

Hautsch, Nikolaus; Hess, Dieter; Müller, Christoph

**Working Paper**

## Price adjustment to news with uncertain precision

CFR Working Paper, No. 08-04 [rev.]

**Provided in Cooperation with:**

Centre for Financial Research (CFR), University of Cologne

*Suggested Citation:* Hautsch, Nikolaus; Hess, Dieter; Müller, Christoph (2011) : Price adjustment to news with uncertain precision, CFR Working Paper, No. 08-04 [rev.], University of Cologne, Centre for Financial Research (CFR), Cologne

This Version is available at:

<https://hdl.handle.net/10419/70120>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

**CFR-working paper no. 08-04**

**price Adjustment to news with  
uncertain precision**

**N. Hautsch • D. Hess • C. Müller**

**centre for financial research**  
Look deeper

# Price Adjustment to News with Uncertain Precision\*

Nikolaus Hautsch, Dieter Hess, and Christoph Müller<sup>†</sup>

October 2011

---

\*For their valuable comments we are grateful to Steven Clark, Maik Dierkes, Hermann Elendner, Günter Franke, Peter R. Hansen, Philipp Harms, Alexander Kempf, Olivers Lorz, Peter Norman Sørensen, K.R. Subramanyam, Marliese Uhrig-Homburg, Dieter Urban and participants at the German Finance Association Meeting 2007 in Dresden, the French Finance Association Meeting 2007 in Paris, the European Economic Association and the Econometric Society Meeting 2008 in Milan, the Midwest Finance Association Meeting 2008 in San Antonio, the Eastern Finance Association Meeting 2008 in St. Pete, the 11th Symposium on Finance, Banking, and Insurance 2008 in Karlsruhe, the European Finance Association Meeting 2009 in Bergen, the Financial Management Association 2011 in Denver and seminar participants at the Universities of Aachen, Berlin, Copenhagen, Frankfurt, Hannover, Karlsruhe, Köln, Konstanz, Tasmania and Würzburg. We thank Kirk Mueller (BLS) and Raman Subri (DOL, ETA) for providing us with background material on employment figures. Hautsch gratefully acknowledges financial support from the EU Commission through MRTN-CT-2006-034270 COMISEF as well as from the Deutsche Forschungsgemeinschaft through the SFB 649 “Economic Risk”.

<sup>†</sup>Hautsch: School of Business and Economics and Center for Applied Statistics and Economics (CASE), Humboldt-Universität zu Berlin, Quantitative Products Laboratory (QPL), Berlin, and Center for Financial Studies (CFS), nikolaus.hautsch@wiwi.hu-berlin.de; Hess: University of Cologne, Corporate Finance Seminar and Centre for Financial Research (CFR), hess@wiso.uni-koeln.de; Müller: EnBW Trading GmbH, Karlsruhe, christ.mueller@enbw.com.

# Price Adjustment to News with Uncertain Precision

## Abstract

We analyze how markets adjust to new information when the reliability of news is uncertain and has to be estimated itself. We propose a Bayesian learning model where market participants receive fundamental information along with noisy estimates of news' precision. It is shown that the efficiency of a precision estimate drives the the slope and the shape of price response functions to news. Increasing estimation errors induce stronger nonlinearities in price responses. Analyzing high-frequency reactions of Treasury bond futures prices to employment releases, we find strong empirical support for the model's predictions and show that the consideration of precision uncertainty is statistically and economically important.

Keywords: Bayesian learning, macroeconomic announcements,  
information quality, precision signals

JEL classification: E44, G14

News on economic fundamentals drives asset prices. A larger amount of news leads to greater and faster price reactions. This is well confirmed by a wide range of empirical studies in asset pricing, market microstructure analysis, corporate finance and financial accounting. Asset-specific news naturally enlarges investors' information set, allowing them to revise their expectations with regard to the underlying fundamental value. We address the issue of precision uncertainty and show that agents underreact to news when there is a chance that the precision of the news could be a lot lower than under regular circumstances.

Investors' updating of expectations in response to the arrival of news and its implications for the underlying asset price process is theoretically best understood in terms of a Bayesian learning model. However, though the mechanism of Bayesian learning is theoretically appealing and tractable, only little empirical evidence of Bayesian updating effects in news-implied asset price reactions is existent. A major reason for this lack of evidence is that Bayesian updating processes ultimately depend on the reliability of the news. Think of announcements on economic fundamentals – typically stemming from surveys – as realizations of a random distribution with a given variance. The reliability of the news is then naturally measured in terms of the random variable's precision (i.e., the inverse of its variance). A major implication of Bayesian learning is that prices react more strongly to more precise news. However, the reliability of a piece of news is generally

unknown in reality. If they can at all, market participants can only *estimate* precision of news, leaving them with a noisy estimate.

This paper addresses the missing link between Bayesian learning theory and actually observed news-implied asset price reactions. To confront the theoretical framework with empirical observations, we address the fundamental question of how market participants actually do infer the reliability of news in practice. In this context, we distinguish between two ways in which investors estimate the precision of announcements: first, traders might use additional publicly available information linked to the reliability of news releases. This results in a so-called "external" precision estimate. For example, natural precision indicators could be sampling statistics on the underlying survey, information on sampling errors, or information on the expected magnitude of revisions to currently released figures as suggested by Hautsch and Hess (2007). Second, in situations where no information on the quality of announcements is readily available, investors are left with inferring the precision of the news from the released information itself, e.g., by looking at the size of a surprise as suggested by Subramanyam (1996). This would result in a non-linear price response. However, such a size-based (or "internal") precision signal is rather uninformative and restrictive since it implicitly conjectures that large surprises can only come with low precision.

A major contribution of the paper is to show that the distinction between these two

types of precision signals is theoretically important and is empirically supported by the data. In an extended Bayesian learning framework we illustrate that the relative impact of both types of precision proxies ultimately depends on the efficiency of the external estimate. If traders have a highly reliable external precision estimate, the magnitude of a surprise itself provides only little additional information on news' quality. In the limiting case, when the precision of the news is certain, the size of a surprise as a reliability proxy can be completely ignored. In this situation, the resulting price reaction function is linear with its slope positively depending on the indicated precision of releases. In contrast, if the external precision estimate is very noisy, traders are left alone with the size (and sign) of the release. This induces deviations from linearity which increase with surprises' magnitude making the price response curve S-shaped. We empirically show that actually observed news implied price reactions are significantly driven by both underlying effects and that their neglect can induce severe pricing errors.

To date, surprisingly little emphasis has been placed on the role of uncertainty in the reliability of news in financial models. For example, in the informed trade models of Kyle (1985) and Admati and Pfleiderer (1988), information asymmetry is introduced via private signals drawn from a distribution with *known* parameters. Similarly, in the market microstructure models of Blume, Easley, and O'Hara (1994) or Easley, Kiefer, and O'Hara (1997), privately informed agents hold different beliefs but individuals have parameter

certainty regarding the distribution (and hence the precision) of their beliefs. Providing another example, models of speculative trade are focusing on the combination of private information and public announcements. Awaiting public releases, heterogeneity among agents is created by differences in prior beliefs (e.g., Holthausen and Verrecchia (1988, 1990), Harris and Raviv (1993) or Kim and Verrecchia (1991a, 1991b)), additional efforts to acquire private information (Kim and Verrecchia 1997) or afterwards simply through individual interpretations (e.g., Harris and Raviv (1993) and Kandel and Pearson (1995)). Again, in these models, the parameters describing the information sets are assumed to be known, at least to individual agents. Likewise, in the Bayesian learning models of David (1997), Veronesi (1999, 2000) and Pástor and Veronesi (2003), where agents face uncertainty about a key valuation parameter, the (im)precision of this parameter is assumed to be known. In a similar way, recent option pricing and trading models consider heterogeneous beliefs but abstract from uncertain precision (e.g., David and Veronesi, 2002, Guidolin and Timmermann, 2003, Buraschi and Jiltsov, 2006, and Buraschi, Trojani, and Vedolin, 2009). Finally, Bayesian learning models assuming differences in information with *given* precision are applied in a wide range of financial markets research dealing with the predictability of asset returns, stock price bubbles, portfolio choice, and mutual fund flows. For a recent survey, see Pástor and Veronesi (2009).

In contrast, empirical research regarding information precision is sparse. Only a few



papers stress the importance of accounting for releases' reliability in the analysis of news-induced price reactions. Bayesian learning requires a relative precision measure, i.e., the variance of the announced news has to be weighted against the variance of ex-ante beliefs. Earlier studies have focussed on one of these two components of the (external) precision measure. For example, Buraschi and Jiltsov (2006) and Pasquariello and Vega (2007) use the standard deviation of analyst forecasts surveyed by Money Market Services (MMS) as a measure of the heterogeneity of ex-ante beliefs. On the other hand, Krueger and Fortson (2003) assume that the variance of ex-ante beliefs is constant and suggest to use the sample size as an (external) precision estimate. However, survey size counts are not available in real time, and Krueger and Fortson find only limited evidence for the importance of quality of employment news. Moreover, Pasquariello and Vega (2007) and Gilbert, Scotti, Strasser, and Vega (2010) suggest to use revisions to approximate noise in the announced data assuming that market participants can forecast future revisions, as suggested, for example, by Aruoba (2008) and Gilbert (2010). Hautsch and Hess (2007) combine MMS survey dispersions and revision information to obtain a precision measure in the Bayesian sense. Based on this release-specific precision measure they document a significantly positive relationship between the magnitude of price reactions and the perceived precision of news for the employment report.

Nevertheless, the above mentioned studies do not incorporate the effects of uncertainty

in their precision measures. Subramanyam (1996) is the only study relaxing the assumption of known news' precision. However, Subramanyam's setting accounts only for an internal precision signal. By extending this framework to also allow for noisy (external) estimates of the precision of the news, we bridge the gap between the two extreme cases of assuming a perfectly known precision of releases or alternatively assuming precision to be completely unknown with any (external) estimate being absent. As shown in the remainder of the paper this extended framework is flexible enough to capture different scenarios that are realistic in financial practice.

To test the model's implications, we analyze high-frequency price responses in the 10-year U.S. Treasury bond futures market to the U.S. employment report. We focus on the employment report for several reasons. First, numerous studies show that among macroeconomic announcements, employment figures (in particular, the nonfarm payrolls headline) have by far the most pronounced impact on financial markets; see, e.g., Fleming and Remolona (1999c), Balduzzi, Elton, and Green (2001), McQueen and Roley (1993) or Andersen, Bollerslev, Diebold, and Vega (2003). Second, this report provides a unique opportunity to derive an external precision estimate for its most important headline, i.e., the nonfarm payrolls figure. We follow Hautsch and Hess (2007) and exploit predictability in (absolute) sampling errors as revealed by revisions of releases. In principle, we could derive such a measure for other headlines as well. However, there are only a few macroe-

conomic series for which a sufficiently long history of revision data exists, e.g., for the consumer price report. But unlike the employment report, revision data are not available for the report's most influential headline.<sup>1</sup>

Our estimated price responses reflect that market participants do indeed process *both* types of precision indicators. Differentiating between two benchmark categories associated with high- and low-precision estimates, we observe a steep and nearly linear response curve in the case of precise news and a nonlinear and less steep response function in the case of imprecise news. The fact that price reactions are significantly different in both scenarios suggests that the external precision signal is informative. On the other hand, significant nonlinearities in the price response, particularly for imprecise news, indicates that market participants are well aware of estimation errors influencing the external precision estimate and thus also take into account the size of a surprise as an internal proxy.

The remainder of this paper is organized as follows. The following section presents a theoretical Bayesian learning framework that allows for noise in precision signals. Section II describes the used high-frequency return data as well as employment announcement data and outlines the estimation procedure. The empirical results are presented and discussed in Section III. Section IV concludes.

---

<sup>1</sup>For example, for consumer prices, producer prices or retail sales revision data are not available for the less volatile components (e.g., CPI excluding food and energy) which have the strongest price impact.

