1 shows the results of the final German CPI release together with the German laender releases. In order to put the result into perspective, estimates on the German bond market reactions surrounding the US non-farm payroll data releases are also provided. The non-farm payroll release measures the amount of new jobs created each month in the US non-farm sector and has been found to be one of the most important US data releases in the present context.

As seen in the Table, the release of the aggregated German CPI is not significant whereas two Laender releases - the Bavaria and the North Rhine-Westphalia - both exert a significant impact on the ten-year maturity spectrum. Furthermore, although Baden-Wuerttemberg is the second most important state for the compilation of the pan-German estimate, surprisingly, the market seems not to react to the release. In the case of Brandenburg and Saxony, the parameter estimates are insignificant.

What could explain the significant reaction from the Bavaria and North-Rhine Westphalia estimates? A closer inspection reveals that the co-movements between Bavaria and North-Rhine Westphalia on the one hand, and pan-German CPI on the other is slightly stronger than for the other states, see fig.1. While the technical difficulties in interpreting correlations between annual growth rates is well known, a priori this indication would support the view that markets deem the releases of these two Laender as particularly informative for the pan-German CPI release, which can be one reason behind the significant impacts they exert on the German bond markets. Furthermore, it should be noted that the coefficients of the two significant laender estimates are relatively small compared to the coefficient for the non-farm payroll.

There is no pre-specified order for the publications of the Laender. Consequently, it is reasonable to assume that the 'new news' component as regards the pan-German CPI should be larger if a region publishes its estimate among the first regions. To evaluate if the ordering matters for market reactions, Table 2 shows the results when bond market returns are regressed on the standardised surprise component of the first, second and third releases (independent of which region that provides the estimate). As seen, the markets seem to react significantly to the first release of the monthly cycle. In line with the evidence provided in Table 1, the explanatory power of the regressions is broadly similar. The second and third releases tend not to be particularly informative, as they are often insignificant. This finding support the idea that investors use early releases to update their beliefs for other announcements (released later) within the same categories.

3 A Bayesian updating framework

As a next step, this section introduces a Baysian updating model of how investors how go about filtering out the news component contained in early releases. In general, many macroeconomic announcements can be grouped into broad categories where the announcements can be regarded as noisy measurements of the same underlying phenomenon. The proposed model specifies how similar announcements within such a group can be linked, and how their impact on asset prices can be related to the amount of new information they provide. In a related paper, Hautsch and Hess (2007) apply a simple learning model to the case of one important macroeconomic announcement, i.e. the US employment report. Their focus, though, is to examine the relevance of information precision for price discovery, while the methodology developed here aims at linking the market impact of different releases over time.

Our framework consists of two main building blocks.

Firstly, a time-series model for an $N \times 1$ vector of macroeconomic announcements $X_t = \{x_{1,t}, ..., x_{N,t}\}$, time subscripts t denote the reference period of the announcements, typically in time steps of one month. We assume that all announcements $x_{i,t} \in X_t$ are observed each period, but not necessarily simultaneously. We consider the following simple, autoregressive model for X_t

$$A(L)X_t = \Lambda Z_t + \Omega\varepsilon_t \tag{2}$$

where $\varepsilon_t \sim N(0, I_N)$ and Z_t is a set of exogenous variables, e.g. commodity prices or taxes. $A(L)$ is a lag polynomium in X, and Λ and Ω are model parameters. Let $\Sigma = \Omega'\Omega$ denote the conditional covariance matrix. The model thus specifies the conditional mean and covariance of the macroeconomic announcements.

Secondly, asset prices are supposed to be linearly related to macroeconomic announcements through a function $f(X_t)$[1]. Therefore, asset prices respond as market participants update their estimate of $f(X_t)$ in light of new information. To facilitate a precise description of the market participants' information set, we introduce the additional real-time subscript τ, which is used to denote the precise (possibly intra-day) poins in time, e.g. the exact time of a release.

