Information processing under ambiguity in financial markets

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Abstract

We show that ambiguity affects how information is incorporated into prices. Using earnings announcements of 624 S&P 500 firms from 2006 to 2024, we find underreaction to positive news and overreaction to negative news under high ambiguity, with price discounts of 8% to 35%. These effects are not driven by expected volatility and are robust to alternative ambiguity measures, highlighting a distinction between ambiguity and risk. We further show that these effects persist for at least 10 days but reverse within 30 days. This pattern suggests that ambiguity induces temporary price distortions rather than persistent post-earnings announcement drift.

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1 Introduction

Individuals often need to make decisions under ambiguity. An event qualifies as ambiguous if no objective probabilities are assigned to its outcomes. This contrasts risk, where outcomes are also unknown ex-ante, but can be summarized probabilistically. This paper empirically tests whether high ambiguity (e.g., the rise of the financial crisis) can affect information processing by financial markets because individuals are found to be averse to ambiguity (Ellsberg, 1961).

We use an event-study framework to show that ambiguity affects the incorporation of positive and negative information into market prices. We focus on earnings announcements in our identification as they introduce new information to the market with a clear direction (positive, negative, or neutral). We demonstrate that markets overreact to negative earnings surprises and underreact to positive ones during periods of high ambiguity. These effects dissipate and become statistically insignificant within approximately 30 days after ambiguity levels return to normal. This suggests that ambiguity affects information processing in capital markets as predicted by theoretical models (Epstein and Schneider, 2008; Illeditsch, 2011) and highlights that these effects are temporary rather than persistent.

We proxy ambiguity using the VVIX, a forward-looking measure of volatility of volatility following previous literature (Kostopoulos et al., 2022; Meyer and Uhr, 2024). Our results are robust to alternative ambiguity proxies, including Economic Policy Uncertainty (Baker et al., 2016), Survey of Professional Forecasters (Ilut and Schneider, 2014), and Omega (Brenner and Izhakian, 2018). They are also robust to controlling for expected volatility (VIX) (Williams, 2015), correlation neglect (Guo and Wachter, 2025), and firm-level accounting choices such as accounting conservatism (Ruch and Taylor, 2015), indicating that the documented effects are distinct from risk-based explanations and other known drivers of earnings announcement returns.

Our study provides empirical evidence that *both* over- and underreaction to earnings announcements can be jointly explained by market-level ambiguity, consistent with theoretical predictions (Epstein and Schneider, 2008; Illeditsch, 2011). Prior literature documents underreaction to good news, which has also been discussed in the context of post-earnings announcement drift (Bernard and Thomas, 1989; Ball and Brown, 2014), as well as overreaction to earnings news (De Bondt and

Thaler, 1987; Abarbanell and Bernard, 1992; De Bondt and Thaler, 1990; Freeman et al., 1982). However, existing explanations have struggled to reconcile both phenomena within a unified framework (Benjamin, 2019) or to distinguish between temporary distortions and persistent return patterns.

A first rigorous definition of ambiguity as events whose outcome probabilities are not known to the individual decision maker between is attributed to Keynes (1936) and Knight (1921) [1]. The Ellsberg (1961) experiment points out that this distinction matters in the decision-making of people and demonstrates that the average individual is averse to ambiguity.[2] This distaste for ambiguity cannot be rationalized under a (Bayesian) expected utility framework (Gilboa and Schmeidler, 1989). A Bayesian decision maker treats ambiguity as an increase in variance (risk). Consequently, they treat ambiguity as a second-order phenomenon. The ambiguity-averse investor accounts for ambiguity as a mean-affecting phenomenon; hence, ambiguity is a first-order concern. This is a direct consequence of incorporating ambiguity aversion in the agents' utility functions, for example, in the Multiple Priors min-max utility (Gilboa and Schmeidler, 1989; Epstein and Schneider, 2008). Ambiguity-averse investors maximize expected utility under their worst-case prior,[3] thus behaving as if a claim held its worst-case pay-off (Epstein and Schneider, 2008). This framework helps explain several empirical puzzles, including limited stock market participation, portfolio under-diversification, and reduced risk-taking under ambiguity (Guiso et al., 2003; Garlappi et al., 2007; Dimmock et al., 2016). It also gives rise to an ambiguity premium, whose magnitude and source depend on whether ambiguity is firm- or market-wide (Epstein and Schneider, 2008; Miao et al., 2019). Yet, little empirical work examines how ambiguity affects the processing of corporate information, and in particular how it shapes the asymmetric incorporation of good and bad news into prices, which we address.

Despite limited empirical evidence, micro-theory provides clear, testable implications for how

[1] Ambiguity differs from subjective expected utility where probability assignment to outcomes differs across decision makers but are unique for each decision maker (Savage, 1954).

[2] Specifically, the Ellsberg (thought) experiment asks people to choose between a risky urn and an urn for which the probability is unknown. In this situation, subjects strongly prefer choosing the urn with known probabilities (Ellsberg, 1961). Later experiments with investors in the US (Dimmock et al., 2016) and in Germany (Kostopoulos et al., 2022) have documented similar results.

[3] Formally, investors minimise utility across all probability distributions in the set of probability distributions they deem possible (their prior set). We refer to the argmin of this minimisation programme as the worst-case prior. Agents then maximise utility with expectation taken under this worst-case prior. The argmax of this second problem is their optimal action under multiple prior utility.

ambiguity affects information processing (Epstein and Schneider, 2008; Illeditsch, 2011). In this literature, ambiguity is modelled as a time-varying feature that distorts the perceived precision of signals (i.e., their variance).[4] Under high ambiguity, agents perceive signals as less reliable and, within a Max-Min framework, behave as if the worst-case realization—namely, low precision—were true.[5] These models assume ambiguity aversion, consistent with evidence from the Ellsberg paradox and related empirical studies (Ellsberg, 1961; Dimmock et al., 2016; Kostopoulos et al., 2022). Ambiguity-averse investors prefer situations with known probabilities over those with multiple plausible distributions. This behavior can be captured by multiple-priors utility (Gilboa and Schmeidler, 1989), under which agents act as if evaluating outcomes using the worst-case belief from a set of priors. The size of this set reflects the level of perceived ambiguity.

A central implication of this framework is that ambiguity generates asymmetric responses to information (Epstein and Schneider, 2008). Importantly, it provides a unified mechanism for both overreaction and underreaction—something that existing empirical and theoretical explanations have struggled to reconcile within a single framework. Although this mechanism is formalized in Epstein and Schneider (2008), it has not been directly tested in asset markets. When observing positive signals, investors act as if these signals are imprecise (high variance), leading to underreaction. In contrast, for negative signals, the worst-case scenario corresponds to high precision (low variance), resulting in overreaction. Thus, ambiguity induces a systematic underreaction to positive news and overreaction to negative news as predicted by models based on perceived signal precision.

This mechanism operates through perceived signal precision. Signals viewed as more precise elicit stronger price responses, while those perceived as imprecise are discounted. By distorting perceived precision asymmetrically across positive and negative information, ambiguity directly affects the magnitude of return responses and provides a unified explanation for both types of reactions.