# I. A Bayesian Learning Model

## A. Standard Bayesian Learning

Bayesian learning models provide a tractable framework to analyze how new information is incorporated into expectations and prices when prior information as well as incoming news may contain errors. Throughout our analysis, we assume that all market participants have the same information just before the release of some public announcement. Each participant is risk-neutral and is equipped with the same utility function as well as the same endowment of assets including a risky asset. The price  $P$  of this risky asset is assumed to be proportional to traders' expectations of an (unknown) economic variable  $X$ , i.e.,  $P = \nu \cdot E[X]$ . The beliefs on  $X$  prior to the announcement are assumed to be normally distributed with known parameters, i.e.,  $X \sim N(\mu_F, 1/\rho_F)$ , where  $\mu_F$  is the mean of the prior information on  $X$  in the market, and  $\rho_F$  denotes its precision, defined as the inverse of the variance. This prior information represents the market's assessment of  $X$  given all available information and is characterized by a corresponding probability distribution. Empirical research on the impact of scheduled announcements typically assumes that prior beliefs in the market may be approximated by analysts' forecasts. It is thus implicitly assumed that analysts' forecasts are unbiased for  $X$ .

Throughout the paper, we assume that  $\mu_F$  and  $\rho_F$  are known. However, this assump-

tion can easily be relaxed to also allow for uncertainty in priors without changing the fundamental implications of the paper.<sup>2</sup> Moreover, as is discussed in more detail in the empirical part, both  $\mu_F$  and  $\rho_F$  can be straightforwardly estimated by the cross-sectional mean and variance of analysts' forecasts. As for most important macroeconomic figures, the cross-section of publicly available analysts' forecasts is quite large, such estimates can be considered to be relatively efficient, making the assumption of known parameters  $\mu_F$  and  $\rho_F$  less restrictive. Accounting for both arguments and aiming to keep the paper possibly simple, we maintain this assumption.

Assume an announcement is released providing a noisy estimate of  $X$  including an additive error, i.e.,  $A = X + \varepsilon$ , where  $\varepsilon$  is a zero-mean normally distributed error term with variance  $V[\varepsilon] = 1/\rho_\varepsilon$  and  $E[X \cdot \varepsilon] = 0$ . Consequently, traders receive an unbiased estimate of the underlying variable  $X$  whose precision is reflected by  $\rho_\varepsilon$ . The additive error term implies that the unconditional variance of a news release exceeds the variance of the market's prior information. Accordingly, announcement  $A$  is distributed as  $A \sim N(\mu_F, 1/\rho_A)$  with  $\rho_A^{-1} = \rho_F^{-1} + \rho_\varepsilon^{-1}$ . After observing this public announcement, traders adjust their beliefs according to Bayes' rule. Then, it is easily shown that traders' posterior

---

<sup>2</sup>For example, it can be shown that the main results also hold for the case of  $\rho_F$  to be stochastic. For brevity these results are omitted here.

beliefs are normally distributed with

$$\mu_P := \mathbb{E}[X | A] = \mu_F + (A - \mu_F) \frac{\rho_A}{\rho_F} = \mu_F + (A - \mu_F) \frac{\rho_\varepsilon}{\rho_F + \rho_\varepsilon}$$

and

$$\rho_P := \mathbb{V}[X | A]^{-1} = \rho_F + \rho_\varepsilon.$$

Consequently, the price response is

$$\Delta P = \nu \cdot (\mu_P - \mu_F) = \nu \cdot S \cdot \pi,$$

where  $S := A - \mu_F$  denotes the unanticipated information component, i.e., the so-called surprise, and  $\pi$  defines the so-called ‘price response coefficient’

$$\pi := \frac{\rho_A}{\rho_F} = \frac{\rho_\varepsilon}{\rho_F + \rho_\varepsilon} < 1.$$

Hence, the main implication of standard Bayesian learning is that price changes are proportional to surprises  $S$ , while the proportionality factor  $\pi$  depends on the relative precision of announcements and forecasts. As the precision of the news  $\rho_\varepsilon$  increases, so does the price response coefficient  $\pi$ . In the limit case of  $\rho_\varepsilon \rightarrow \infty$ , we have  $\pi \rightarrow 1$ .

## B. Bayesian Learning with Precision Uncertainty

Contradicting the assumptions of the standard model, announcements such as employment figures are usually released without an associated precision measure. Therefore,

market participants regard the precision of the news as uncertain, with  $\rho_\varepsilon$  and thus  $\rho_A$  itself following a random distribution  $f(\rho_A)$ . Then, the normality of announcements is assumed to hold *conditionally* on  $\rho_A$ , i.e.,  $A|\rho_A \sim N(\mu_F, \rho_A)$ . For simplicity and without loss of generality, we assume that the precision of the news may take on only two values with equal probability, i.e.,  $\rho_A \in \{l, h\}$  with  $P(\rho_A = j) = 0.5$  and  $j \in \{l, h\}$ .<sup>3</sup>

Suppose that market participants have an estimator  $\hat{\rho}_\varepsilon$  that is built on information not directly linked to the announced figure itself. For example,  $\hat{\rho}_\varepsilon$  might be simply the sample size of a survey (e.g., Krueger and Fortson, 2003) or the cross-sectional standard deviation thereof. Alternatively, for the U.S. employment report, Hautsch and Hess (2007) show that traders may make inferences regarding the precision of announced employment figures by exploiting predictability in the magnitude of revisions. We refer to the resulting estimator  $\hat{\rho}_A = \rho_F + \hat{\rho}_\varepsilon$  as an *external* precision signal. Given the discreteness of  $\rho_A$ , we assume that  $\hat{\rho}_A$  is discrete as well, i.e.,  $\hat{\rho}_A \in \{L, H\}$ . The estimate equals the true precision with probability  $1 - p_{err}$ , i.e.,  $P(\hat{\rho}_A = H | \rho_A = h) = P(\hat{\rho}_A = L | \rho_A = l) = 1 - p_{err}$ . Hence,  $p_{err}$  reflects the estimation error in the external precision estimate. Finally, we assume that the announcement  $A$  and the precision signal  $\hat{\rho}_A$  are conditionally independent, given the

---

<sup>3</sup>This kind of discretization is employed in the empirical implementation and makes the theoretical setting directly applicable. Nevertheless, the setting is readily extended to a continuous framework which, however, does not provide additional insights.

true precision  $\rho_A$ .

Bayesian updating of traders' expectations yields

$$\mu_P = E[X | A, \hat{\rho}_A] = \mu_F + (A - \mu_F) \frac{E[\rho_A | A, \hat{\rho}_A]}{\rho_F} = \mu_F + S \cdot \pi(S, \hat{\rho}_A),$$

with  $E[\rho_A | A, \hat{\rho}_A]$  representing traders' conditional expectation of the precision of the news given the available information. As shown in Appendix A, this conditional expectation is given by a weighted average of the form

$$E[\rho_A | A, \hat{\rho}_A] = E[\rho_A | S, \hat{\rho}_A] = \frac{h \cdot \phi_h(S) \cdot P(\hat{\rho}_A | h) + l \cdot \phi_l(S) \cdot P(\hat{\rho}_A | l)}{\phi_h(S) \cdot P(\hat{\rho}_A | h) + \phi_l(S) \cdot P(\hat{\rho}_A | l)},$$

where  $\phi_{\rho_A}(x)$  denote  $N(0, \rho_A^{-1})$  density functions with  $\rho_A \in \{l, h\}$  and  $P(\hat{\rho}_A | \rho_A)$  being the conditional probability for having the estimate  $\hat{\rho}_A \in \{L, H\}$  given  $\rho_A \in \{l, h\}$ . Hence, the price response coefficient,  $\pi(\cdot)$ , is no longer constant but depends on both, the external precision signal and the surprise  $S$  itself serving as an internal signal on its own precision.

The following proposition shows that traders' conditional expectations of the precision of the news positively depend on the external precision signal  $\hat{\rho}_A$ . Hence, the central implication of Bayesian learning that prices react more strongly to news that is perceived to be more precise, still holds:

**Proposition 1** : *As long as the external signal  $\hat{\rho}_A$  is informative, i.e.,  $p_{err} < 0.5$ , the*



price response coefficient  $\pi(S, \hat{\rho}_A)$  and thus the absolute price change  $|\mu_P - \mu_F|$  is larger in the case of  $\hat{\rho}_A = H$  than in the case of  $\hat{\rho}_A = L$ , i.e.,  $E[\rho_A|A, \hat{\rho}_A = H] > E[\rho_A|A, \hat{\rho}_A = L]$ .

**Proof:** See Appendix A.

Analyzing the impact of surprises  $S$  themselves, we show that its (absolute) size  $|S|$  is negatively related to the expected precision of releases:

**Proposition 2 :** *If market participants face uncertainty regarding the precision of the news (i.e.,  $p_{err} > 0$ ), the price response coefficient  $\pi(S, \hat{\rho}_A)$  is strictly decreasing in the absolute value of the surprise:  $\partial\pi(S, \hat{\rho}_A)/\partial|S| < 0$ .*

**Proof:** See Appendix A.

Intuitively, traders interpret large surprises as being "too large to be true" and consequently associate them with low reliability. Conversely, surprises that are small in magnitude appear not to be very noisy. Consequently, the ultimate change in traders' expectations ( $\mu_P - \mu_F$ ) and thus the implied price change  $\Delta P = \nu(\mu_P - \mu_F)$  are determined by two effects. First, given the price response coefficient  $\pi(\cdot)$ , a high (low) surprise  $S$  strengthens (weakens) the price reaction linearly. Second, it decreases (increases) the expected signal

precision and thus decreases (increases)  $\pi(\cdot)$ . The resulting price response function is thus nonlinear in  $S$ .

As one of the major results of the paper, we illustrate that the strength of price adjustments also depends on the precision of the external estimate  $\hat{\rho}_A$ . The following proposition shows that the uncertainty parameter  $p_{err}$  determines how much weight market participants place on both the internal and external precision signals:

**Proposition 3** : *A higher error probability  $p_{err}$  underlying the external precision signal leads to the weakening (strengthening) of the absolute price reaction if the external precision signal indicates a high (low) precision, i.e.,  $\partial|E[X | A, \rho_A = h] - \mu_F|/\partial p_{err} < 0$  and  $\partial|E[X | A, \rho_A = l] - \mu_F|/\partial p_{err} > 0$ .*

**Proof:** *See Appendix A.*

In the extreme case of  $p_{err} = 0$ , the precision of the news is completely revealed by the external signal; therefore  $\rho_A$  is known with certainty. In this scenario, the size of a surprise,  $|S|$ , no longer has informational value, and the nonlinearity in price response functions vanishes. Then, the price response curves are linear with the slopes determined by  $\rho_A$ . Conversely, when the external precision signal is completely uninformative, i.e.,  $p_{err} = 0.5$ , traders cannot employ external information to discriminate between precise and imprecise

news. Then, the curves associated with  $\rho_A = l$  and  $\rho_A = h$  coincide and converge to an average of both (given that  $P(\rho_A = j) = 0.5$  for  $j \in \{l, h\}$ ). The resulting single curve is nonlinear. This scenario corresponds to the setting outlined in Subramanyam (1996), where market participants gather information on the precision of the news by only relying on the released figure itself. As illustrated in the following section, for the case where  $0 < p_{err} < 0.5$ , price responses are driven by a combination of both extreme effects.

## II. Data and Empirical Framework

### A. Data

We do not estimate the model in a structural way, as this would require additional structural assumptions in order to estimate  $E[\rho_A|A, \hat{\rho}_A]$ . Therefore, we instead test the implications of the model in reduced form by estimating the shape of the price reaction curve in response to  $S$  and the perceived precision of news,  $\hat{\rho}_A$ . We use intraday returns of CBOT 10-year Treasury bond futures, corresponding to one of the most liquid futures markets, as well as monthly releases of the U.S. employment report. This report is by far the most influential scheduled macroeconomic release, and its impact on financial markets

is investigated in a wide range of studies.<sup>4</sup> While the employment report contains detailed information on the employment situation in the U.S., market participants focus in particular on two headline figures: the nonfarm payrolls figure and the unemployment rate figure. The release of the employment report offers a rare opportunity to analyze Bayesian learning effects in price adjustments to news, as both the amount of unanticipated information *and* a release-specific precision measure can be obtained.