We assume that the log asset price at time τ, p_τ, is linearly related to the expectation of $f(X_t)$ as of time τ

$$p_\tau = \beta_0 + \beta_1 E_\tau f(X_t)$$

which implies that the return upon the release of new information is given by

$$\Delta p_\tau = \beta_1 \Delta E_\tau f(X_t) \tag{3}$$

[1] In our two empirical applications, f will simply be a weighted average of the $x_{i,t}$'s.

where Δp_τ refers to log return over a short period surrounding the release (which is in line with equation 1 above). To isolate the information provided by the release from other news, it is common to compute the return over a very short window, such as the 10 minutes from 5 minutes before the release to 5 minutes after.

When some element x_i is released, market participants face an information extraction problem: how to update the estimate of $f(X_t)$ given the knowledge of previosuly released elements of X_t? To answer this question, we first partition X_t into two subsets. Let $X_{1,t}^\tau$ denote the set of yet unreleased announcements within the reference period t, as of time τ, i.e. $X_{1,t}^\tau = \{x_{i,t} | x_{i,t} \notin \Im_\tau\}$, where $\Im_\tau$ is the market participants information at time τ. Let $X_{2,t}$ contain those elements which have already been released, i.e $X_{2,t}^\tau = \{x_{i,t} | x_{i,t} \in \Im_\tau\}$. The actually released values of $X_{2,t}$ are denoted $A_{2,t}$.

Using this partition, and dropping time subscripts for notational simplicity, we can write the mean μ and covariance matrix Σ of X as

$$\mu = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix}$$

and

$$\Sigma = \begin{bmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{12} & \Sigma_{22} \end{bmatrix}$$

Standard results for the multivariate normal distribution now imply that the distribution of X_1 conditional on $X_2 = A_2$ is multivariate normal $(X_1 | X_2 = A_2) \sim N(\bar{\mu}_{1|2}, \bar{\Sigma}_{1|2})$ where

$$\bar{\mu}_{1|2} = \mu_1 + \Sigma_{12}\Sigma_{22}^{-1}(A_2 - \mu_2) \tag{4}$$

and

$$\bar{\Sigma}_{11|2} = \Sigma_{11} - \Sigma_{12}\Sigma_{22}^{-1}\Sigma_{21} \tag{5}$$

Equation (4) states how to optimally update the estimate of any unreleased elements in X_t, given an actual announcement 's deviation from its expectation. This deviation, $A_2 - \mu_2$, is commonly refered to as the 'surprise component' of the announcement. Using the updated expectations for X_t, the expectations of $f(X_t)$ can be updated accordingly. Note that the updating rule does not take into account any parameter uncertainty (or non-normality of innovations), and should as such be seen as a first-order approximation to the optimal update[2].

[2]Subramanyam (1996) show how uncertainty about the measurement precision lead to a non-linear price response as a function of the size of the surprise. This analysis has recently

The updating rule in (4) makes intuitive sense. For example, in the case $N = 2$, Σ_{12} is simply the conditional covariance of the two announcements, and Σ_{22} is the conditional variance of the figure released first. So if the announcements are conditionally uncorrelated, i.e. $\Sigma_{12} = 0$, no updating takes as the first announcement is uninformative about the later one. Also, if the announcement released first is very noisy, i.e. Σ_{22} is large, little updating is performed reflecting that the measurement is not very reliable. On the contrary, the observation of a highly correlated and precise announcement, should lead to a large change in the expectation of $f(X_t)$.

Note that the model allows the ordering of the observations of the x_i's to vary from period to period, such that sometimes x_i will be released before x_j, sometimes vice versa. This feature is needed to capture the investors update of German inflation expectations following the German laender releases as they do not follow any pre-specified order.

An important benefit of this framework is that it allows us to theoretically link the market impact of different, but related macro economic announcements. Instead of investigating asset price responses to each release in isolation, the market impact of different releases can be compared using the same metric, namely the extent to which they lead to an update of the underlying quantity of interest, here captured by $\Delta E_\tau f(X_t)$.

4 Empirical applications

The next two subsection will empirically implement the model outlined above. In the first subsection inflation we show how pan-German inflation expectations are updated subsequent to Gearman laender releases. In the second subsection we broaden the analysis and show an example how euro area inflation expectations evolve following national and regional price data releases.