Our paper tests whether this over- and underreaction is directly reflected in announcement returns when market ambiguity varies and shows that these effects differ from standard post-earnings

[4] In Epstein and Schneider (2008), signals contain both firm- and market-level components. The market component is ambiguous and represented by a set of distributions that differ in variance but share the same mean. Ambiguity corresponds to the range of admissible variances. In contrast, the firm-level signal is unambiguous. Ambiguity affects decisions through the perceived covariance between market and firm signals, which decreases with the ambiguous variance of the market component.

[5] In contrast, a Bayesian agent averages across possible distributions.

announcement drift dynamics.

We use earnings announcements as our empirical setting for three reasons. First, announcement timing is largely exogenous, as firms pre-schedule release dates and therefore do not condition disclosure on contemporaneous market ambiguity. Second, earnings announcements provide standardized and frequent disclosures, allowing for consistent comparison across firms and over time. Third, the information content of announcements can be clearly classified as positive, negative, or neutral based on deviations from analyst expectations, which enables us to identify the direction of news and construct a natural control group of neutral announcements.

This natural control group should not be affected by ambiguity, as ambiguity only takes effect through information that diverges from expectations (Epstein and Schneider, 2008). The existence of the neutral control group ensures that neither non-ambiguity-related market-level shocks nor ambiguity in the absence of information drives our results. Due to the earnings announcement, firm-level ambiguity is reduced to comparable levels across all firms, allowing us to isolate the effect of market-based ambiguity.

We focus on firms that at some point were part of the S&P500. This choice reflects the fact that the perceived quality of information is a possible confound in our analysis. Stocks in the S&P 500 are subject to an especially high level of analyst scrutiny. As a result, there should be little difference in the perceived quality of information and the analyst coverage across this subset of firms. The choice of S&P 500 firms allows to control for firm-level variables, and the (quarterly) frequency of announcements makes incorporating both time- and sector fixed effects possible.

We analyze earnings announcements for all firms outlined above. The sample spans the years 2006 to 2024. The start of the sample in 2006 coincides with the emergence of market-level ambiguity measures becoming publicly available.[6] We observe, on average, 51 announcements per firm.

We proxy time-varying market-level ambiguity using the VVIX index, which measures the expected volatility of volatility of the S&P 500. This option-implied, forward-looking measure is motivated by Drechsler (2013) and corresponds closely to ambiguity about volatility as formalized in Epstein and Ji (2013). It has also been used empirically as a proxy for ambiguity by Kostopoulos et al.

[6]The CBOE VVIX index was first made available in March 2006, which marks the beginning of our sample (Cboe Global Indices, 2025).

(2022). In the framework of Epstein and Schneider (2008), ambiguity about volatility directly affects perceived signal precision and thereby drives asymmetric responses to information. The VVIX is therefore a natural empirical proxy in our setting. Consistent with this interpretation, elevated VVIX levels coincide with major geopolitical and macroeconomic events.

Given that no single measure of ambiguity is generally accepted,[7] we test for robustness using alternative proxies, including the Survey of Professional Forecasters (Ilut and Schneider, 2014), the Economic Policy Uncertainty index (Baker et al., 2016), and the variance of return probabilities (Omega) (Brenner and Izhakian, 2018). Our results are robust across these measures.

Finally, we distinguish ambiguity from expected volatility. While prior work (Williams, 2015) shows that increases in VIX lead investors to place greater weight on negative earnings news, this does not generate the joint underreaction to positive and overreaction to negative news predicted by ambiguity models. Consistent with this distinction, replacing ambiguity with VIX yields no significant effect on cumulative abnormal returns, as expected volatility does not generate the asymmetric response implied by Epstein and Ji (2013). These results suggest that expected volatility does not capture the ambiguity channel underlying asymmetric information processing, which operates through perceived signal precision in ambiguity models; hence, ambiguity, rather than risk, drives this joint response to earnings news.

We employ an event-study approach (MacKinlay, 1997), using the Fama-French 3-factor model to calculate expected returns. Note that the results do not change qualitatively when we change the asset pricing model.[8] Abnormal returns are cumulated over a window from $t = -2$ to $t = 2$. We use this window for two reasons. First, earnings announcements can, and often do, occur outside market hours. Although we use announcement timestamps, some uncertainty remains about the time when information actually reaches the markets.[9] Secondly, this time window allows us to capture the

[7] See Kostopoulos et al. (2022) for a literature review.

[8] Our findings replicated when using cumulative abnormal returns calculated using a market model. Table A4 reproduces our results using abnormal returns of a market model. The VVIX ambiguity-induced over- and underreaction remain statistically significant and economically sizable.

[9] We apply the following timing conventions. The event date $t = 0$ coincides with the report date when the announcement takes place during market hours. If an announcement takes place after market hours, we consider the following date as the event date $t = 0$. This is because the announcement return will only show up in the following day's closing price. Excluding these after-hour announcements from our sample does not qualitatively alter our results.

short-lived effects of ambiguity while avoiding confounding through long-term effects such as post-announcement drift or momentum (Johnson, 2002; Bartov, 1992; Moskowitz and Grinblatt, 1999). All analyses account for market trends and other time-variant effects by including year- and month-fixed effects.[10] We also address a potential optimism bias in short sales constrained stocks (Miller hypothesis, Miller (1977)). When investors disagree and pessimistic investors are unable to take short positions, then only optimistic investors remain in the market. This results in an optimism bias in short-sales constraint stocks with high dispersion of investor opinion. It was first theorized by Miller (1977) and empirically demonstrated by Berkman et al. (2009). We therefore include the explanatory variables identified as significant in Miller (1977); Nagel (2005); Berkman et al. (2009) into our analysis.

We find that the well-documented asymmetry in reactions to earnings surprises persists in our setting (Skinner and Sloan, 2002). Accounting for ambiguity, we show that reactions to positive surprises are attenuated, while reactions to negative surprises are amplified. These effects are economically meaningful and consistent with ambiguity affecting perceived signal precision.

Cumulative abnormal return responses to positive earnings news (as opposed to neutral earnings news) are 216 basis points on average. This response is discounted by 55 to 74 basis points under high ambiguity, resulting in an economically significant underreaction by 25% to 35%. Moreover, cumulative abnormal returns to negative surprises (as opposed to neutral ones) amount to -253 basis points on average. The response to negative earnings surprises decreases by an additional 19 to 41 basis points in the presence of high market ambiguity. Negative surprises incur an ambiguity discount of 8% to 16%. We interpret these findings as evidence that market-wide ambiguity influences how investors process good and bad news.[11]

We further show that these effects are temporary. Stocks that underreact to positive news during high ambiguity subsequently earn higher returns and catch up within approximately 15 days. Similarly, stocks that overreact to negative news reverse within about 30 days. This pattern indicates that ambiguity distorts short-term information processing, but markets adjust once ambiguity

[10] We also include firm- and year-fixed effects to control for firm-specific unobservables, such as dividend policy, in Table 9.

[11] These magnitudes are taken from Table 3.

subsides, in contrast to persistent post-earnings announcement drift patterns documented in the literature.

Finally, it is useful to place our results on over- and underreaction to earnings announcements, moderated by market-level ambiguity, in the context of recent developments in the behavioral economics literature. Benjamin (2019) notes that while both over- and underreaction are widely documented in numerous situations, there is no consensus on a theoretical mechanism explaining both, and even argues that the mechanism underlying these different reactions is not entirely understood. Most closely related to our study is a recent paper by Augenblick et al. (2025) using sports betting markets to argue for over- and underreaction to depend on context and perceived signal quality. Decision makers fail to perceive the subtle differences in signal precision and consequently shade their belief toward an intermediate value that depends on the context. Over- and underreaction, therefore, is a function of the context-dependent intermediary value and signal strength. Our paper argues that over- and underreaction to signals change over time and depend on the information environment's ambiguity.