Hautsch and Hess (2007) document the importance of the precision of the news in a framework where traders are assumed to use external information to make inferences about the precision of news. To facilitate a comparison with these results, we employ an almost identical data set based on two-minute log returns of 10-year Treasury bond futures in 90-minute windows around employment announcements. In particular, our dataset covers a sample of 15 years, from January 4th, 1991 to December 2nd, 2005, of high-frequency Treasury bond data obtained from the Chicago Board of Trade (via their Time & Sales records). Log returns are calculated on the basis of the last trading price observed during a two-minute interval. We use the same time window, 8:22-9:52 a.m. EST. Because trading starts at 8:20, we discard the first interval. In order to avoid interference with other announcements, released at 10:00 a.m. EST, only price observations up to 9:52 a.m. EST

---

<sup>4</sup>See, e.g., Fleming and Remolona (1999c), Hautsch and Hess (2002), Andersen, Bollerslev, Diebold, and Vega (2003) or Boyd, Hu, and Jagannathan (2005).

are used. As in most previous studies, we focus on the front month contract, i.e., the most actively traded contract among the nearby and second nearby contracts. From our sample period, we obtain 161 event windows in which no other major information event occurs aside from the release of the employment report.<sup>5</sup> With this setting, we can be quite sure that information processing during these event windows is primarily driven only by employment figures. In line with previous studies, we use so-called consensus estimates, i.e., medians of analysts' forecasts, to approximate the anticipated part of information in the employment headline figures. These analysts' forecasts are obtained from Informa Global Markets (formerly S&P Money Market Services, MMS).<sup>6</sup> The announcement data are extracted from the original, unrevised employment releases from the Bureau of Labor Statistics (BLS).

---

<sup>5</sup>We eliminate 15 days in which other reports were released during our 90-minute window, particularly releases of Leading Indicators, Personal Income, and the Gross Domestic Product. Furthermore, we eliminate one inadvertently early employment release in November 1998 (Fleming and Remolona 1999b) and another three releases that were presumably affected by the temporary shutdown of federal agencies due to the budget dispute during the Clinton administration. This leaves us with a total of 161 observations.

<sup>6</sup>The use of MMS survey forecasts to approximate market participants is standard in the literature. See, for example, McQueen and Roley (1993), Balduzzi, Elton, and Green (2001), Flannery and Protopadakis (2002) or Andersen, Bollerslev, Diebold, and Vega (2003), to cite only a few. For a recent study on the rationality of these forecasts, see Hess and Orbe (2010).

In line with other studies, we concentrate on the headline information in the employment report, i.e., surprises in the nonfarm payrolls figure  $S_{NF}$  and the unemployment rate  $S_{UN}$ . The surprise in releases of month  $m$  is then measured as the difference between the announced figure  $A_{.,m}$  and its median forecast  $\mu_{F,.,m}$ . Note that nonfarm payrolls are revised in the subsequent month. This revision information,  $R_{NF,m}$ , is included into our analysis as well. In order to facilitate a direct comparison across the information components, all surprise and revision variables are measured in percentage changes.

To measure information precision, we follow the procedure outlined in Hautsch and Hess (2007). First, the precision of prior information,  $\rho_F$ , is estimated using the inverse of the cross-sectional standard deviation of analysts' forecasts  $\hat{s}_{F,m}$  for a particular month  $m$ , i.e.,  $\hat{\rho}_{F,m} = \hat{s}_{F,m}^{-2}$ . This is well in accordance with Abarbanell, Lanen, and Verrecchia (1995), Mohammed and Yadav (2002), Andersen, Bollerslev, Diebold, and Vega (2003) and Hautsch and Hess (2007), among others. See, for example Pasquariello and Vega (2007) for a detailed discussion of the properties of analysts' forecasts dispersion. Second, in order to obtain a measure for the precision of the announced information  $\rho_\varepsilon$  itself, we exploit information in revisions of releases. A large revision of the previous month's figure (as provided in the *current* report) indicates that the reliability of this release has been poor. Unfortunately, at the time of an announcement, it is unknown to what extent the currently released information will be revised one month later. Nevertheless, we exploit

the fact that the *size* of revisions is autocorrelated and thus predictable. Specifically, we compute out-of-sample forecasts using ARMA-GARCH models fitted to the time series of revisions based on rolling 10-year windows. For this exercise we use an extended sample of real-time revisions, i.e., 1980 - 2005, obtained from the Federal Reserve's ALFRED database. Model specification and (re-)estimation are done on a monthly basis. Then,  $\hat{\rho}_{\varepsilon,m}$  is computed as the one-step-ahead forecast of the (conditional) variance of revisions,  $\hat{\rho}_{\varepsilon,m} = \hat{V}[R_{NF,m}|R_{NF,m-1}, R_{NF,m-2}, \dots]^{-1}$ .

To reduce the impact of estimation noise on the quantification of the precision of the news and to avoid the need to impose additional assumptions on the functional relationship between the precision measure and the induced price reaction, we distinguish (in line with our theoretical setup) only between precise and imprecise news. It is sensible to assess the magnitude of the precision of the news relative to the (estimated) precision of prior information,  $\hat{\rho}_{F,m}$ . Therefore, we define two dummy variables  $D^{\pi high}$  and  $D^{\pi low}$  indicating whether  $\hat{\pi}_m = \hat{\rho}_{\varepsilon,m}/(\hat{\rho}_{\varepsilon,m} + \hat{\rho}_{F,m})$  is above (precise news) or below (imprecise news) its sample median.

Summary statistics for the main variables are given in Table I. We distinguish between the entire sample as well as subsamples differentiated by the value of the external precision signal. To control for the possible impact of the general state of the economy on news' quality, we also report summary statistics for observations for which the NBER indicated

that the economy had been in a recession (12 out of 161 months). However, there is no systematic link of NBER recessions and the value of the precision measure. Interestingly, we observe a larger range of surprises in states of low information precision. This is well in accordance with our model, since lower precision implies a larger variance of announcements. Table II reports correlations of log returns and the main news variables. As a first piece of evidence supporting our theoretical predictions we can see that price responses are stronger (negatively) correlated with nonfarm payrolls surprises when the information is perceived to more precise.

## B. Specification of Price Response Curves

We model the two-minute log return process during the 90-minute-window around news arrival based on ARMA-GARCH specifications augmented by regressors  $x_t$  capturing the impact of announced information,

$$r_t = c + \sum_{j=1}^{p_1} \phi_{1,j} r_{t-j} + \sum_{j=1}^{q_1} \phi_{2,j} \varepsilon_{t-j} + x_t' \beta + \varepsilon_t, \quad \varepsilon_t \sim N(0, h_t), \quad (1)$$

with

$$h_t = \omega + \sum_{j=1}^{p_2} \psi_{1,j} \varepsilon_{t-j}^2 + z_t' \theta, \quad (2)$$

where  $t$  indexes the two-minute intervals around the release of the employment report for a given month  $m$ . In particular,  $t = 0$  indicates the interval immediately following the



announcement, i.e., 8:30 - 8:32 a.m. EST, whereas  $t = 1$  denotes the 8:32 - 8:34 interval. For simplicity, the index  $m$  is suppressed.

To account for conditional heteroskedasticity, the conditional variance equation (2) captures ARCH effects. In addition,  $z_t$  consists of regressors controlling for deterministic volatility patterns around news releases. As in Hautsch and Hess (2007), these patterns are modeled using a flexible Fourier form approximation defined over the 90-minute announcement interval. Though it is evident that such a specification captures most of the variation in conditional variances during the analyzed period we cannot exclude the possibility of remaining heteroskedasticity in the error terms. Therefore, we use robust standard errors as proposed by Bollerslev and Wooldridge (1992).

To test for non-linearities, we use different specifications of the vector  $x_t$ , covering the cases of linear and nonlinear news response functions as well as the distinction between precise and imprecise news. Possible nonlinearities in news responses are captured by polynomial terms of the surprise, whereas the precision of the news is indicated by interactions with  $D^{\pi^{high}}$  and  $D^{\pi^{low}}$ . To keep the model parsimonious and tractable, we mainly concentrate on the price response induced by announcements in nonfarm payrolls, which is by far the most influential macroeconomic headline figure.

### III. Empirical Results

Table III reports estimation results based on five different specifications of equation (1) allowing for different degrees of nonlinearities in the price response function to nonfarm payroll surprises. The lag order of the autoregressive components in both the mean and variance function is chosen according to the Bayes information criterion (BIC) and reveals an AR(2)-ARCH(3) specification as the preferred model. Apart from the variables capturing the price response to nonfarm payroll surprises, the conditional mean function includes variables capturing surprises in the unemployment rate  $S_{UN}$  as well as revisions in the nonfarm payrolls figure  $R_{NF}$ . Moreover, we allow for potential information leakage effects in the interval 8:28-8:30 as well as lagged price responses in the interval 8:32-8:34.

Specification (A) provides estimation results for the most restrictive model, which does not account for any release-specific precision and assumes only one single linear price response function. This is equivalent to assuming that precision is constant over time and is known corresponding to a specification used in most previous studies.<sup>7</sup> Estimation results largely confirm previous findings: first, the large values of the highly significant coefficients of  $D_{8:30} \cdot S_{NF}$  and  $D_{8:30} \cdot S_{UN}$  show that surprising headline information has

---

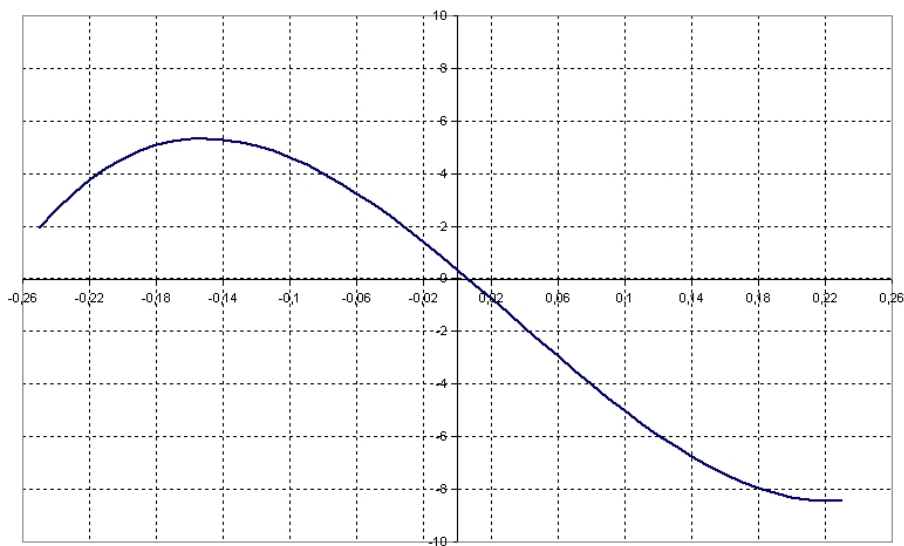
<sup>7</sup>See, for example, Balduzzi, Elton, and Green (2001), Fleming and Remolona (1999a, b, c), or Hautsch and Hess (2002) for bond markets, McQueen and Roley (1993) for stock markets and Almeida, Goodhart, and Payne (1998) or Andersen, Bollerslev, Diebold, and Vega (2003) for foreign exchange markets.

an immediate, strong, and significant impact on intraday returns. The directions of observed price reactions are consistent with standard theory, i.e., 10-year Treasury bond futures prices increase in response to "good" news from the labor factor, i.e., a lower-than-expected increase in nonfarm payrolls and a higher-than-expected unemployment rate. Second, markets process unanticipated headline information very rapidly. As indicated by the insignificant coefficient of  $D_{8:32} \cdot S_{UN}$  and the relatively small coefficient of  $D_{8:32} \cdot S_{NF}$  (as compared to  $D_{8:30} \cdot S_{NF}$ ), the price reaction is completed within two to four minutes.

Specifications (B) - (E) allow for nonlinearities in price responses by including  $D_{8:30} \cdot S_{NF}$  as polynomial terms up to order five. Though our theoretical model suggests only symmetric price reactions around zero, the imposed polynomials also capture possible asymmetric effects of "good" and "bad" news in price responses to information releases. This is in line with, e.g., Conrad, Cornell, and Landsman (2002), Andersen, Bollerslev, Diebold, and Vega (2003) or Hautsch and Hess (2007). Specification (B) gives estimation results for a quadratic price response specification, while specifications (C), (D), and (E) include terms up to the orders three, four, and five, respectively. According to likelihood ratio (LR) tests evaluating the individual specifications against each other and the Bayesian information criterion (BIC), we find specification (C) to be mostly supported by the data.

Figure 1 shows the corresponding estimated price response functions according to specification (C). The strong nonlinearities depicted by this function suggest that market participants are aware of a variation in the precision of information across individual releases and that they try to infer this release-specific precision from inspecting the size of surprises. The S-shape pattern clearly indicates that surprises that are "too large to be true" induce lower (marginal) price reactions.