4.1 Application 1: Dynamic formation of German inflation expectations

Eq. (4) shows how to optimally update the estimate of any unreleased elements, $E_\tau f(X_t)$. This subsection will apply the update equation on the German laender

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been applied to macroeconomic announcements by Hautsch, Hess, and Müller (2007). The nonlinearity arises as K_t itself becomes a function of the surprise component, because an observed surprise in this set-up leads to an update of both the level of the process and the precision of its measurement.
We abstract from this potential non-linearity in this paper.

releases. We implement the procedure over the sample period Dec 1999 to October 2007. In order to start the iteration procedure, initial expectations for the state CPI are needed. As discussed above, German laender expectations are not available in standard market surveys, expectations for each state CPI are derived from one-step ahead forecasts from the time-series model, see Appendix. The conditional mean equation also includes conditional covariances and variances. To this end, we use CPI outcomes from January 1994 to November 1999, run a VAR(1) estimation, and use the variance-covariance matrix to derive the first update extimates for December 1999. The sample for the VAR(1) estimation is then extended by one observation for each iteration to, as best possible, mimick investors' real-time information.

As a case study, the six subplots in fig. 2 shows the model-implied pan-German updates in reponses to each state-level release in December 2006. In that monthly cycle all laender released their inflation data on 30 January. The timing differed though with Sachsen coming out first followed by Brandenburg, Hessen, Bayern, North Rhine-Westfalia and last Baden-Wuerttemberg, see Table 3. The thin solid line in all six subplots in fig. 2 represents the time varying expectations of the final pan-German CPI outcome. Starting with the upper left subplot, the thick solid line shows the estimated expected outcome for Sachsen: 2.25%. The circle represents the actual outcome of 1.9%, i.e. lower than anticipated. Feeding in the negative surprise component as well as the correlation between different laender and the percieved noisiness of the estimate triggered the pan-German inflation expectations to be revised down to 1.25% from 1.45%. 70 minutes after the Sachsen release, Brandenburg released their estimate (see upper-right subplot in fig. 2). This release also came out slightly lower than anticipated, triggering some further, but less pronounced, downward revisions in the expected pan-German estimate. Following the same logic, the remaining four subplots show how the pan-German estimate fluctuate around as a result of the Hessen, North Rhine-Westfalia, Baden-Wuerttemberg and Bayern releases.

In principle, the the impact of a release x_i can be decomposed into two effects. The first effect is a direct effect equal to $\delta_i(x_{i,t} - E_\tau x_{i,t})$, which reflect the weight of the state in the pan-German CPI as well as the size of the surprise. The second effect is indirect and captures the fact that the whole vector $X_{1,t}$ is updated in response to each new release.This suggest that the overall update should be larger for early releases compared with releases later on in the cycle where the market impact will be confined to the direct effect. Fig. 3 shows the absolute average changes (in basis points) for pan-German inflation expectations over the sample period Dec 1999 to October 2007. As seen, the first state release give rise to an, onaverage, 15 basis point update of the pan-German release. The update then gradually falls as more information (i.e. state releases) become available. For the last release the update is limited to a few basis points, at least in this setting.

4.2 Application 2: Dynamic formation of euro area inflation expectations

The application on pan-Germany can be broaden to the euro area as a whole. To this end we conduct a similar exercise as above but include two additional national indicators, French and German CPI. Fig. 4 shows the model implied update for the same month, December 2007. In this monthly cycle, the pan-German CPI was released on 22 December 2006, shortly after the last leander publication. The French CPI came out later, on 12 January 2007. Needless to say, the results coming out from this case study should be taken with some caution as the derived time-variation of euro area inflation expectations is calculated on the basis of updated inflation expectations from two member states only. Still, Germany and France together make up nearly 50 percent in the euro area HICP calculation. As seen in the chart, publications of regional releases cause revisions also in euro area inflation expectations. This is because a surprising outcome of a laender release give rise to an update of the entire vector $X_{1,t}$ (i.e. the remaining laender as well as pan-German and French inflation expectations). Overall, also here the magnitudes of the updates tend to gradually diminish as more information become available.