2 Methodology

2.1 Identification

We aim to identify the effect of ambiguity aversion on asset prices. If the marginal investor is ambiguity-averse, they evaluate assets under ambiguity according to a max-min framework.[12] In this setting, ambiguity affects how investors process signals: positive signals are treated as less precise, while negative signals are perceived as more precise (Epstein and Schneider, 2008). We therefore focus on situations in which new information enters the market and restrict our analysis to earnings announcements because they provide a setting that allows for a causal interpretation of the effect of ambiguity on information processing.

First, the assignment of high ambiguity (VVIX above the 75th percentile) to earnings announcements is plausibly exogenous. Earnings announcements are scheduled well in advance, so firms cannot time

[12] Ambiguity aversion may also take an attenuated form; see smooth ambiguity preferences (Klibanoff et al., 2005).

the release of information in response to market ambiguity. This is also supported by the data: positive, neutral, and negative surprises are approximately evenly distributed across ambiguity quartiles (see Table A2).

Second, earnings announcements provide standardized and comparable information across firms. Focusing on S&P 500 firms ensures a relatively homogeneous information environment, limiting variation in disclosure quality and analyst coverage. This allows us to compare market reactions across firms under different levels of market-wide ambiguity.

Third, earnings announcements provide novel information with a clear direction—positive, negative, or neutral—relative to analyst expectations. This allows us to distinguish the direction of news and construct a natural control group. Under ambiguity, theory predicts underreaction to positive news and overreaction to negative news (Epstein and Schneider, 2008). In contrast, neutral announcements should not be affected, as they confirm prior expectations. We focus on cases in which ambiguity is already elevated at the time of announcements, thereby mitigating concerns about reverse causality.

The presence of neutral announcements allows us to rule out alternative explanations based on market-wide shocks. For example, a simultaneous increase in expected volatility (proxied by VIX) would affect returns broadly and thus also influence reactions to neutral announcements. However, we do not observe such effects. This distinction helps isolate the impact of ambiguity from general changes in market conditions.

We proxy ambiguity using the VVIX index, which captures the expected volatility of volatility of the S&P 500 and reflects second-order beliefs about uncertainty. While VVIX and VIX are positively correlated, they capture distinct concepts. In particular, ambiguity about volatility—captured by VVIX—is central to the mechanism in Epstein and Schneider (2008). To address potential confounding effects, we control for expected volatility and show that VIX does not explain the observed asymmetries in market reactions. Furthermore, results are tested for robustness to other ambiguity proxies used in the literature. Our results are robust across alternative ambiguity proxies, such as including the Survey of Professional Forecasters (Ilut and Schneider, 2014), the Economic Policy Uncertainty index (Baker et al., 2016), and the variance of return probabilities (Omega)

(Brenner and Izhakian, 2018)

Taken together, our identification strategy relies on two key features. First, ambiguity levels are plausibly exogenous to the timing of earnings announcements. Second, neutral announcements provide a control group, allowing us to isolate the effect of ambiguity on the processing of new information. Empirically, we implement this by interacting measures of earnings surprises (positive, neutral, negative) with ambiguity (primarily VVIX) to explain cumulative abnormal returns.

2.2 Empirical approach

To identify the effects of ambiguity on earnings announcements, we run a two-step procedure. In the first step, we conduct an event study following MacKinlay (1997). Each firm is analyzed over a 260-day window, from 260 days prior to each quarterly earnings announcement to 30 days after. The estimation period runs from 260 days prior to the event to 10 days before the event. During the estimation period, we use the Fama-French three-factor model (Fama and French, 2015) to derive the firm's factor coefficients. To substantiate our findings, we have also estimated results using a market model rather than a three-factor model. Our results are robust to this alternative specification and are reported in Table A4. The event window for which we compute cumulative abnormal returns (CAR) runs from two days before the event to two days after the event.[13]

In the second step, we explain these CARs using regression analyses that include earnings surprises, ambiguity, their interaction, a set of control variables from the literature on earnings announcements, and industry- and time-fixed effects. Detailed specifications are introduced in the respective results sections.

Earnings surprises are incorporated through three categories—positive, neutral, and negative—based on deviations from analyst expectations. Ambiguity is primarily proxied using the VVIX index; the construction of this and alternative ambiguity measures is described in Section 2.3. Our empirical specification focuses on the interaction between surprise categories and ambiguity to explain cumulative abnormal returns.

We use industry-fixed effects based on the Fama-French industry classification to control for

[13] In later tests on the persistence of potential effects, we extend the event window in 5-day increments up to 45 days.

differences across industries [14]. Time-variant unobservables are controlled for using year- and month-fixed effects, which capture seasonal patterns and changing market conditions. We employ year- and month-fixed effects rather than year-month fixed effects for the following reason. Under year-month fixed effects, the average treatment effect would be drawn from variation within a given month, but several periods contain very few high-ambiguity observations, challenging identification. Using year and month fixed effects allows us to exploit variation across the year while controlling for seasonality. Still, our results are robust to year-month fixed effects (see Table A5).

Earnings announcement events are not evenly distributed throughout the year but cluster during earnings seasons. Clustering of corporate events has been extensively documented in the literature (e.g., Andrade et al. (2001), Harford (2005)) and introduces potential correlation in the residuals (Kolari and Pynnönen, 2010). Additional clustering may arise from markets underappreciating the informative value of a firm's announcement for the entire industry (Guo and Wachter, 2025). Consequently, earnings surprises driven by industry news rather than idiosyncratic factors are systematically overpriced at announcement (Guo and Wachter, 2025). This suggests residual correlation at the industry and year-month level. To account for these sources of event clustering, we cluster standard errors at the year-month and industry levels in all analyses.

There is a substantial body of literature explaining market reactions to earnings announcements (Berkman and Truong, 2009; Savor and Wilson, 2016). We use this literature to identify control variables. An overview of all control variables, their description, and sources can be found in Table A1.

Specifically, we collect the firm's market value (MV) on the first day of the month preceding the announcement. We thereby ensure that market value is unaffected by potential pre-announcement returns. Similarly, we obtain the book-to-market ratio (MB) as last quarter's total assets and market value. Firm size and book-to-market ratio have also been shown to proxy ambiguity about the firm's productivity and potential weaknesses of its reporting system (Budanova et al., 2021). Moreover, we control for earnings-announcement spill-overs by including a dummy variable for the first firm in each industry to announce its earnings results (FEA) (Ma, 2017). The binary indicator

[14] Kenneth French's webpage

of the first announcing firm by industry (*FEA*) indicates the first firm announcing by industry in each calendar quarter. Since the business cycle of the announcement has been shown to matter for abnormal returns (Gómez-Cram, 2022), we control for recessions through the NBER *Recession* indicator. Following Berkman et al. (2009), we also control for momentum effects. We define *Momentum return* as the excess 12-month buy-and-hold return over the value-weighted CRSP index, ending 10 days prior to the announcement. Furthermore, the Miller hypothesis suggests that short-sale constraints and disagreement about value expectations lead to an optimism bias for short-sale-constrained securities (Miller, 1977). This optimism bias is resolved with the release of new information via earnings announcements, leading to declining returns for high-disagreement stocks back to their fundamental values (Berkman et al., 2009). To control for this effect, our analysis proxies for short-sale constraints (*Shr. institutional holdings*) using institutional holdings (Berkman et al., 2009; Nagel, 2005). The share of institutional holdings is recorded on the first of the month; we use the value from one month prior to the earnings announcement. Moreover, we proxy for firm-level disagreement using analyst forecast dispersion (*AEPS dispersion*).