**FIGURE 1:**  
**Estimated price response curve allowing only for size-based signals**

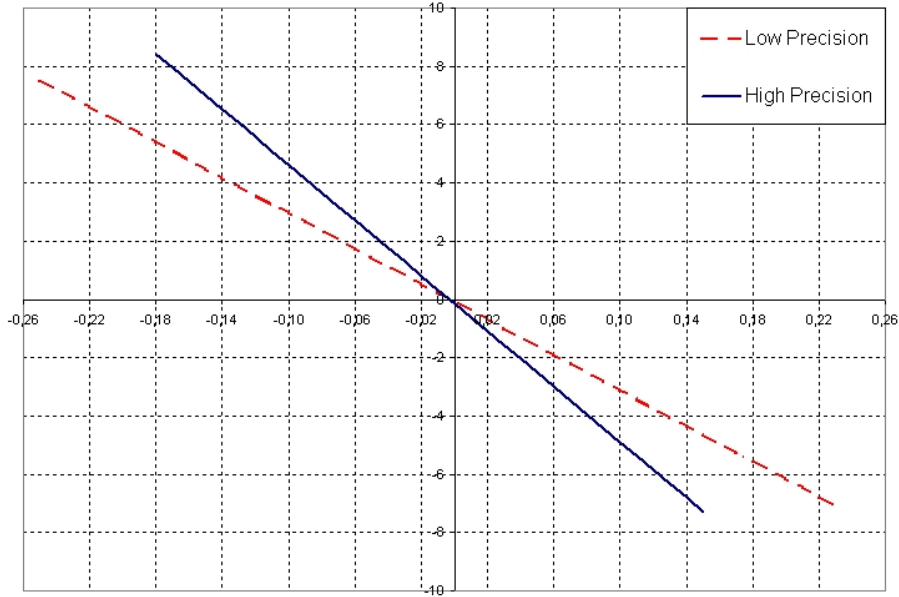


Estimated price response function according to specification (C) in Table III. x-axis: surprises in the U.S. nonfarm payrolls figure  $S_{NF}$  (in percentage points), y-axis: estimated price response  $\hat{r}_t$  (log-returns  $\times 1000$ ).

To test whether market participants are trying to infer the release-specific precision

from external information and hence react differently according to high or low external estimates, we interact the variable  $D_{8:30} \cdot S_{NF}$  and corresponding higher-order terms with the dummy variables  $D^{\pi high}$  and  $D^{\pi low}$ . The corresponding estimation results are given in Table IV. The results for specification (F) associated with linear price response functions are largely in line with the findings of Hautsch and Hess (2007), i.e., more precise information leads to significantly stronger (linear) price adjustments. The resulting price response functions for specification (F) are shown in Figure 2. A comparison of the goodness-of-fit of specifications (A) and (F) based on LR tests and likelihood values, the inclusion of precision dummies leads to a significant improvement in the model's goodness-of-fit. This suggests that market participants' reactions to precise vs. imprecise news are better explained by precision estimates on the basis of external information rather than on the basis of the magnitude of surprises solely.

**FIGURE 2:**  
**Estimated linear price response curves for high and low external precision signals**

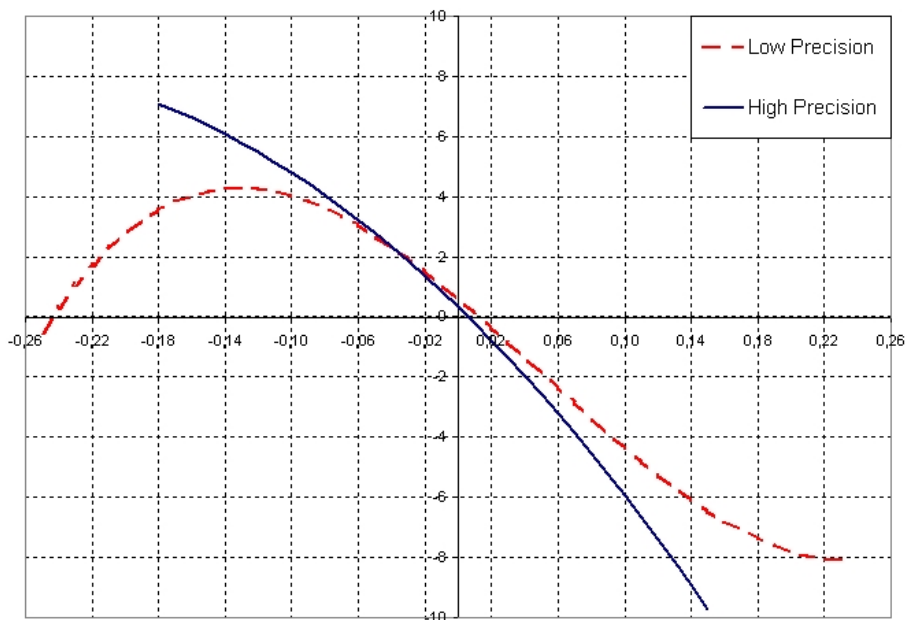


Estimated price response function according to specification (F) in Table IV. x-axis: surprises in the U.S. nonfarm payrolls figure  $S_{NF}$  (in percentage points), y-axis: estimated price response  $\hat{r}_t$  (log-returns  $\times 1000$ ).

Finally, successively introducing polynomial terms up to the third order in specifications (G)-(L), we allow for more flexible functional forms and thus, for the case that market participants base their trading decision on both precision proxies. Higher-order polynomials (results not reported) do not significantly improve the model fit. As shown in Table IV, the individual interactions are highly significant. To test for the economic significance of (external) precision effects, we employ a battery of LR tests. It turns out that the most general specification (L) clearly rejects specification (C), providing evidence for the importance of the precision of the news. On the other hand, (L) is rejected against

the more parsimonious specification (J), which yields the highest likelihood value and the second-highest BIC.<sup>8</sup>

**FIGURE 3:**  
**Estimated price response curves allowing for both  
size-based and external precision signals**



Estimated price response function according to specification (J) in Table IV. x-axis: surprises in the U.S. nonfarm payrolls figure  $S_{NF}$  (in percentage points), y-axis: estimated price response  $\hat{r}_t$  (log-returns  $\times 1000$ ).

We thus find evidence for market participants inferring information precision not only from the magnitude of surprises but also from external information. Finding significantly different price response curves associated with precise and imprecise news suggests that

---

<sup>8</sup>In terms of the BIC, specifications (C) and (J) yield a comparable fit as induced by the BIC's strong penalization of additional regressors to avoid over-fitting.

the external precision signal is not completely noisy and is obviously taken into account. On the other hand, the strong nonlinearities in the price response functions indicate that traders seem to be well aware of possible errors in the precision estimate, making it necessary to also exploit the size of surprises.

Figure 3 shows that price reactions are particularly nonlinear if the perceived precision using external information is low. In contrast, the nonlinearity is dampened if the external precision signal is high. In this case, we observe a much more linear relationship between price changes and surprises. Consequently, if an announcement is perceived to be of relatively high precision, market participants react to large surprises with almost the same strength as they do to small surprises. In contrast, if the external precision measure indicates that the announced information is of low quality, investors react more moderately to larger surprises. Given the nearly linear shape of the price response curve in a state of high information precision, it seems that market participants almost ignore surprises' size once the precision estimate indicates a high reliability.

Note that instead of capturing nonlinearities based on power functions, we also estimated the model using flexible spline functions defined over the range of surprises receiving. The fact that we get quantitatively the same results indicates the robustness of our findings.<sup>9</sup>

As with any empirical analysis, the question remains whether other potential reasons could explain the observed data. A maintained hypothesis throughout the paper is that the "true" price dependence on the released news is linear. While bond prices are convex

---

<sup>9</sup>For the sake of brevity, the latter results are not included in the paper, but they are available upon request from the authors.



in interest rates, at least for the observed small range of intradaily price changes it seems save to assume that price changes are approximately linear in yield changes. Nevertheless, the question remains whether employment news might affect interest rates for some other reason in a non-linear fashion. But it is difficult to imagine factors what could generate an s-shaped response. For example, the news content of employment could be be dependent on the anticipated Federal Reserve response to the implications for both inflation and real growth. The likelihood of a Federal Reserve move could well depend on the size of the announcement. However, if at all, a move would be more (not less) likely when larger changes in (un)employment are reported. Hence, it would be difficult to explain why traders might conjecture that the Federal Reserve will hold tight in face of a large employment drop, if is not that they believe the Federal Reserve also will deem the data to be unreliable. Likewise, other factors might influence the price dependence on employment news, for example, option expiration days or rollover effects. However, it is quite unlikely that these effects are systematically related to a information precision of a macroeconomic release.

## IV. Conclusion

Announcements of macroeconomic variables are inherently noisy. From standard Bayesian learning theory, we know that the reliability of news releases has an impact on to what degree investors update their beliefs about the underlying fundamental. However, empirical evidence on these effects is virtually nonexistent. A major reason is that information on the precision of the news is rarely disclosed and thus is itself unknown. In this paper,

we theoretically and empirically analyze the role of information precision if the latter is unknown and has to be estimated by market participants. We introduce a framework in which traders can learn about the precision of news from additional (external) information such as, for example, sampling statistics or sampling error estimates from underlying surveys. Moreover, traders can make inferences from the observed surprise itself. In particular, if no other information is available, the size of a surprise is negatively correlated with the reliability of the news, inducing price updates that are nonlinear in terms of the underlying surprise.

We show that the relative importance of both precision signals and thus the shape of the resulting price response functions ultimately depend on the efficiency of the precision estimator. In the extreme case of an error-free precision estimate, the model boils down to a standard Bayesian learning framework with known precision parameters. In this context, the price response function is linear with the slope determined by the precision of the news. In contrast, if the external precision estimate is completely uninformative, traders only can make inferences from the announced information itself. The intuition that a surprise that is "too large to be true" reduces the probability that the news is reliable and induces an S-shaped price response. For intermediate cases between these two extremes, we observe mixtures of both scenarios driven by the error probability of the precision estimate.

Analyzing the impact of U.S. nonfarm payroll announcements on high-frequency data of the U.S. Treasury bond future, we provide evidence for the importance of the precision of the news. By estimating the precision of the news based on information on nonfarm payroll revisions, following the procedure suggested by Hautsch and Hess (2007), we distinguish between the cases of more and less precise news. The estimated price response functions

are in line with the theoretical predictions of the proposed extended Bayesian learning model and significantly support the hypothesis that market participants indeed account for both external and size-based precision signals. Observing two significantly different price response functions for the cases of precise and imprecise news implies that market participants obviously employ additional data to obtain information on the precision of the news. Observing also strong nonlinearities in the price response functions indicates that traders are obviously aware of possible estimation errors in the external precision estimate and thus consider also the size of surprises as an indicator for the reliability of releases. In fact, this nonlinearity is clearly stronger when the external signal suggests a low precision. This indicates that the incremental value of a surprise's size depends on whether market participants expect precise or imprecise information to be released.

Overall, our empirical results show that precision effects are important. Ignoring the reliability of the news can lead to significant under- or overestimations of price responses. Given the strong impact of announcements of the leading macroeconomic figures on several markets, a better understanding of the price updating process is crucial for portfolio management, risk management and asset allocation. In this sense, the current paper makes a contribution that should be of interest not only to academics but also to practitioners.