5 Conclusion

Each day, investors have to incorporate and filter the information content of a vast number of macroeconomic announcements, earning statements and monetary policy publications when they price financial assets. Using a simple learning model, this paper proposes a general framework of how investors update their information set concerning a number of data releases that measure the same underlying phenomenon. Applied on monthly announcements, we use the learning setup to show that releases of early estimates induce revised expectations for those announcements that are released later on in the cycle. The magnitude of the revisions depends however not only on the surprise components but crucially also on the perceived reliability and variability of the early estimates.

In the empirical part, the paper make use of the learning model to examine the asset price impact on a closely monitored categories of data releases - price releases in the euro area. We show that the muted market impact on pan-German CPI releases is related to the fact that six German federal states (Bundeslaender) publish their own estimates, before the aggregate German inflation data are released. In contrast to the previous findings, we uncover systematic asset price responses and show how the learning model handles the stochastic ordering of regional German CPI releases in a simple and consistent way. This suggests that

German inflation data do indeed influence asset prices, but via the individual federal state releases, rather than the pan-German inflation release. In a second application, we show how this update procedure can be extended to the euro area as a whole. Extensions to other announcements and economies are left for future research.

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Table 1

	Coefficient		R2
Baden-Wuerttemberg	-0.003		0.05
Bavaria	-0.006	*	0.21
Brandenburg	0.004		0.32
Hesse	-0.003		0.20
North Rhine-Westphalia	-0.007	***	0.22
Saxony	0.001		0.15
German CPI	-0.005		0.03
Non-Farm Payroll	0.15		0.26

OLS estimates of the impact of surprises in individual German state CPI releases on bond futures prices. The regression is: $R_t = \alpha_t + \beta_{i,t} S_{i,t} + \theta C + \varepsilon_{i,t}$ where R_t is the ten-minute return surrounding the release and S_i is the surprise component for the release i. Using a dataset of 81 of the most important US, UK and euro area macro releases, the vector C controlls for concurrent announcements. *,**,*** represent significance at the 10, 5 and 1 percent level. Sample length: Dec 1999 to Dec 2006. Newey-West standard errors are used.

Table 2

	Coefficient		R2
1st	-0.009	***	0.20
2nd	0.0001		0.41
3rd	-0.002		0.17

OLS estimates of the impact of surprises in individual German state CPI releases on bond futures prices. The regression is: $R_t = \alpha_t + \beta_{i,t} S_{i,t} + \theta C + \varepsilon_{i,t}$ where R_t is the ten-minute return surrounding the release and S_i is the surprise component for the release i. Using a dataset of 81 of the most important US, UK and euro area macro releases, the vector C controlls for concurrent announcements. *,**,*** represent significance at the 10, 5 and 1 percent level. Sample length: Dec 1999 to Dec 2006. Newey-West standard errors are used.

Table 3

	Time	Expectations	Release	Pan-German
Sachsen	21 Dec 2006 10:00	2.25	1.9	1.27
Brandenburg	21 Dec 2006 11:10	2.2	1.7	1.2
Hessen	22 Dec 2006 10:30	1.3	1.3	1.35
North Rhine-Westfalia	22 Dec 2006 11:00	1.6	1.7	1.42
Baden-Wuerttemberg	22 Dec 2006 12:00	1.2	1.1	1.40
Bayern	22 Dec 2006 13:00	1.4	1.4	1.39

Central European time. The expectations for the laender are derived from one-step-ahead forecasts as outlined in the Appendix.

Table 4

	Time	Expectations	Release	Euro area
Sachsen	21 Dec 2006 10:00	2.25	1.9	1.27
Brandenburg	21 Dec 2006 11:10	2.2	1.7	1.2
Hessen	22 Dec 2006 10:30	1.3	1.3	1.35
North Rhine-Westfalia	22 Dec 2006 11:00	1.6	1.7	1.42
Baden-Wuerttemberg	22 Dec 2006 12:00	1.2	1.1	1.40
Bayern	22 Dec 2006 13:00	1.4	1.4	1.39
Germany	22 Dec 2006 15:40	1.6	1.4	1.74
France	12 Jan 2007 08:45	1.5	1.5	1.85

Central European time. The expectations for the laender are derived from one-step-ahead forecasts as outlined in the Appendix.