To summarize, we control for market value (*MV*), book-to-market ratio (*MB*), first announcing firm in industry (*FEA*), *Recession*, *Momentum return*, *Shr. institutional holdings*, and analyst dispersion (*AEPS dispersion*).

Moreover, in the robustness section, we additionally control for several accounting variables. We include *total firm leverage*, defined as total assets divided by total debt. Though our sample features only relatively liquid stocks, we include *Illiquidity*, proxied by the average absolute return over dollar trading volume in the 250 days preceding the announcements, ending 10 days prior (Amihud, 2002). We also control for *Accruals* over total assets to capture firms' strategic reporting choices. A detailed account of the interpretation of these accounting variables by investors can be found in Section 4.4.

2.3 Data

This paper uses a survivorship-bias-free sample of 624 S&P 500 firms from March 2006 through December 2024. The sample begins in 2006 due to the availability of the VVIX index (Cboe

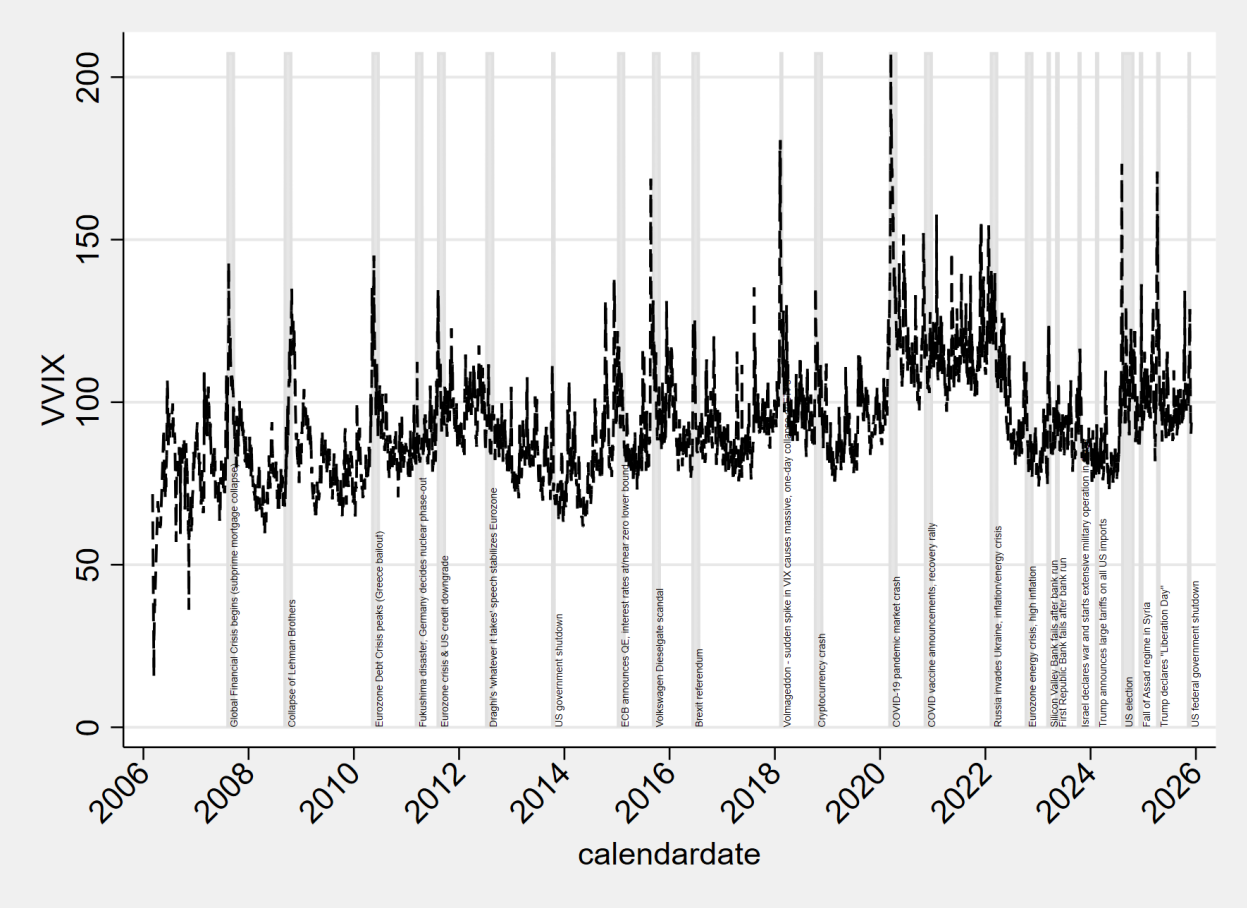

Figure 1: VVIX end of month levels from inception (March 2006) to 2025
This figure depicts daily levels of the CBEO VVIX index from March 2006 to 2025. Grey vertical bars mark events resulting in increased uncertainty, such as the collapse of Lehman Brothers or the Fukushima nuclear disaster.

Global Indices, 2025). We focus on S&P 500 firms because they are widely followed by analysts, regularly covered by the media, and subject to strict reporting standards, ensuring a relatively homogeneous information environment. Changes introduced by the Sarbanes-Oxley Act had only limited effects on market reactions (Burks, 2011), suggesting that information quality is already high.

All market data are sourced from LSEG Datastream, and earnings announcements, analyst forecasts, and firm characteristics are obtained from LSEG Workspace. Table 1 provides summary statistics. We compute earnings surprises as the percentage deviation of realized earnings per share (EPS) from analyst expectations (AEPS).[15] We classify earnings announcements into positive, neutral,

[15]We consider earnings surprises in percentage terms to capture economic magnitude. This definition may lead

	(1)	(2)	(3)	(4)	(5)
	Count	Mean	Sd	Min	Max
Cumulative abnormal returns (CAR) Fama-French 3 factor model	31221	0.002	0.068	-0.627	1.586
Cumulative abnormal returns (CAR) market model	31221	0.002	0.070	-0.636	1.891
Earnings per share (EPS)	32172	1.018	1.692	-68.400	48.280
Analyst earnings per share estimations (AEPS)	32169	0.958	1.462	-29.046	50.938
AEPS estimates issued	32172	18.028	15.988	5.000	41.000
AEPS surprise	32171	0.000	0.668	-3.100	2.994
AEPS surprise positive	10723	0.383	0.582	0.084	2.994
AEPS surprise neutral	10724	0.043	0.021	0.011	0.084
AEPS surprise negative	10724	-0.425	0.820	-3.100	0.011
VVIX	31946	-0.421	15.108	-66.060	96.430
Omega	32172	1.386	1.156	0.130	7.336
SPF	32172	18.920	12.230	0.994	34.726
EPU	32172	-14.205	62.552	-115.712	324.484
AEPS dispersion	30613	0.097	0.243	0.000	1.823
Shr. Insititutional holdings	32032	39.766	9.096	0.000	84.006
Momentum return	31221	0.015	0.258	-0.581	0.973
ln(MB)	31399	0.009	1.060	-2.206	2.963
ln(MV)	32121	23.413	1.257	20.511	26.551
Illiquidty	29151	4.594	164.728	0.000	13788.780
Total firm leverage	30310	0.276	0.177	0.000	0.873
Accruals relative to total assets	26763	-0.047	0.063	-1.371	0.485
Indicator FEA	32053	0.041	0.198	0.000	1.000
Indicator Recession	32172	0.094	0.292	0.000	1.000
Monthly return two month prior to first month of quarter	18414	0.005	0.041	-0.101	0.125
Monthly return one month prior to second month of quarter	11545	0.013	0.051	-0.172	0.136