## Appendix A

We first derive the posterior beliefs of traders after observing an announcement  $A$  and an external signal on its precision  $\hat{\rho}_A$  which may take on the values  $H, L$ . Recall the assumption that these random variables are conditionally independent given the true precision  $\rho_A$ , i.e.,

$$f_{A, \hat{\rho}_A | \rho_A}(A, \hat{\rho}_A | \rho_A) = f_{A | \rho_A}(A | \rho_A) f_{\hat{\rho}_A | \rho_A}(\hat{\rho}_A | \rho_A) = f_{A | \rho_A}(A | \rho_A) P(\hat{\rho}_A | \rho_A).$$

Then, the conditional expectation of  $X$  given  $A$  and  $\hat{\rho}_A$  is given by

$$\begin{aligned} \mu_P &= \mathbb{E}[X | A, \hat{\rho}_A] \\ &= \mathbb{E}[E[X | A, \hat{\rho}_A, \rho_A] | A, \hat{\rho}_A] \\ &= \mathbb{E}[\mu_F + (A - \mu_F)\rho_A/\rho_F | A, \hat{\rho}_A] \\ &= \mu_F + \mathbb{E}[(A - \mu_F)\rho_A/\rho_F | A, \hat{\rho}_A] \\ &= \mu_F + (A - \mu_F)\mathbb{E}[\rho_A | A, \hat{\rho}_A]/\rho_F \\ &\equiv \mu_F + S \cdot \pi(S, \hat{\rho}_A). \end{aligned}$$

The expected precision of the announcement is obtained by

$$\begin{aligned}
E[\rho_A | A, \hat{\rho}_A] &= \int_{S_{\rho_A}} \rho_A f(\rho_A | A, \hat{\rho}_A) d\rho_A \\
&= \int_{S_{\rho_A}} \rho_A \frac{f(A, \hat{\rho}_A | \rho_A) f(\rho_A)}{f(A, \hat{\rho}_A)} d\rho_A \\
&= \frac{\int_{S_{\rho_A}} \rho_A f(A | \rho_A) f(\hat{\rho}_A | \rho_A) f(\rho_A) d\rho_A}{f(A, \hat{\rho}_A)} \\
&= \frac{\int_{S_{\rho_A}} \rho_A f(A | \rho_A) f(\hat{\rho}_A | \rho_A) f(\rho_A) d\rho_A}{\int_{S_{\rho_A}} f(A, \hat{\rho}_A | \rho_A) f(\rho_A) d\rho_A} \\
&= \frac{\int_{S_{\rho_A}} \rho_A f(A | \rho_A) f(\hat{\rho}_A | \rho_A) f(\rho_A) d\rho_A}{\int_{S_{\rho_A}} f(A | \rho_A) f(\hat{\rho}_A | \rho_A) f(\rho_A) d\rho_A},
\end{aligned}$$

where the support of  $f(\rho_A)$  is given by  $S_{\rho_A} \in (0, \rho_F)$ . In our setup, we obtain

$$E[\rho_A | A, \hat{\rho}_A] = E[\rho_A | S, \hat{\rho}_A] = \frac{h \cdot \phi_h(S) \cdot P(\hat{\rho}_A | h) + l \cdot \phi_l(S) \cdot P(\hat{\rho}_A | l)}{\phi_h(S) \cdot P(\hat{\rho}_A | h) + \phi_l(S) \cdot P(\hat{\rho}_A | l)},$$

where  $\phi_{rho_A}(x)$  denote  $N(0, \rho_A^{-1})$  density functions with precisions  $\rho_A \in \{h, l\}$ . The fact that  $E[\rho_A | A, \hat{\rho}_A] = E[\rho_A | S, \hat{\rho}_A]$  is induced by the assumption that  $\mu_F = E[A]$  is assumed to be known. Using these relations we now turn to the proofs of the particular theorems.

**Proof of Theorem 1:** We need to show that the inequality

$$E[\rho_A | A, h] > E[\rho_A | A, l]$$

holds. This follows directly from

$$\begin{aligned} E[\rho_A | A, h] &> E[\rho_A | A, l] \\ \frac{h \cdot \phi_h(S) \cdot (1 - p_{err}) + l \cdot \phi_l(S) \cdot p_{err}}{\phi_h(S) \cdot (1 - p_{err}) + \phi_l(S) \cdot p_{err}} &> \frac{h \cdot \phi_h(S) \cdot p_{err} + l \cdot \phi_l(S) \cdot (1 - p_{err})}{\phi_h(S) \cdot p_{err} + \phi_l(S) \cdot (1 - p_{err})} \\ (1 - 2 \cdot p_{err})(h - l) \cdot \phi_h(S) \cdot \phi_l(S) &> 0. \quad \square \end{aligned}$$

**Proof of Theorem 2:** Due to conditional normality, we have  $\partial\phi_{\rho_A}(S)\partial S^2 = (-\frac{1}{2}\rho_A)\phi_{\rho_A}(S)$ . We need to show that the partial derivative of the conditional expected precision with respect to the absolute surprise is strictly negative:

$$\begin{aligned} \frac{\partial E[\rho_A | A, \hat{\rho}_A]}{\partial S^2} &= \frac{\partial}{\partial S^2} \frac{h \cdot \phi_h(S) \cdot P(\hat{\rho}_A | h) + l \cdot \phi_l(S) \cdot P(\hat{\rho}_A | l)}{\phi_h(S) \cdot P(\hat{\rho}_A | h) + \phi_l(S) \cdot P(\hat{\rho}_A | l)} \\ &= \frac{\frac{\partial}{\partial S^2}[h \cdot \phi_h(S) \cdot P(\hat{\rho}_A | h) + l \cdot \phi_l(S) \cdot P(\hat{\rho}_A | l)](\phi_h(S) \cdot P(\hat{\rho}_A | h) + \phi_l(S) \cdot P(\hat{\rho}_A | l))}{(\phi_h(S) \cdot P(\hat{\rho}_A | h) + \phi_l(S) \cdot P(\hat{\rho}_A | l))^2} \\ &\quad - \frac{(h \cdot \phi_h(S) \cdot P(\hat{\rho}_A | h) + l \cdot \phi_l(S) \cdot P(\hat{\rho}_A | l))\frac{\partial}{\partial S^2}[\phi_h(S) \cdot P(\hat{\rho}_A | h) + \phi_l(S) \cdot P(\hat{\rho}_A | l)]}{(\phi_h(S) \cdot P(\hat{\rho}_A | h) + \phi_l(S) \cdot P(\hat{\rho}_A | l))^2} \\ &= \frac{-\frac{1}{2}(h^2 \cdot \phi_h(S) \cdot P(\hat{\rho}_A | h) + l^2 \cdot \phi_l(S) \cdot P(\hat{\rho}_A | l))}{\phi_h(S) \cdot P(\hat{\rho}_A | h) + \phi_l(S) \cdot P(\hat{\rho}_A | l)} \\ &\quad - \frac{(-\frac{1}{2})(h \cdot \phi_h(S) \cdot P(\hat{\rho}_A | h) + l \cdot \phi_l(S) \cdot P(\hat{\rho}_A | l))^2}{(\phi_h(S) \cdot P(\hat{\rho}_A | h) + \phi_l(S) \cdot P(\hat{\rho}_A | l))^2} \\ &= -\frac{1}{2} \left[ \frac{h^2 \cdot \phi_h(S) \cdot P(\hat{\rho}_A | h) + l^2 \cdot \phi_l(S) \cdot P(\hat{\rho}_A | l)}{\phi_h(S) \cdot P(\hat{\rho}_A | h) + \phi_l(S) \cdot P(\hat{\rho}_A | l)} \right. \\ &\quad \left. - \left( \frac{h \cdot \phi_h(S) \cdot P(\hat{\rho}_A | h) + l \cdot \phi_l(S) \cdot P(\hat{\rho}_A | l)}{\phi_h(S) \cdot P(\hat{\rho}_A | h) + \phi_l(S) \cdot P(\hat{\rho}_A | l)} \right)^2 \right] \\ &= -\frac{1}{2} (E[\rho_A^2 | A, \hat{\rho}_A] - (E[\rho_A | A, \hat{\rho}_A])^2) \\ &= -\frac{1}{2} Var[\rho_A | A, \hat{\rho}_A] < 0. \end{aligned}$$

Since  $|S|$  and  $S^2$  are positively and monotonically related, the result can be also applied for  $|S|$ . Then, it is straightforwardly shown that  $\partial\pi(S, \hat{\rho}_A)/\partial|S| < 0$ .  $\square$

**Proof of Theorem 3:** We need to show that  $E[\rho_A|A, h]$  is strictly decreasing in  $p_{err}$ .

$$\begin{aligned} \frac{\partial E[\rho_A|A, h]}{\partial p_{err}} &= \frac{\partial}{\partial p_{err}} \frac{h \cdot \phi_h(S) \cdot (1 - p_{err}) + l \cdot \phi_l(S) \cdot p_{err}}{\phi_h(S) \cdot (1 - p_{err}) + \phi_l(S) \cdot p_{err}} \\ &= \frac{(l - h)\phi_h(S)\phi_l(S)}{(\phi_h(S) \cdot (1 - p_{err}) + \phi_l(S) \cdot p_{err})^2} < 0 \end{aligned}$$

Analogously, it may be shown that  $E[\rho_A|A, l]$  is strictly increasing in  $p_{err}$ .  $\square$

# Appendix B

TABLE I  
Summary statistics

---

Panel A: Entire Sample					
	N	mean	std	min	max
$r_t$	161	.0129	.6344	-3.4656	2.2060
$S_{NF}$	161	-.0143	.0856	-.2508	.2233
$S_{UN}$	161	-.0332	.1473	-.4	.4
$R_{NF}$	161	.0182	.1187	-.5952	.7440
NBER recession months	12				
Panel B: $\pi$ high subsample					
	N	mean	std.	min.	max.
$r_t$	81	.0156	.6020	-1.6510	2.2060
$S_{NF}$	81	-.0171	.0788	-.2145	.1508
$S_{UN}$	81	-.0377	.1305	-.3	.3
$R_{NF}$	81	.0316	.0996	-.0727	.7440
NBER recession months	10				
Panel C: $\pi$ low subsample					
	N	mean	std.	min.	max.
$r_t$	80	.0101	.6693	-3.4656	1.3629
$S_{NF}$	80	-.0113	.0924	-.2508	.2233
$S_{UN}$	80	-.0288	.1632	-.4	.4
$R_{NF}$	80	.0046	.1346	-.5952	.5067
NBER recession months	2				

---

The table provides summary statistics for the major variables underlying the study. The sample period covers 15 years (Jan. 1991 - Dec. 2005).  $r_t$  denotes log returns,  $S_{NF}$  surprises in U.S. nonfarm payrolls,  $S_{UN}$  surprises in unemployment rates, and  $R_{NF}$  revisions of previous month's nonfarm payrolls figures (all variables are given in percent). Panel A displays the number of observations (N), sample means (mean), sample standard deviations (std), minima (min) and maxima (max) for the entire sample. Panel B and C give the corresponding statistics for the subsamples for which  $\pi$  is high and low, resp. In addition, the number of recession months according to NBER within these samples are given.



TABLE II  
Correlations

---

	(1) Entire sample	(2) $\pi$ high subsample	(3) $\pi$ low subsample
$Corr(r_t, S_{NF})$	-0.5665	-0.6844	-0.4756
$Corr(r_t, S_{UN})$	0.2137	0.1652	0.2500
$Corr(r_t, R_{NF})$	-0.2236	-0.3710	-0.1293

---

The table displays sample correlations of log returns in the 2-min interval following an announcement with the main news variables.  $r_t$  denotes log returns,  $S_{NF}$  surprises in U.S. nonfarm payrolls,  $S_{UN}$  surprises in unemployment rates, and  $R_{NF}$  revisions of previous month's nonfarm payrolls figures. Column (1) displays correlations for the entire sample, column (2) for the subsample for which  $\pi$  is high and column (3) for the subsample for which  $\pi$  is low.