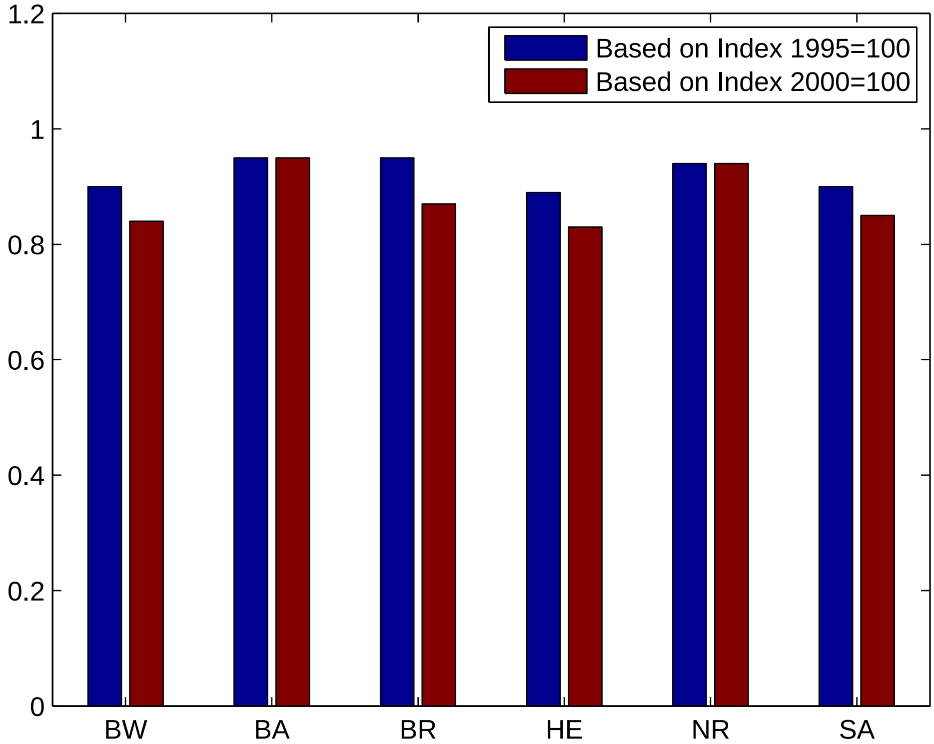

Figure 1: Correlation between pan-German and Laender inflation. Annual percentage changes, over the sample 1994 to 2006.