Table 1: Descriptive Statistics This table depicts descriptive statistics across all major variables used in this study. The cumulative abnormal returns (CAR) are measured from the day prior to the day after announcement and are obtained from a Fama-French three-factor model on a sample of 250 days, ending 10 days prior to announcement Fama and French (2015). The Cumulative Abnormal Returns (CAR) market model is the excess returns on a single factor (market model). Similar timing conventions are applied to all company-specific variables to ensure timing consistency. The level of VVIX is measured on the day of the announcement. Omega is the variance of intraday return probabilities across the past month. SPF is the twofold variance of professional forecaster's probabilistic GDP growth forecasts in the quarter of the announcement. EPU is the Economic Policy Uncertainty Index in the month of the announcement (Baker et al., 2016). AEPS surprise is computed as the percentage deviation of analyst earnings per share estimates from the actually recorded EPS. A positive percentage deviation reflects positive surprises, a negative percentage deviation reflects negative surprises, and no deviation reflects no surprises. AEPS is the average expectations for the EPS by analysts (AEPS). Ln(MV) is the natural log of the firm value, measured as shares outstanding times the share price and ln(MB) is the natural log of the firm's book-to-market ratio. Shr. Institutional holdings is the percentage share of institutional holdings. Total leverage is the firm's leverage measured by its debt-to-equity ratio. AEPS dispersion is the standard deviation of analysts' EPS estimates divided by their respective means. Monthly return two months prior to first month of quarter (MR1Q) and monthly return one month prior to second month of quarter (MR2Q) both are drawn from Guo and Wachter (2025). MR1Q addresses the fact that market returns during the first month of the quarter predict the quarter's second month's market returns. MR2Q accounts for the fact that the second month's market return then predicts the following quarter's first month return (Guo and Wachter, 2025).

to arbitrarily large surprises for near-zero analyst expectations. However, near-zero expectations are economically meaningful rather than a statistical artifact. Out of 30,302 earnings announcements, the interquartile range of only 473 analyst estimates contains zero. Results are robust to excluding such observations (see Table A6).

and negative surprises by splitting the distribution into three equally populated groups. Positive surprises correspond to AEPS above the 66th percentile, while negative surprises fall below the 33rd percentile. Since positive surprises are more frequent, the neutral category is centred around a slightly positive mean.

We apply several data filters. We exclude announcement events with more than 30 days of zero returns in the year preceding the event. We further exclude events with fewer than five analyst estimates. Analyst forecasts are restricted to those issued after the previous earnings announcement and at least two days before the current announcement to ensure information consistency and avoid contamination from announcement-related information (Berkman and Truong, 2009).

Following previous literature, we proxy time-varying market-level ambiguity using the volatility of volatility (vol-of-vol). Our main measure is the CBOE VVIX index, which captures the volatility of implied volatility of VIX options. It reflects expected fluctuations in the S&P 500's volatility over the following 30 days and thus captures second-order beliefs. Using an index option-based measure is motivated by Drechsler (2013) and corresponds closely to ambiguity about volatility as formalized in Epstein and Ji (2013).[16] The VVIX is available daily, market-based, model-free, and forward-looking.

Given the lack of consensus on a single ambiguity measure, we consider alternative proxies. We use the dispersion of professional forecasters' GDP growth expectations (SPF) following Ilut and Schneider (2014). We include the Economic Policy Uncertainty (EPU) index (Baker et al., 2016), a news-based measure of uncertainty constructed from US newspapers and government communications. Finally, we use the variance of return probabilities (Omega) (Brenner and Izhakian, 2018), constructed from S&P 500 tick data obtained from TAQ.

We test all ambiguity measures for time-series stationarity using the Dickey-Fuller test (Said and Dickey, 1984). We linearly detrend VVIX and Omega, while SPF is stationary in levels. The EPU index requires quadratic detrending. As demonstrated in Figure 1, the VVIX exhibits a clear time trend, with levels remaining below 100 prior to the financial crisis and frequently exceeding this level thereafter. Moreover, peaks in the VVIX coincide with major geopolitical and macroeconomic

[16] Our measure relates to ambiguity about volatility rather than drift (Meyer and Uhr, 2024; Kostopoulos et al., 2022).

events, supporting its interpretation as a proxy for periods of elevated ambiguity.

We also address nonlinearities in ambiguity by including measures as bins in the empirical analysis. Correlations among ambiguity measures are low, consistent with Brenner and Izhakian (2018). The correlation between VVIX and Omega is -0.001, between VVIX and VIX is 0.547, between VVIX and SPF is 0.078, and between VVIX and EPU is 0.386.

The final sample comprises 31,221 earnings announcements across 624 firms, with an average of 52 earnings announcements per firm. On average, 18 analyst forecasts are issued per announcement, with a dispersion of 9.7%.

3 Results and discussion

3.1 Response to earnings surprises and ambiguity

The literature has established that the market's reaction to earnings announcements depends on the direction and magnitude of the surprise (Ziebart, 1990) relative to analysts' forecasts: market reactions to negative (positive) earnings surprises are negative (positive). This relationship also holds in our sample. Our paper shows new insights into the short- and long-term effects of ambiguity on information incorporation by financial markets around earnings announcements, supporting the model by (Epstein and Schneider, 2008).

As discussed above, ambiguity-averse investors are expected to react asymmetrically to good and bad news, as their worst case coincides with low (high) signal precision for positive (negative) signals. When grouping earnings announcements by surprise (positive, neutral, and negative) and ambiguity levels in equal bins (low, medium, high), such an asymmetric response is apparent in the data, as illustrated in Figure 2. Reactions to positive earnings surprises diminish when ambiguity on the day of the earnings announcement is high, while reactions to negative surprises increase in absolute value. In line with the theory, there is no visible effect for zero-surprise signals.