TABLE III  
 Estimation of price response functions  
 with surprises as a size-based precision signal

Model	(A)	(B)	(C)	(D)	(E)
Mean equation					
<i>cons</i>	-0,002	-0,002	-0,002	-0,002	-0,002
$D^{8:28} \cdot S_{NF}$	4,406	3,619	3,927	4,078	3,829
$D^{8:30}$	-0,080	0,530	0,355	0,558	0,637
$D^{8:30} \cdot S_{NF}^1$	-37,873 ***	-42,415 ***	-53,447 ***	-54,909 ***	-50,344 ***
$D^{8:30} \cdot S_{NF}^2$		-91,220 **	-55,336 *	-119,526	-145,530
$D^{8:30} \cdot S_{NF}^3$			531,752 ***	624,49 ***	80,073
$D^{8:30} \cdot S_{NF}^4$				1658,397	2337,978
$D^{8:30} \cdot S_{NF}^5$					9945,756
$D^{8:32} \cdot S_{NF}$	-4,000 **	-4,322 **	-4,274 **	-4,181 **	-4,277 **
$D^{8:28} \cdot S_{UN}$	1,636	1,278	1,320	1,314	1,175
$D^{8:30} \cdot S_{UN}$	5,003 **	5,617 **	5,746 ***	6,212 ***	6,367 ***
$D^{8:32} \cdot S_{UN}$	1,448 *	1,325	1,356	1,332	1,286
$D^{8:28} \cdot R_{NF}$	2,206	1,841	2,010	1,999	1,839
$D^{8:30} \cdot R_{NF}$	-6,872 ***	-6,390 ***	-6,215 **	-5,889 **	-5,808 **
$D^{8:32} \cdot R_{NF}$	0,083	-0,428	-0,071	-0,106	-0,258
$r_{t-1}$	-0,091 ***	-0,091 ***	-0,090 ***	-0,090 ***	-0,091 ***
$r_{t-2}$	-0,001	0,000	0,000	0,000	0,000
Variance equation					
<i>cons</i>	0,439 ***	0,439 ***	0,436 ***	0,436 ***	0,437 ***
<i>ARCH</i> (1)	0,148 **	0,141 ***	0,146 ***	0,145 ***	0,144 ***
<i>ARCH</i> (2)	0,057 ***	0,059 ***	0,058 ***	0,058 ***	0,058 ***
<i>ARCH</i> (3)	0,031 ***	0,033 ***	0,034 ***	0,034 ***	0,034 ***
LL	-8020,69	-7999,57	-7987,29	-7985,32	-7984,12
BIC	2,2485	2,2439	2,2417	2,2424	2,2433
LR-Test against model (A)		42,24 ***	66,80 ***	70,73 ***	73,13 ***
LR-Test against model (B)			24,56 ***	28,49 ***	30,89 ***
LR-Test against model (C)				3,93 **	6,33 **
LR-Test against model (D)					2,40

---

TABLE III (continued)

QML estimation of AR(2)-ARCH(3) models for two-min log returns during the intraday interval 8:22-9:52 a.m. EST on employment announcement days for which no other macroeconomic report is released at the same time. The sample period is Jan. 1991 - Dec. 2005, resulting in 7245 observations (i.e., 161 days with no overlapping announcements  $\times$  45 2-min intervals).

The estimated model for log returns  $r_t$  is given by  $r_t = c + \sum_{j=1}^2 \phi_j r_{t-j} + x_t' \beta + \varepsilon_t$ , where  $\varepsilon_t \sim N(0, h_t)$ ,  $t$  indexes the first interval after the announcement, 8:30-8:32 a.m.,  $x_t$  denotes a vector of explanatory variables and  $\beta$  is the corresponding coefficient vector.  $h_t$  is given by  $h_t = \omega + \sum_{j=1}^3 \psi_j \varepsilon_{t-j}^2 + s_t$ , where  $s_t = \delta^s \cdot \bar{t} + \sum_{j=1}^5 (\delta_{c,j}^s \cos(j \cdot \bar{t} \cdot 2\pi) + \delta_{s,j}^s \sin(j \cdot \bar{t} \cdot 2\pi))$  denotes the seasonality function based on the parameters  $\delta^s$ ,  $\delta_{c,j}^s$ ,  $\delta_{s,j}^s$  and a normalized time trend  $\bar{t} \in [0, 1]$  given by the elapsed time (in minutes) in the interval 8:22 to 9:52 a.m. divided by 90. The estimated seasonality parameters are omitted in the table.

The regressors  $x_t$  are the surprise in U.S. nonfarm payrolls,  $S_{NF}$ , and in unemployment rates,  $S_{UN}$ , as well as revisions of nonfarm payrolls  $R_{NF}$  interacted with time dummies indicating the intervals 8:28-8:30 a.m. ( $D^{8:28}$ ), 8:30-8:32 a.m. ( $D^{8:30}$ ) and 8:32-8:34 a.m. ( $D^{8:32}$ ). To capture nonlinear immediate price responses in the interval 8:30-8:32, surprises in nonfarm payrolls  $S_{NF}$  are included as polynomials up to the order 5. Surprises are computed based on U.S. employment report figures released by the BLS and consensus forecasts provided by Informa Global Markets, formerly MMS.

The table reports the log likelihood (LL), the Bayes information criterion (BIC) and  $\chi^2$  statistics of LR tests on the inequality of individual parameters. Statistical inference is based on QML standard errors (Bollerslev and Wooldridge 1992). \*\*\*, \*\*, and \* indicates significance at the 1%, 5%, and 10% level, respectively. Except for the LR tests, the level of significance is based on two-sided tests.

---

TABLE IV  
**Estimation of price response functions**  
**differentiated by low and high values of the external precision estimate**

Model	(F)	(G)	(H)	(I)
Mean equation				
<i>cons</i>	-0,002	-0,002	-0,002	-0,002
$D^{8:28} \cdot S_{NF}$	4,365	3,411	3,862	4,147
$D^{8:30} \cdot D^{\pi low}$	-0,074	0,782	0,611	-0,069
$D^{8:30} \cdot D^{\pi high}$	-0,141	0,315	-0,131	0,203
$D^{8:30} \cdot S_{NF}^1 \cdot D^{\pi low}$	-30,439 ***	-34,498 ***	-46,901 ***	-30,356 ***
$D^{8:30} \cdot S_{NF}^1 \cdot D^{\pi high}$	-47,601 ***	-53,413 ***	-47,713 ***	-56,190 ***
$D^{8:30} \cdot S_{NF}^2 \cdot D^{\pi low}$		-106,693 **	-77,937 **	
$D^{8:30} \cdot S_{NF}^2 \cdot D^{\pi high}$		-87,544 *		-61,651
$D^{8:30} \cdot S_{NF}^3 \cdot D^{\pi low}$			503,544 **	
$D^{8:30} \cdot S_{NF}^3 \cdot D^{\pi high}$				217,349
$D^{8:32} \cdot S_{NF}$	-4,020 **	-4,694 **	-4,422 **	-4,305 **
$D^{8:28} \cdot S_{UN}$	1,623	1,197	1,327	1,499
$D^{8:30} \cdot S_{UN}$	5,553 **	6,275 ***	6,286 ***	5,723 **
$D^{8:32} \cdot S_{UN}$	1,484 *	1,286	1,414	1,349
$D^{8:28} \cdot R_{NF}$	2,051	1,701	1,989	1,885
$D^{8:30} \cdot R_{NF}$	-5,901 **	-5,220 **	-5,424 **	-5,585 **
$D^{8:32} \cdot R_{NF}$	-0,080	-0,664	0,010	-0,460
$r_{t-1}$	-0,091 ***	-0,091 ***	-0,091 ***	-0,090 ***
$r_{t-2}$	0,000	0,000	0,000	0,000
Variance equation				
<i>cons</i>	0,437 ***	0,437 ***	0,437 ***	0,437 ***
<i>ARCH(1)</i>	0,151 **	0,143 **	0,148 **	0,148 **
<i>ARCH(2)</i>	0,057 ***	0,059 ***	0,057 ***	0,058 ***
<i>ARCH(3)</i>	0,032 ***	0,035 ***	0,033 ***	0,034 ***
LL	-8008,54	-7982,99	-7981,52	-8002,00
BIC	2,2476	2,2430	2,2426	2,2482
LR-Test against model (A)	24,30 ***	75,40 ***	78,34 ***	37,38 ***
LR-Test against model (F)		51,10 ***	54,04 ***	13,08 ***

TABLE IV (continued)

**Estimation of price response functions  
differentiated by low and high values of the external precision proxy**

Model	(J)	(K)	(L)
Mean equation			
<i>cons</i>	-0,002	-0,002	-0,002
$D^{8:28} \cdot S_{NF}$	3,660	3,400	3,651
$D^{8:30} \cdot D^{\pi low}$	0,630	0,774	0,624
$D^{8:30} \cdot D^{\pi high}$	0,323	0,236	0,264
$D^{8:30} \cdot S_{NF}^1 \cdot D^{\pi low}$	-46,957 ***	-34,580 ***	-46,950 ***
$D^{8:30} \cdot S_{NF}^1 \cdot D^{\pi high}$	-53,605 ***	-55,948 ***	-55,534 ***
$D^{8:30} \cdot S_{NF}^2 \cdot D^{\pi low}$	-78,320 **	-106,453 **	-78,297 **
$D^{8:30} \cdot S_{NF}^2 \cdot D^{\pi high}$	-89,156 *	-66,847	-73,585
$D^{8:30} \cdot S_{NF}^3 \cdot D^{\pi low}$	512,233 **		509,326 **
$D^{8:30} \cdot S_{NF}^3 \cdot D^{\pi high}$		186,343	141,106
$D^{8:32} \cdot S_{NF}$	-4,692 **	-4,693 **	-4,692 **
$D^{8:28} \cdot S_{UN}$	1,169	1,207	1,176
$D^{8:30} \cdot S_{UN}$	6,694 ***	6,097 ***	6,556 ***
$D^{8:32} \cdot S_{UN}$	1,230	1,338	1,267
$D^{8:28} \cdot R_{NF}$	1,707	1,745	1,744
$D^{8:30} \cdot R_{NF}$	-4,736 **	-5,464 **	-4,932 **
$D^{8:32} \cdot R_{NF}$	-0,549	-0,510	-0,435
$r_{t-1}$	-0,091 ***	-0,091 ***	-0,091 ***
$r_{t-2}$	0,000	0,000	0,000
Variance equation			
<i>cons</i>	0,436 ***	0,437 ***	0,436 ***
$\varepsilon_{t-1}^2$	0,146 **	0,143 **	0,146 **
$\varepsilon_{t-2}^2$	0,059 ***	0,059 ***	0,058 ***
$\varepsilon_{t-3}^2$	0,035 ***	0,035 ***	0,035 ***
LL	-7974,53	-7982,74	-7974,38
BIC	2,2419	2,2441	2,2431
LR-Test against model (A)	92,32 ***	75,90 ***	92,62 ***
LR-Test against model (C)			25,82 ***
LR-Test against model (F)	68,02 ***	51,59 ***	68,31 ***
LR-Test against model (G)	16,92 ***	0,50	17,21 ***
LR-Test against model (H)	13,98 ***		14,27 ***
LR-Test against model (I)		38,51 ***	55,22 ***
LR-Test against model (J)			0,29
LR-Test against model (K)			16,71 ***

---

TABLE IV (continued)

QML estimation of AR(2)-ARCH(3) models for two-min log returns during the intraday interval 8:22-9:52 a.m. EST on employment announcement days for which no other macroeconomic report is released at the same time. The sample period is Jan. 1991 - Dec. 2005, resulting in 7245 observations (i.e., 161 days with no overlapping announcements  $\times$  45 2-min intervals).

The estimated model for log returns  $r_t$  is given by  $r_t = c + \sum_{j=1}^2 \phi_j r_{t-j} + x_t' \beta + \varepsilon_t$ , where  $\varepsilon_t \sim N(0, h_t)$ ,  $t$  indexes the first interval after the announcement, 8:30-8:32 a.m.,  $x_t$  denotes a vector of explanatory variables and  $\beta$  is the corresponding coefficient vector.  $h_t$  is given by  $h_t = \omega + \sum_{j=1}^3 \psi_j \varepsilon_{t-j}^2 + s_t$ , where  $s_t = \delta^s \cdot \bar{t} + \sum_{j=1}^5 (\delta_{c,j}^s \cos(j \cdot \bar{t} \cdot 2\pi) + \delta_{s,j}^s \sin(j \cdot \bar{t} \cdot 2\pi))$  denotes the seasonality function based on the parameters  $\delta^s$ ,  $\delta_{c,j}^s$ ,  $\delta_{s,j}^s$  and a normalized time trend  $\bar{t} \in [0, 1]$  given by the elapsed time (in minutes) in the interval 8:22 to 9:52 a.m. divided by 90. The estimated seasonality parameters are omitted in the table.

The regressors  $x_t$  are the surprise in U.S. nonfarm payrolls,  $S_{NF}$ , and in unemployment rates,  $S_{UN}$ , as well as revisions of nonfarm payrolls  $R_{NF}$  interacted with time dummies indicating the intervals 8:28-8:30 a.m. ( $D^{8:28}$ ), 8:30-8:32 a.m. ( $D^{8:30}$ ) and 8:32-8:34 a.m. ( $D^{8:32}$ ). Surprises are computed based on U.S. employment report figures released by the BLS and consensus forecasts provided by Informa Global Markets (IGM), formerly MMS. The variables  $S_{NF}$  are included as polynomials up to order 3 and interact with dummy variables  $D^{\pi^{high}}$  ( $D^{\pi^{low}}$ ) which takes on the value 1 if estimated price response coefficient  $\hat{\pi}_m$  at month  $m$  is higher (lower) than its sample median, and 0 otherwise.  $\hat{\pi}_m$  is given by  $\hat{\pi}_m = \hat{\rho}_{A,m} / (\hat{\rho}_{F,m} + \hat{\rho}_{A,m})$ , where  $\hat{\rho}_{A,m} = 1/\hat{g}_{m+1|m}$ ,  $\hat{g}_{m+1|m}$  is the one-step-ahead prediction of the conditional variance of (percentage) revision of the nonfarm payroll figure in month  $m$ ,  $\hat{R}_{NF,m}$ , computed based on rolling sample ARMA-GARCH models for the time series of historical revisions, and  $\hat{\rho}_{F,m} = 1/\hat{s}_{F,m}^2$  with  $\hat{s}_{F,m}$  denoting the cross-sectional standard deviation of IGM forecasts for the employment release for a particular month  $m$ .