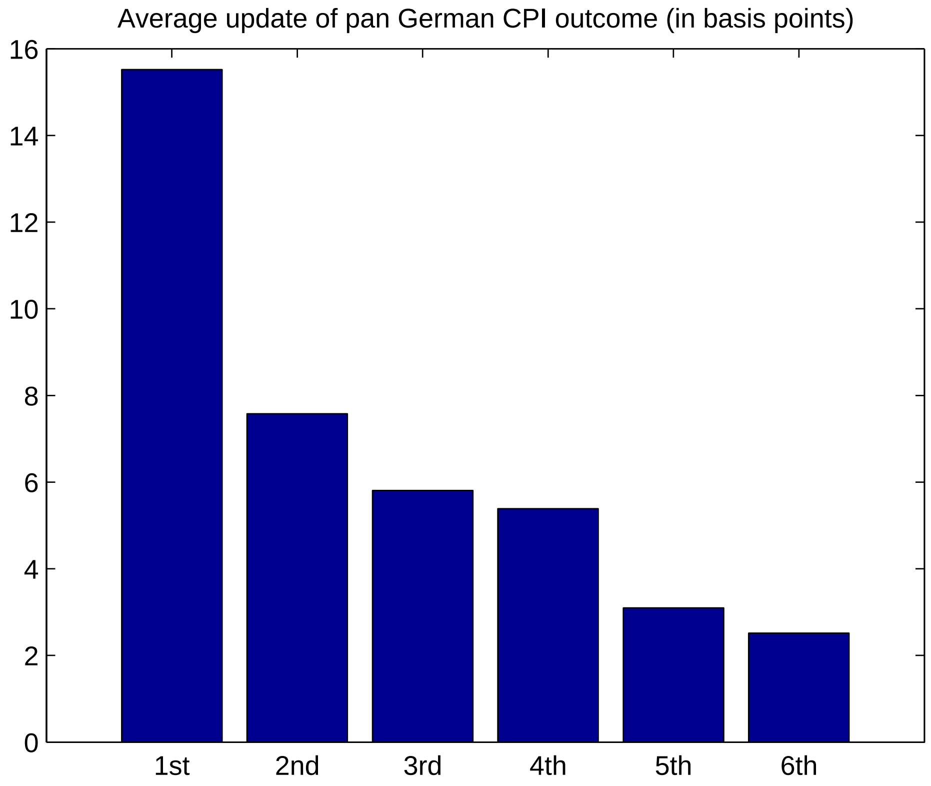

Figure 2: Average update of German inflation expectations following Leander publication (in basis points).