We next test whether the patterns in Figure 2 hold in a regression framework using cumulative abnormal returns from $t-2$ to $t+2$. The suffix t refers to event time, where $t=0$ is the announcement date. Firms are indexed by i, and announcement year-quarter by m, such that each

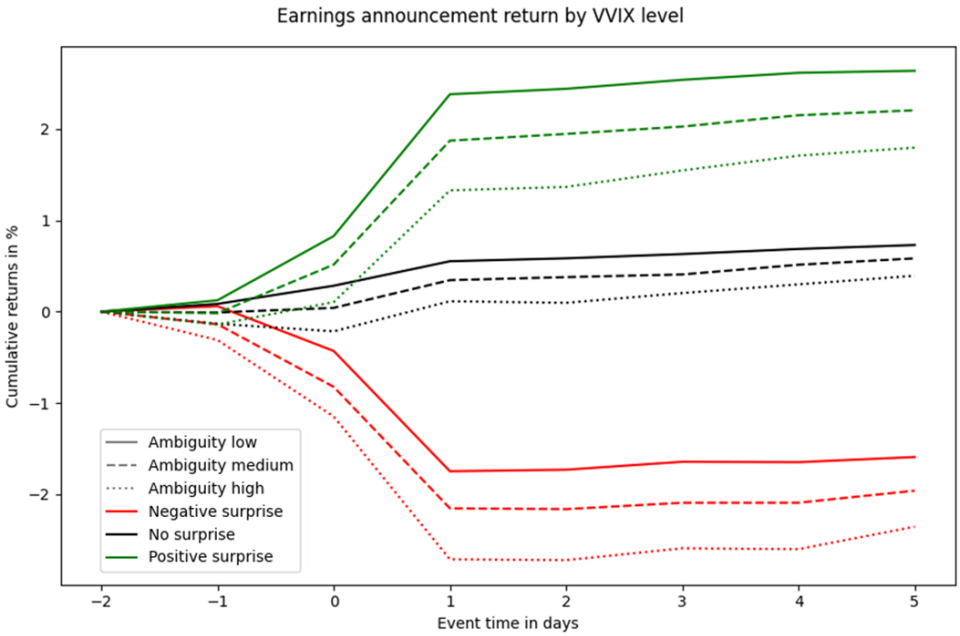

Figure 2: Earnings announcement responses grouped by ambiguity and surprises
This figure depicts raw cumulative returns by announcement time ($t = 0$ being the announcement date). The cumulative returns are grouped by earnings surprises (AEPS) and levels of VVIX ambiguity. AEPS surprises are obtained as the percentage deviation from analyst EPS estimates (AEPS) for stocks with more than 5 analyst estimates. Solid lines represent cumulative returns of earnings announcements with ambiguity below the median (low ambiguity), dashed lines represent cumulative returns of earnings announcements with ambiguity above the median (medium ambiguity). Lastly, dotted lines show cumulative returns of earnings announcements with ambiguity above the 75th percentile (high ambiguity). The level of VVIX is measured on the day of the earnings announcement. Red-colored lines represent CARs of earnings announcements that are considered a negative surprise, green-colored lines represent CARs of earnings announcements that are considered a positive surprise, and gray-colored lines represent CARs of earnings announcements that are considered no surprise.

(i, m) uniquely identifies a quarterly earnings announcement. Event time is aligned across firms, while differences in calendar time are accounted for through year and month fixed effects.

In our first analysis, we split the sample into four (almost equally sized) groups by the level of the VVIX. Given the five-day cumulated return window, we alternatively use VVIX on day t (columns (1) to (4)), $t-1$ (columns (5) to (8)), and $t-2$ (columns (9) to (12)) as ambiguity proxies. This choice accounts for potential variation in the timing of announcements and information leakage prior to public disclosure (Berkman and Truong, 2009).[17]

AEPS surprises (denoted as *surp* in Equation (1)) are binned into three equally populated groups, with the middle bin serving as the reference category; we refer to them as positive, neutral, and

[17]Berkman and Truong (2009) highlights that after-hours announcements may only appear in the following day's closing price. We therefore include ambiguity on the days preceding the announcement.

negative surprises.[18]

The term γ^i refers to a firm's sector, δ^m to the announcement year, and θ^m to month fixed effects. The matrix $\mathbf{X}^{i,m}$ captures the control variables defined in Section 2.2 and summarized in Table A1.[19] We estimate the following regression:

$$\text{car}_{t-1,t+1}^{i,m} = \alpha + \gamma^i + \delta^m + \theta^m + \beta \text{surp}^{i,m} + \eta \mathbf{X}^{i,m} + \varepsilon^{i,m} \tag{1}$$

The results are reported in Table 2. Consistent with prior literature, we find that market reactions to negative (positive) earnings surprises are negative (positive) (Ziebart, 1990), and these effects are statistically significant. These patterns are largely independent of ambiguity levels. However, the magnitude of the response varies with ambiguity: reactions to negative surprises become more negative as ambiguity increases, while reactions to positive surprises are attenuated. Although these effects are not strictly monotonic across all ambiguity bins, the difference between high and low ambiguity is clearly visible, consistent with an asymmetric response to news under elevated ambiguity.

While these results document differences across ambiguity levels, they do not directly test whether these differences are statistically significant. To do so, we estimate the following specification with interaction terms:

$$\text{car}_{t-1,t+1}^{i,m} = \alpha + \gamma^i + \delta^m + \theta^m + \beta^1 \text{surp}^{i,m} + \beta^2 \text{ambi}_t + \beta^3 \text{surp}^{i,m} \times \text{ambi}_t + \eta \mathbf{X}^{i,m} + \varepsilon^{i,m} \tag{2}$$

Table 3 reports the results.[20] The interaction term captures whether the response to earnings surprises differs under high ambiguity. Columns (1) to (3) use an ambiguity dummy based on the third quartile, while columns (4) to (6) use the fourth quartile. Ambiguity is measured using VVIX on the announcement date (columns (1), (4)), the day before (columns (2), (5)), and two days

[18] Summary statistics for each surprise category can be found in Table 1.

[19] We control for firm characteristics through market value and book-to-market ratio, for disagreement through analyst dispersion and institutional ownership, and for announcement-specific effects through first announcer indicators and recession controls.

[20] The slight difference in observations between Tables 2 and 3 is due to singular observations being dropped in the sample split.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	$VVIX_t$				$VVIX_{t-1}$				$VVIX_{t-2}$			
	1st quartile	2nd quartile	3rd quartile	4th quartile	1st quartile	2nd quartile	3rd quartile	4th quartile	1st quartile	2nd quartile	3rd quartile	4th quartile
Negative surprise	-0.0250***	-0.0255***	-0.0264***	-0.0290***	-0.0246***	-0.0262***	-0.0264***	-0.0285***	-0.0256***	-0.0255***	-0.0253***	-0.0282***
	(0.0030)	(0.0031)	(0.0031)	(0.0029)	(0.0031)	(0.0031)	(0.0033)	(0.0031)	(0.0031)	(0.0039)	(0.0027)	(0.0031)
Positive surprise	0.0212***	0.0231***	0.0192***	0.0139***	0.0216***	0.0238***	0.0169***	0.0149***	0.0214***	0.0234***	0.0193***	0.0143***
	(0.0023)	(0.0023)	(0.0028)	(0.0030)	(0.0021)	(0.0026)	(0.0025)	(0.0027)	(0.0024)	(0.0027)	(0.0021)	(0.0026)
ln(MB)	-0.0005	-0.0025	-0.0002	-0.0018	0.0000	-0.0023	-0.0015	-0.0013	-0.0011	-0.0002	-0.0022*	-0.0012
	(0.0010)	(0.0018)	(0.0011)	(0.0014)	(0.0010)	(0.0017)	(0.0016)	(0.0012)	(0.0012)	(0.0017)	(0.0013)	(0.0013)
ln(MV)	-0.0015	-0.0002	-0.0015	-0.0018	-0.0018	-0.0004	-0.0017**	-0.0012	-0.0016	-0.0012	-0.0004	-0.0018
	(0.0011)	(0.0009)	(0.0009)	(0.0014)	(0.0012)	(0.0007)	(0.0008)	(0.0014)	(0.0013)	(0.0009)	(0.0006)	(0.0012)
AEPS dispersion	0.0000*	-0.0001	-0.0002*	-0.0003	0.0000**	-0.0002	-0.0001	-0.0004*	0.0000*	-0.0000	-0.0002***	-0.0006
	(0.0000)	(0.0003)	(0.0001)	(0.0002)	(0.0000)	(0.0002)	(0.0001)	(0.0002)	(0.0000)	(0.0003)	(0.0001)	(0.0004)
Constant	0.0420	0.0088	0.0426*	0.0466	0.0476	0.0105	0.0511**	0.0306	0.0493	0.0247	0.0143	0.0476
	(0.0294)	(0.0196)	(0.0237)	(0.0347)	(0.0324)	(0.0157)	(0.0214)	(0.0355)	(0.0326)	(0.0215)	(0.0146)	(0.0307)
R-squared	0.0892	0.0977	0.0759	0.0660	0.0934	0.0951	0.0772	0.0644	0.0933	0.0987	0.0799	0.0614
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N obs	7931	7269	7483	7411	7812	7004	7642	7676	7932	6694	7766	7747