The table reports the log likelihood (LL), the Bayes information criterion (BIC) and  $\chi^2$  statistics of LR tests on the inequality of individual parameters. Statistical inference is based on QML standard errors (Bollerslev and Wooldridge 1992). \*\*\*, \*\*, and \* indicates significance at the 1%, 5%, and 10% level, respectively. Except for the LR tests, the level of significance is based on two-sided tests.

---

## References

- ABARBANELL, J. S., W. N. LANEN, AND R. E. VERRECCHIA (1995): “Analysts’ forecasts as proxies for investor beliefs in empirical research,” *Journal of Accounting and Economics*, 20(1), 31 – 60.
- ADMATI, A., AND P. PFLEIDERER (1988): “A theory of intra-day patterns: Volume and price variability,” *Review of Financial Studies*, 1, 3 – 40.
- ALMEIDA, A., C. A. E. GOODHART, AND R. PAYNE (1998): “The effects of macroeconomic news on high frequency exchange rate behavior,” *Journal of Financial and Quantitative Analysis*, 33(3), 383 – 408.
- ANDERSEN, T. G., T. BOLLERSLEV, F. X. DIEBOLD, AND C. VEGA (2003): “Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange,” *American Economic Review*, 93(1), 38 – 62.
- ARUOBA, B. (2008): “Data Revisions are not Well-Behaved,” *Journal of Money, Credit and Banking*, 40(2 - 3), 319 – 340.
- BALDUZZI, P., E. J. ELTON, AND T. C. GREEN (2001): “Economic news and bond prices: Evidence from the U.S. Treasury market,” *Journal of Financial and Quantitative Analysis*, 36(4), 523 – 543.
- BLUME, L., D. EASLEY, AND M. O’HARA (1994): “Market statistics and technical analysis: The role of volume,” *Journal of Finance*, 49(1), 153 – 181.

- BOLLERSLEV, T., AND J. WOOLDRIDGE (1992): “Quasi-Maximum Likelihood Estimation and Inference in Dynamic Models with Time Varying Covariances,” *Econometric Reviews*, 11(2), 143 – 172.
- BOYD, J. H., J. HU, AND R. JAGANNATHAN (2005): “The Stock Market’s Reaction to Unemployment News: Why Bad News Is Usually Good for Stocks,” *Journal of Finance*, 60(2), 649 – 673.
- BURASCHI, A., AND A. JILTSOV (2006): “Model Uncertainty and Option Markets with Heterogeneous Beliefs,” *Journal of Finance*, 61(6), 2841 – 2897.
- BURASCHI, A., F. TROJANI, AND A. VEDOLIN (2009): “When Uncertainty Blows in the Orchard: Comovement and Volatility Risk Premia,” Discussion paper, Cambridge, MA.
- CONRAD, J., B. CORNELL, AND W. R. LANDSMAN (2002): “When Is Bad News Really Bad News?,” *Journal of Finance*, 57(6), 2507 – 2533.
- DAVID, A. (1997): “Fluctuating confidence in stock markets: Implications for returns and volatility,” *Journal of Financial and Quantitative Analysis*, 32(4), 427 – 462.
- DAVID, A., AND P. VERONESI (2002): “Option prices with uncertain fundamentals,” Discussion paper, Working paper, University of Chicago.
- EASLEY, D., N. KIEFER, AND M. O’HARA (1997): “The information content of the trading process,” *Journal of Empirical Finance*, 4(2 - 3), 159 – 186.
- FLANNERY, M. J., AND A. A. PROTOPAPADAKIS (2002): “Macroeconomic Factors Do Influence Aggregate Stock Returns,” *Review of Financial Studies*, 15(3), 751 – 782.



- FLEMING, M. J., AND E. M. REMOLONA (1999a): “Price Formation and Liquidity in the U.S. Treasury Market: The Response to Public Information,” *Journal of Finance*, 54(5), 1901 – 1915.
- (1999b): “The term structure of announcement effects,” Discussion paper, Federal Reserve Bank of New York.
- (1999c): “What Moves Bond Prices,” *Journal of Portfolio Management*, 25(4), 28 – 38.
- GILBERT, T. (2010): “Information Aggregation Around Macroeconomic Announcements: Revisions Matter,” Discussion paper, University of Washington.
- GILBERT, T., C. SCOTTI, G. STRASSER, AND C. VEGA (2010): “Why Do Certain Macroeconomic News Announcements Have a Big Impact on Asset Prices,” Discussion paper, Boston College.
- GUIDOLIN, M., AND A. G. TIMMERMANN (2003): “Option Prices under Bayesian Learning: Implied Volatility Dynamics and Predictive Densities,” *Journal of Economic Dynamics and Control*, 27, 717 – 769.
- HARRIS, M., AND A. RAVIV (1993): “Difference of opinion make a horse race,” *Review of Financial Studies*, 6(3), 473 – 506.
- HAUTSCH, N., AND D. HESS (2002): “The processing of non-anticipated information in financial markets: Analyzing the impact of surprises in the employment report,” *European Finance Review*, 6(2), 133 – 161.

- (2007): “Bayesian Learning in Financial Markets: Testing for the Relevance of Information Precision in Price Discovery,” *Journal of Financial and Quantitative Analysis*, 42(1), 189 – 208.
- HESS, D., AND S. ORBE (2010): “How Serious is the Anchoring Bias in US Macroeconomic Consensus Forecasts?,” Discussion paper, Centre for Financial Research (CFR), University of Cologne.
- HOLTHAUSEN, R. W., AND R. E. VERRECCHIA (1988): “The effect of sequential information releases on the variance of price changes in an intertemporal multi-asset market,” *Journal of Accounting Research*, 26(1), 82 – 106.
- (1990): “The effect of informedness and consensus on price and volume behavior,” *The Accounting Review*, 65(1), 191 – 208.
- KANDEL, E., AND N. D. PEARSON (1995): “Differential Interpretation of Public Signals and Trade in Speculative Markets,” *Journal of Political Economy*, 103(4), 831 – 872.
- KIM, O., AND R. VERRECCHIA (1991a): “Market reaction to anticipated announcements,” *Journal of Financial Economics*, 30(2), 273 – 309.
- (1991b): “Trading volume and price reactions to public announcements,” *Journal of Accounting Research*, 29(2), 302 – 321.
- (1997): “Pre-announcement and event-period private information,” *Journal of Accounting and Economics*, 24(3), 395 – 419.

- KRUEGER, A. B., AND K. N. FORTSON (2003): “Do Markets Respond More to More Reliable Labor Market Data? A Test of Market Rationality,” *Journal of the European Economic Association*, 1(4), 931 – 957.
- KYLE, A. (1985): “Continuous Auctions and Insider Trading,” *Econometrica*, 22(6), 477 – 498.
- MCQUEEN, G., AND V. V. ROLEY (1993): “Stock Prices, News and Business Conditions,” *Review of Financial Studies*, 6(3), 683 – 707.
- MOHAMMED, S. R., AND P. K. YADAV (2002): “Quality of Information and Volatility Around Earnings Announcements,” Discussion paper, University of Strathclyde.
- PASQUARIELLO, P., AND C. VEGA (2007): “Informed and Strategic Order Flow in the Bond Markets,” *Review of Financial Studies*, 20(5), 1975 – 2019.
- PÁSTOR, Ľ., AND P. VERONESI (2003): “Stock Valuation and Learning about Profitability,” *Journal of Finance*, 58(5), 807 – 837.
- (2009): “Learning in Financial Markets,” *Annual Review of Financial Economics*, 1, *forthcoming*.
- SUBRAMANYAM, K. R. (1996): “Uncertain Precision and Price Reactions to Information,” *Accounting Review*, 71(2), 207 – 220.
- VERONESI, P. (1999): “Stock market overreaction to bad news in good times: A rational expectations equilibrium model,” *Review of Financial Studies*, 12(5), 975 – 1007.
- (2000): “How does information quality affect stock returns,” *Journal of Finance*, 55(2), 807 – 837.

cfr working papers are available for download from [www.cfr-cologne.de](http://www.cfr-cologne.de).

hardcopies can be ordered from: centre for financial research (cfr),  
albertus magnus platz, 50923 koeln, germany.

**2012**

No.	Author(s)	Title
12-06	A. Kempf, A. Pütz, F. Sonnenburg	Fund Manager Duality: Impact on Performance and Investment Behavior
12-05	R. Wermers	Runs on Money Market Mutual Funds
12-04	R. Wermers	A matter of style: The causes and consequences of style drift in institutional portfolios
12-03	C. Andres, A. Betzer, I. van den Bongard, C. Haesner, E. Theissen	Dividend Announcements Reconsidered: Dividend Changes versus Dividend Surprises
12-02	C. Andres, E. Fernau, E. Theissen	Is It Better To Say Goodbye? When Former Executives Set Executive Pay
12-01	L. Andreu, A. Pütz	Are Two Business Degrees Better Than One? Evidence from Mutual Fund Managers' Education

**2011**

No.	Author(s)	Title
11-16	V. Agarwal, J.-P. Gómez, R. Priestley	Management Compensation and Market Timing under Portfolio Constraints
11-15	T. Dimpfl, S. Jank	Can Internet Search Queries Help to Predict Stock Market Volatility?
11-14	P. Gomber, U. Schweickert, E. Theissen	Liquidity Dynamics in an Electronic Open Limit Order Book: An Event Study Approach
11-13	D. Hess, S. Orbe	Irrationality or Efficiency of Macroeconomic Survey Forecasts? Implications from the Anchoring Bias Test
11-12	D. Hess, P. Immenkötter	Optimal Leverage, its Benefits, and the Business Cycle
11-11	N. Heinrichs, D. Hess, C. Homburg, M. Lorenz, S. Sievers	Extended Dividend, Cash Flow and Residual Income Valuation Models – Accounting for Deviations from Ideal Conditions
11-10	A. Kempf, O. Korn, S. Saßning	Portfolio Optimization using Forward - Looking Information

11-09	V. Agarwal, S. Ray	Determinants and Implications of Fee Changes in the Hedge Fund Industry
11-08	G. Cici, L.-F. Palacios	On the Use of Options by Mutual Funds: Do They Know What They Are Doing?
11-07	V. Agarwal, G. D. Gay, L. Ling	Performance inconsistency in mutual funds: An investigation of window-dressing behavior
11-06	N. Hautsch, D. Hess, D. Veredas	The Impact of Macroeconomic News on Quote Adjustments, Noise, and Informational Volatility
11-05	G. Cici	The Prevalence of the Disposition Effect in Mutual Funds' Trades
11-04	S. Jank	Mutual Fund Flows, Expected Returns and the Real Economy
11-03	G.Fellner, E.Theissen	Short Sale Constraints, Divergence of Opinion and Asset Value: Evidence from the Laboratory
11-02	S.Jank	Are There Disadvantaged Clienteles in Mutual Funds?
11-01	V. Agarwal, C. Meneghetti	The Role of Hedge Funds as Primary Lenders

## 2010

No.	Author(s)	Title
10-20	G. Cici, S. Gibson, J.J. Merrick Jr.	Missing the Marks? Dispersion in Corporate Bond Valuations Across Mutual Funds
10-19	J. Hengelbrock, E. Theissen, C. Westheide	Market Response to Investor Sentiment
10-18	G. Cici, S. Gibson	The Performance of Corporate-Bond Mutual Funds: Evidence Based on Security-Level Holdings
10-17	D. Hess, D. Kreutzmann, O. Pucker	Projected Earnings Accuracy and the Profitability of Stock Recommendations
10-16	S. Jank, M. Wedow	Sturm und Drang in Money Market Funds: When Money Market Funds Cease to Be Narrow
10-15	G. Cici, A. Kempf, A. Puetz	The Valuation of Hedge Funds' Equity Positions
10-14	J. Grammig, S. Jank	Creative Destruction and Asset Prices
10-13	S. Jank, M. Wedow	Purchase and Redemption Decisions of Mutual Fund Investors and the Role of Fund Families
10-12	S. Artmann, P. Finter, A. Kempf, S. Koch, E. Theissen	The Cross-Section of German Stock Returns: New Data and New Evidence
10-11	M. Chesney, A. Kempf	The Value of Tradeability
10-10	S. Frey, P. Herbst	The Influence of Buy-side Analysts on Mutual Fund Trading
10-09	V. Agarwal, W. Jiang, Y. Tang, B. Yang	Uncovering Hedge Fund Skill from the Portfolio Holdings They Hide
10-08	V. Agarwal, V. Fos, W. Jiang	Inferring Reporting Biases in Hedge Fund Databases from Hedge Fund Equity Holdings
10-07	V. Agarwal, G. Bakshi,	Do Higher-Moment Equity Risks Explain Hedge Fund