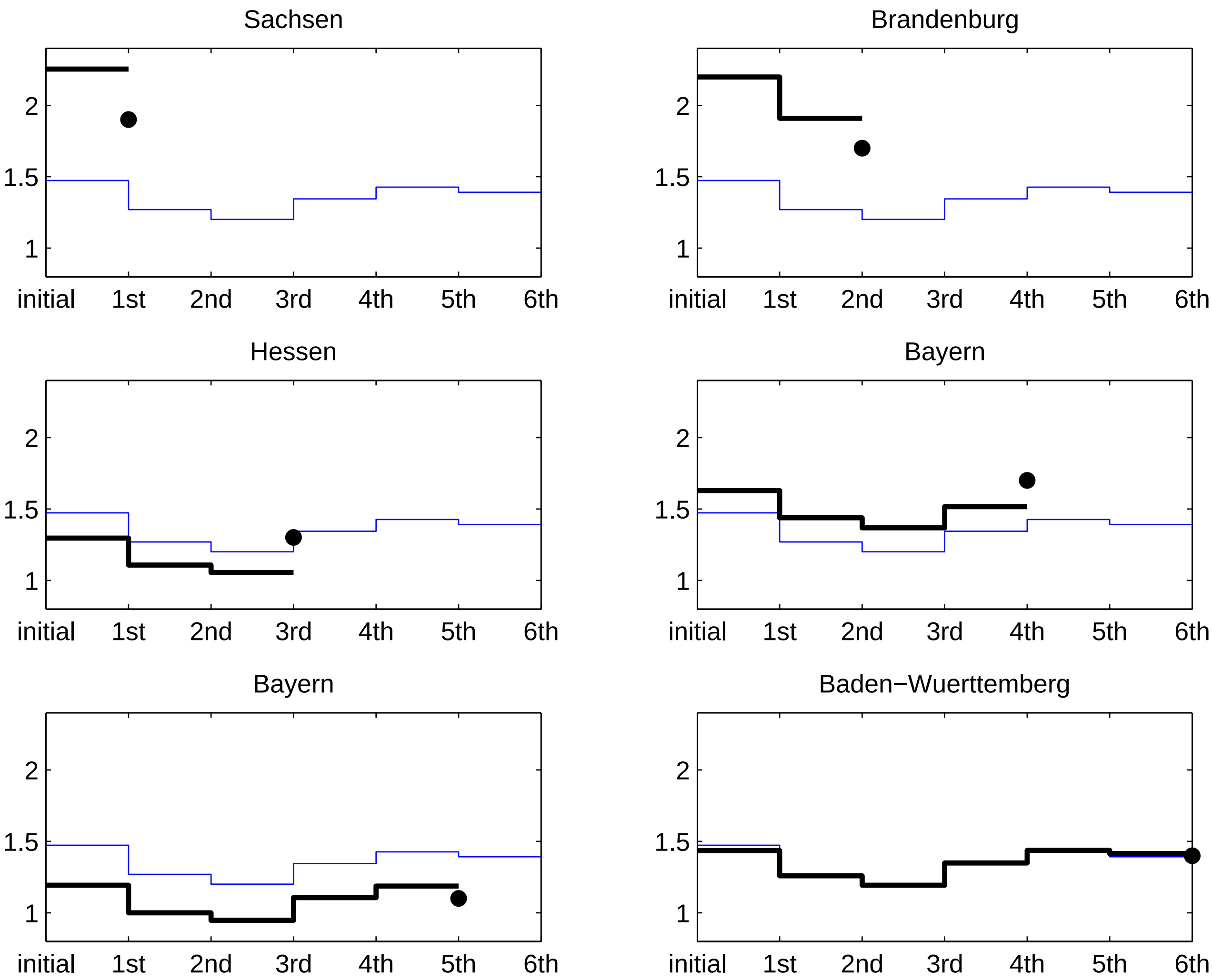

Figure 3: Time-varying inflation expectations in Germany, December 2006. Thin lines represents pan-German inflation expectations. The solid lines and the dots show the various Laenders ' inflation expectations and the actual outcome, respectively.

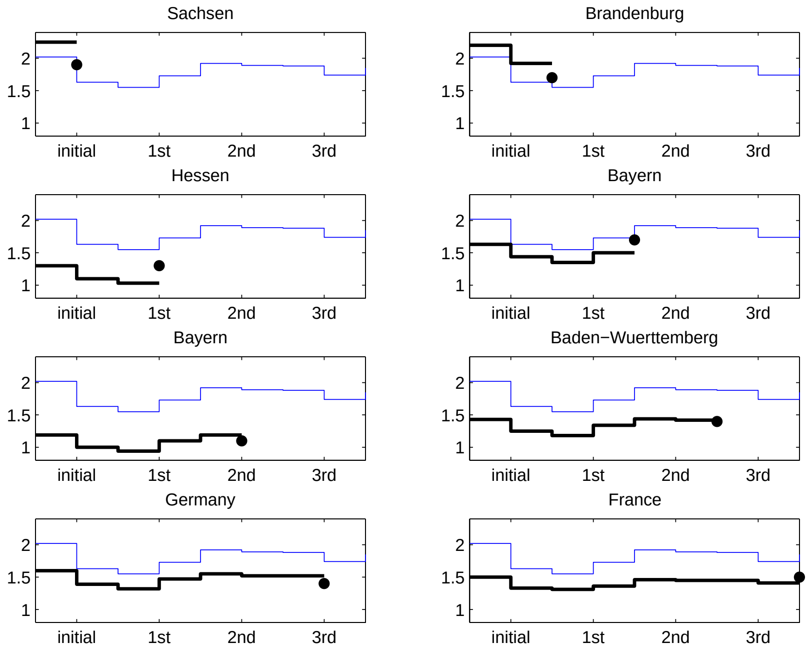

Figure 4: Time-varying inflation expectations in the euro area, December 2006. Thin lines represents euro area inflation expectations. The solid lines and the dots show the various Laender and national inflation expectations and the actual outcome, respectively

Appendix: Forecasting model for state-level German CPI

Since no surveys exist for the state-level German CPI releases, we construct a proxy for market expectation by use of forecasts from a dynamically reestimated time-series model, including relevant exogenous factors. The forecast for the individual states are constructed using autoregressive linear regression model estimated on a sample beginning in 1991:1 up to the respective forecast period, i.e. 1999:12 to 2007:12

$$\pi_t^i = \sum_{j=1}^{12} \alpha_j^i \pi_{t-j}^i + \beta f_t + \delta \Delta com_t + \phi tax_t + \varepsilon_t$$

where π_t^i is the annual percentage change in the CPI of a state (with i = BA, BR, BW, HE, NRW, SA) in period t, f_t is the Bloomberg expectation for the German CPI for the current month, Δcom_t is the annual percentage change in the HWWA (Hamburg Institute of International Economics) commodity price index and tax_t

is the annual percentage change in a step dummy capturing the evolution of the mineral oil tax. For Saxony and Brandenburg, additional dummy variables are included for 1994:1 to capture price liberalisation in those two Länder. Up to and including January 2003, the forecast were computed on the basis of the original state CPIs (1995=100) as they were relevant. From February 2003 onwards, the CPI with weighting scheme from 2000 was used.