Year-month and industry clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2: OLS estimates for cumulative abnormal returns, sample split by ambiguity in three equally populated bins

This table contains the coefficient estimates for three equally populated AEPS surprise bins (with neutral surprise as base). The sample has been divided into quartiles (25th, 50th and 75th percentiles) of ambiguity, proxied through $VVIX_t$, $VVIX_{t-1}$ and $VVIX_{t-2}$. Each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator.
A variable overview can be found in Table A1: Variable Overview

before (columns (3), (6)).[21]

The theoretical framework of Epstein and Schneider (2008) yields two predictions: ambiguity does not directly affect abnormal returns, but influences returns through asymmetric responses to news. Our results support both predictions. In line with theory, we find no direct effect of ambiguity on returns. However, the interaction terms indicate that ambiguity significantly affects how markets respond to earnings surprises. Specifically, the coefficients imply an underreaction to positive surprises and an overreaction to negative surprises. The interaction effects are statistically significant for positive news across all specifications and for negative news primarily at higher ambiguity levels.

The weaker significance of negative surprises may reflect the perception that negative news is

[21]Results are robust to alternative cutoffs (see Table C).

	(1)	(2)	(3)	(4)	(5)	(6)
	3rd quartile			4th quartile		
	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$
Negative surprise	-0.0250***	-0.0252***	-0.0254***	-0.0254***	-0.0255***	-0.0256***
	(0.0029)	(0.0029)	(0.0030)	(0.0028)	(0.0028)	(0.0028)
Positive surprise	0.0220***	0.0225***	0.0223***	0.0211***	0.0208***	0.0210***
	(0.0022)	(0.0022)	(0.0023)	(0.0021)	(0.0021)	(0.0021)
Ambiguity high	0.0018	0.0009	0.0001	0.0003	-0.0012	-0.0003
	(0.0013)	(0.0015)	(0.0016)	(0.0019)	(0.0020)	(0.0019)
Negative surprise & Ambiguity high	-0.0029*	-0.0024	-0.0019	-0.0041***	-0.0035*	-0.0033**
	(0.0015)	(0.0019)	(0.0019)	(0.0014)	(0.0018)	(0.0016)
Positive surprise & Ambiguity high	-0.0055***	-0.0063***	-0.0059***	-0.0074**	-0.0057**	-0.0065***
	(0.0020)	(0.0018)	(0.0017)	(0.0028)	(0.0025)	(0.0022)
Constant	0.0345**	0.0351**	0.0354**	0.0350**	0.0353**	0.0351**
	(0.0146)	(0.0147)	(0.0147)	(0.0149)	(0.0149)	(0.0148)
R-squared	0.0802	0.0804	0.0804	0.0806	0.0807	0.0806
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
N obs.	30302	30302	30302	30302	30302	30302

Year-month and industry clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3: OLS estimates for cumulative abnormal returns
This table presents the coefficient estimates for VVIX ambiguity at t, $t-1$ and $t-2$ event time. The ambiguity dummy is either cut off at the median (columns (1) to (3)) or at the 75th percentile (columns (4) to (6)). AEPS surprise is binned in 3 equally populated bins with neutral surprise as the reference category. Each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator.
A variable overview can be found in Table A1: Variable Overview

generally more informative (Womack, 1996; Barber et al., 2001). Consistent with this interpretation, negative surprises elicit larger absolute return responses than positive surprises by 12% to 23% [22], as documented in Skinner and Sloan (2002).

In summary, our findings show that market-wide ambiguity affects how investors process information, amplifying reactions to negative news and attenuating responses to positive news, consistent with Epstein and Schneider (2008).

[22]The CAR response to negative surprises is 12 to 23% larger than the CAR response to positive surprises. For example, for $VVIX_t$ binned at the 3rd quartile 3 finds a 0.022 % response to positive surprises and a -0.025 % response to negative surprises. The absolute response to negative surprises exceeds that to positive surprises by $13\% = \frac{0.025}{0.022} - 1$

The economic magnitude of these effects is substantial. The average response to positive earnings surprises is at least 208 basis points, which is reduced by 57 to 74 basis points under high ambiguity, corresponding to an underreaction of 25% to 35%. Negative surprises generate average returns of at least -250 basis points, with ambiguity increasing the magnitude by an additional 19 to 41 basis points, corresponding to an overreaction of 8% to over 16%.

3.2 Ambiguity, ambiguity resolution and post-announcement returns

The previous chapters established that high levels of ambiguity affect market reactions to earnings surprises within a five-day window surrounding the earnings announcement. In this section, we investigate the market reaction from two days before the announcement to one month after the announcement to assess whether these effects are temporary and revert over time.

Periods of high ambiguity, i.e., high VVIX, are typically short-lived. The median period of elevated VVIX ambiguity is 4 days.[23] As ambiguity disappears, the set of priors shrinks, eventually containing only a single probability distribution. The ambiguity-averse agent's prior should then coincide with the objective probability distribution. Given the short-lived nature of ambiguity, we expect the effects of ambiguity on prices to be temporary. In particular, firms that announced under high ambiguity should converge in returns to firms that announced under low ambiguity once ambiguity subsides.

This prediction contrasts with the well-documented post-earnings announcement drift (PEAD), which describes the tendency of stock prices to continue drifting in the direction of the earnings surprise after the announcement (Bernard and Thomas, 1989; Ball and Brown, 2014). While PEAD is typically interpreted as gradual incorporation of information, the ambiguity mechanism implies that announcement returns may initially be distorted and subsequently corrected. This distinction is particularly relevant for negative surprises: while PEAD predicts continued negative drift, ambiguity-induced overreaction suggests that returns may partially reverse once ambiguity resolves.

In the previous chapter, we established that cumulative returns from $t-2$ to $t+2$ incur a statistically

[23] Elevated VVIX ambiguity refers to a period during which the VVIX remains above its 75th quantile for consecutive CBOE trading days. Similarly, Meyer and Uhr (2024) reports a median length of high ambiguity regimes of 3 days.

significant ambiguity discount. We now examine whether this discount disappears over time by comparing the medium-run performance of firms that announced under different ambiguity regimes. To test this conjecture, we compare buy-and-hold returns across firms announcing similar surprises under different levels of ambiguity. We focus on the median of ambiguity and compare firms that announced when the VVIX was above its 50th percentile to those that announced when VVIX was below the 50th percentile. Since ambiguity affects returns through surprises, there should be no ambiguity effect for neutral announcements (Epstein and Schneider, 2008) (as evidenced in Section 3.1). We therefore focus on positive and negative surprises and compare firms within each category across ambiguity regimes.