	J. Huij	Returns?
10-06	J. Grammig, F. J. Peter	Tell-Tale Tails
10-05	K. Drachter, A. Kempf	Höhe, Struktur und Determinanten der Managervergütung- Eine Analyse der Fondsbranche in Deutschland
10-04	J. Fang, A. Kempf, M. Trapp	Fund Manager Allocation
10-03	P. Finter, A. Niessen- Ruenzi, S. Ruenzi	The Impact of Investor Sentiment on the German Stock Market
10-02	D. Hunter, E. Kandel, S. Kandel, R. Wermers	Endogenous Benchmarks
10-01	S. Artmann, P. Finter, A. Kempf	Determinants of Expected Stock Returns: Large Sample Evidence from the German Market

## 2009

No.	Author(s)	Title
09-17	E. Theissen	Price Discovery in Spot and Futures Markets: A Reconsideration
09-16	M. Trapp	Trading the Bond-CDS Basis – The Role of Credit Risk and Liquidity
09-15	A. Betzer, J. Gider, D.Metzger, E. Theissen	Strategic Trading and Trade Reporting by Corporate Insiders
09-14	A. Kempf, O. Korn, M. Uhrig-Homburg	The Term Structure of Illiquidity Premia
09-13	W. Bühler, M. Trapp	Time-Varying Credit Risk and Liquidity Premia in Bond and CDS Markets
09-12	W. Bühler, M. Trapp	Explaining the Bond-CDS Basis – The Role of Credit Risk and Liquidity
09-11	S. J. Taylor, P. K. Yadav, Y. Zhang	Cross-sectional analysis of risk-neutral skewness
09-10	A. Kempf, C. Merkle, A. Niessen-Ruenzi	Low Risk and High Return – Affective Attitudes and Stock Market Expectations
09-09	V. Fotak, V. Raman, P. K. Yadav	Naked Short Selling: The Emperor`s New Clothes?
09-08	F. Bardong, S.M. Bartram, P.K. Yadav	Informed Trading, Information Asymmetry and Pricing of Information Risk: Empirical Evidence from the NYSE
09-07	S. J. Taylor , P. K. Yadav, Y. Zhang	The information content of implied volatilities and model-free volatility expectations: Evidence from options written on individual stocks
09-06	S. Frey, P. Sandas	The Impact of Iceberg Orders in Limit Order Books
09-05	H. Beltran-Lopez, P. Giot, J. Grammig	Commonalities in the Order Book
09-04	J. Fang, S. Ruenzi	Rapid Trading bei deutschen Aktienfonds: Evidenz aus einer großen deutschen Fondsgesellschaft
09-03	A. Banegas, B. Gillen, A. Timmermann, R. Wermers	The Performance of European Equity Mutual Funds

09-02	J. Grammig, A. Schrimpf, M. Schuppli	Long-Horizon Consumption Risk and the Cross-Section of Returns: New Tests and International Evidence
09-01	O. Korn, P. Koziol	The Term Structure of Currency Hedge Ratios

## 2008

No.	Author(s)	Title
08-12	U. Bonenkamp, C. Homburg, A. Kempf	Fundamental Information in Technical Trading Strategies
08-11	O. Korn	Risk Management with Default-risky Forwards
08-10	J. Grammig, F.J. Peter	International Price Discovery in the Presence of Market Microstructure Effects
08-09	C. M. Kuhnen, A. Niessen	Public Opinion and Executive Compensation
08-08	A. Pütz, S. Ruenzi	Overconfidence among Professional Investors: Evidence from Mutual Fund Managers
08-07	P. Osthoff	What matters to SRI investors?
08-06	A. Betzer, E. Theissen	Sooner Or Later: Delays in Trade Reporting by Corporate Insiders
08-05	P. Linge, E. Theissen	Determinanten der Aktionärspräsenz auf Hauptversammlungen deutscher Aktiengesellschaften
08-04	N. Hautsch, D. Hess, C. Müller	Price Adjustment to News with Uncertain Precision
08-03	D. Hess, H. Huang, A. Niessen	How Do Commodity Futures Respond to Macroeconomic News?
08-02	R. Chakrabarti, W. Megginson, P. Yadav	Corporate Governance in India
08-01	C. Andres, E. Theissen	Setting a Fox to Keep the Geese - Does the Comply-or-Explain Principle Work?

## 2007

No.	Author(s)	Title
07-16	M. Bär, A. Niessen, S. Ruenzi	The Impact of Work Group Diversity on Performance: Large Sample Evidence from the Mutual Fund Industry
07-15	A. Niessen, S. Ruenzi	Political Connectedness and Firm Performance: Evidence From Germany
07-14	O. Korn	Hedging Price Risk when Payment Dates are Uncertain
07-13	A. Kempf, P. Osthoff	SRI Funds: Nomen est Omen
07-12	J. Grammig, E. Theissen, O. Wuensche	Time and Price Impact of a Trade: A Structural Approach
07-11	V. Agarwal, J. R. Kale	On the Relative Performance of Multi-Strategy and Funds of Hedge Funds
07-10	M. Kasch-Haroutounian, E. Theissen	Competition Between Exchanges: Euronext versus Xetra
07-09	V. Agarwal, N. D. Daniel, N. Y. Naik	Do hedge funds manage their reported returns?

07-08	N. C. Brown, K. D. Wei, R. Wermers	Analyst Recommendations, Mutual Fund Herding, and Overreaction in Stock Prices
07-07	A. Betzer, E. Theissen	Insider Trading and Corporate Governance: The Case of Germany
07-06	V. Agarwal, L. Wang	Transaction Costs and Value Premium
07-05	J. Grammig, A. Schrimpf	Asset Pricing with a Reference Level of Consumption: New Evidence from the Cross-Section of Stock Returns
07-04	V. Agarwal, N.M. Boyson, N.Y. Naik	Hedge Funds for retail investors? An examination of hedged mutual funds
07-03	D. Hess, A. Niessen	The Early News Catches the Attention: On the Relative Price Impact of Similar Economic Indicators
07-02	A. Kempf, S. Ruenzi, T. Thiele	Employment Risk, Compensation Incentives and Managerial Risk Taking - Evidence from the Mutual Fund Industry -
07-01	M. Hagemeister, A. Kempf	CAPM und erwartete Renditen: Eine Untersuchung auf Basis der Erwartung von Marktteilnehmern

## 2006

No.	Author(s)	Title
06-13	S. Čeljo-Hörhager, A. Niessen	How do Self-fulfilling Prophecies affect Financial Ratings? - An experimental study
06-12	R. Wermers, Y. Wu, J. Zechner	Portfolio Performance, Discount Dynamics, and the Turnover of Closed-End Fund Managers
06-11	U. v. Lilienfeld-Toal, S. Ruenzi	Why Managers Hold Shares of Their Firm: An Empirical Analysis
06-10	A. Kempf, P. Osthoff	The Effect of Socially Responsible Investing on Portfolio Performance
06-09	R. Wermers, T. Yao, J. Zhao	Extracting Stock Selection Information from Mutual Fund holdings: An Efficient Aggregation Approach
06-08	M. Hoffmann, B. Kempa	The Poole Analysis in the New Open Economy Macroeconomic Framework
06-07	K. Drachter, A. Kempf, M. Wagner	Decision Processes in German Mutual Fund Companies: Evidence from a Telephone Survey
06-06	J.P. Krahenen, F.A. Schmid, E. Theissen	Investment Performance and Market Share: A Study of the German Mutual Fund Industry
06-05	S. Ber, S. Ruenzi	On the Usability of Synthetic Measures of Mutual Fund Net-Flows
06-04	A. Kempf, D. Mayston	Liquidity Commonality Beyond Best Prices
06-03	O. Korn, C. Koziol	Bond Portfolio Optimization: A Risk-Return Approach
06-02	O. Scaillet, L. Barras, R. Wermers	False Discoveries in Mutual Fund Performance: Measuring Luck in Estimated Alphas
06-01	A. Niessen, S. Ruenzi	Sex Matters: Gender Differences in a Professional Setting

## 2005

No.	Author(s)	Title
05-16	E. Theissen	An Analysis of Private Investors' Stock Market Return Forecasts



05-15	T. Foucault, S. Moinas, E. Theissen	Does Anonymity Matter in Electronic Limit Order Markets
05-14	R. Kosowski, A. Timmermann, R. Wermers, H. White	Can Mutual Fund „Stars“ Really Pick Stocks? New Evidence from a Bootstrap Analysis
05-13	D. Avramov, R. Wermers	Investing in Mutual Funds when Returns are Predictable
05-12	K. Griese, A. Kempf	Liquiditätsdynamik am deutschen Aktienmarkt
05-11	S. Ber, A. Kempf, S. Ruenzi	Determinanten der Mittelzuflüsse bei deutschen Aktienfonds
05-10	M. Bär, A. Kempf, S. Ruenzi	Is a Team Different From the Sum of Its Parts? Evidence from Mutual Fund Managers
05-09	M. Hoffmann	Saving, Investment and the Net Foreign Asset Position
05-08	S. Ruenzi	Mutual Fund Growth in Standard and Specialist Market Segments
05-07	A. Kempf, S. Ruenzi	Status Quo Bias and the Number of Alternatives - An Empirical Illustration from the Mutual Fund Industry
05-06	J. Grammig, E. Theissen	Is Best Really Better? Internalization of Orders in an Open Limit Order Book
05-05	H. Beltran-Lopez, J. Grammig, A.J. Menkveld	Limit order books and trade informativeness
05-04	M. Hoffmann	Compensating Wages under different Exchange rate Regimes
05-03	M. Hoffmann	Fixed versus Flexible Exchange Rates: Evidence from Developing Countries
05-02	A. Kempf, C. Memmel	Estimating the Global Minimum Variance Portfolio
05-01	S. Frey, J. Grammig	Liquidity supply and adverse selection in a pure limit order book market


#### **2004**

No.	Author(s)	Title
04-10	N. Hautsch, D. Hess	Bayesian Learning in Financial Markets – Testing for the Relevance of Information Precision in Price Discovery
04-09	A. Kempf, K. Kreuzberg	Portfolio Disclosure, Portfolio Selection and Mutual Fund Performance Evaluation
04-08	N.F. Carline, S.C. Linn, P.K. Yadav	Operating performance changes associated with corporate mergers and the role of corporate governance
04-07	J.J. Merrick, Jr., N.Y. Naik, P.K. Yadav	Strategic Trading Behaviour and Price Distortion in a Manipulated Market: Anatomy of a Squeeze
04-06	N.Y. Naik, P.K. Yadav	Trading Costs of Public Investors with Obligatory and Voluntary Market-Making: Evidence from Market Reforms
04-05	A. Kempf, S. Ruenzi	Family Matters: Rankings Within Fund Families and Fund Inflows
04-04	V. Agarwal, N.D. Daniel, N.Y. Naik	Role of Managerial Incentives and Discretion in Hedge Fund Performance
04-03	V. Agarwal, W.H. Fung, J.C. Loon, N.Y. Naik	Risk and Return in Convertible Arbitrage: Evidence from the Convertible Bond Market
04-02	A. Kempf, S. Ruenzi	Tournaments in Mutual Fund Families

04-01

I. Chowdhury, M.  
Hoffmann, A. Schabert

Inflation Dynamics and the Cost Channel of Monetary  
Transmission



centre for financial research  
cfr/university of cologne  
albertus-magnus-platz  
D-50923 cologne  
fon +49(0)221-470-6995  
fax +49(0)221-470-3992  
kempf@cfr-cologne.de  
www.cfr-cologne.de