We analyze buy-and-hold returns from two days before to 35 days after the announcement and test for differences in return distributions in five-day intervals. For example, in the third row of Table 4, we compare the distribution of 10-day post-announcement buy-and-hold returns of firms announcing under high ambiguity to those announcing under low ambiguity. Columns (1) to (3) tabulate mean returns and their differences for negative surprises, while columns (7) to (9) report the same for positive surprises.

Because this analysis compares return distributions over longer horizons, and buy-and-hold returns are positively skewed, we report multiple complementary statistical tests. In addition to mean differences, we provide results from the non-parametric Mann-Whitney test, as well as permutation-based and Welch t-tests, which are robust to skewness. The corresponding test statistics are reported in columns (4) to (6) for negative surprises and columns (10) to (12) for positive surprises. As shown in Table 4, we find statistically significant differences between high- and low-ambiguity firms for both positive and negative surprises. Importantly, we test for differences in the entire distribution of returns rather than only mean differences. While the reported mean differences are informative, the Mann-Whitney test captures differences in the underlying return distributions.

For negative surprises, the difference in returns between high- and low-ambiguity firms amounts to approximately 100 basis points over the window from two days prior to the announcement to one day after. This difference increases to around 150 basis points after 10 days and peaks at approximately 190 basis points after 20 days. It then gradually declines and becomes statistically

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Negative surprise						Positive surprise					
Event time	Mean ambi low	Mean ambi high	Difference ambi high-low	Mann Whitney Test	T-test	Welch Test	Mean ambi low	Mean ambi high	Difference ambi high-low	Mann Whitney Test	T-test	Welch Test
						$VVIX_t$						
1	-0.020	-0.010	-0.010	-0.010*** (3963153.5)	-0.010*** (-5.313)	-0.010*** (-5.313)	0.014	0.025	-0.011	-0.011*** (3909821.0)	-0.011*** (-6.0)	-0.011*** (-6.029)
5	-0.018	-0.009	-0.009	-0.009*** (4104785.5)	-0.009*** (-4.0)	-0.009*** (-4.0)	0.020	0.027	-0.007	-0.007*** (4093220.5)	-0.007*** (-3.39)	-0.007*** (-3.406)
10	-0.019	-0.004	-0.015	-0.015*** (4056472.5)	-0.015*** (-5.658)	-0.015*** (-5.658)	0.022	0.031	-0.009	-0.009*** (4108070.0)	-0.009*** (-3.503)	-0.009*** (-3.527)
15	-0.020	-0.001	-0.019	-0.019*** (4035925.0)	-0.019*** (-6.351)	-0.019*** (-6.351)	0.026	0.034	-0.009	-0.009*** (4126523.5)	-0.009*** (-2.915)	-0.009*** (-2.942)
20	-0.020	-0.001	-0.019	-0.019*** (4057624.0)	-0.019*** (-5.893)	-0.019*** (-5.893)	0.027	0.033	-0.006	-0.006 (4231558.0)	-0.006* (-1.893)	-0.006** (-1.916)
25	-0.017	-0.002	-0.015	-0.015*** (4147553.5)	-0.015*** (-4.245)	-0.015*** (-4.245)	0.033	0.035	-0.002	-0.002 (4294095.0)	-0.002 (-0.536)	-0.002 (-0.543)
30	-0.013	0.001	-0.014	-0.014*** (4165352.0)	-0.014*** (-3.674)	-0.014*** (-3.674)	0.037	0.038	-0.002	-0.002 (4272754.0)	-0.002 (-0.508)	-0.002 (-0.514)
35	-0.009	0.003	-0.013	-0.013 (4242986.0)	-0.013*** (-3.084)	-0.013*** (-3.084)	0.039	0.043	-0.004	-0.004* (4209306.5)	-0.004 (-0.985)	-0.004 (-0.997)
						$VVIX_{t-1}$						
1	-0.020	-0.010	-0.010	-0.010*** (3963153.5)	-0.010*** (-5.313)	-0.010*** (-5.313)	0.014	0.025	-0.011	-0.011*** (3909821.0)	-0.011*** (-6.0)	-0.011*** (-6.029)
5	-0.018	-0.009	-0.009	-0.009*** (4104785.5)	-0.009*** (-4.0)	-0.009*** (-4.0)	0.020	0.027	-0.007	-0.007*** (4093220.5)	-0.007*** (-3.39)	-0.007*** (-3.406)
10	-0.019	-0.004	-0.015	-0.015*** (4056472.5)	-0.015*** (-5.658)	-0.015*** (-5.658)	0.022	0.031	-0.009	-0.009*** (4108070.0)	-0.009*** (-3.503)	-0.009*** (-3.527)
15	-0.020	-0.001	-0.019	-0.019*** (4035925.0)	-0.019*** (-6.351)	-0.019*** (-6.351)	0.026	0.034	-0.009	-0.009*** (4126523.5)	-0.009*** (-2.915)	-0.009*** (-2.942)
20	-0.020	-0.001	-0.019	-0.019*** (4057624.0)	-0.019*** (-5.893)	-0.019*** (-5.893)	0.027	0.033	-0.006	-0.006 (4231558.0)	-0.006* (-1.893)	-0.006** (-1.916)
25	-0.017	-0.002	-0.015	-0.015*** (4147553.5)	-0.015*** (-4.245)	-0.015*** (-4.245)	0.033	0.035	-0.002	-0.002 (4294095.0)	-0.002 (-0.536)	-0.002 (-0.543)
30	-0.013	0.001	-0.014	-0.014*** (4165352.0)	-0.014*** (-3.674)	-0.014*** (-3.674)	0.037	0.038	-0.002	-0.002 (4272754.0)	-0.002 (-0.508)	-0.002 (-0.514)
35	-0.009	0.003	-0.013	-0.013 (4242986.0)	-0.013*** (-3.084)	-0.013*** (-3.084)	0.039	0.043	-0.004	-0.004* (4209306.5)	-0.004 (-0.985)	-0.004 (-0.997)

Test statistic parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Buy-and-hold return distribution over time periods of up to 30 days
The table presents the average buy-and-hold post-announcement returns of firms announcing positive and negative surprises under low and high ambiguity, proxied by VVIX ambiguity. The average difference between returns of similar surprises (split by ambiguity) is displayed in columns (3) and (9) ("Difference ambi high-low"). High ambiguity announcements are all firms announcing when the $VVIX$ is above its 50th percentile. We test the null hypothesis of both groups sharing the same distribution of buy-and-hold returns for several time periods. The different time periods always start from *t-2* but end at x where x can range from 1 to 30 days. The final day of the respective time period is indicated in the left-most column. The null hypothesis is tested across three different tests: an independent sample t-test, the Welch test, and the Mann-Whitney test. Both the t-test and the Welch test have been conducted as permutation tests, alleviating the need for distributional assumptions. This addresses the concern of strong positive skewness in cumulative medium- or long-term concerns (Lyon et al., 1999).

insignificant after 30 days. Although a sizable difference of about 130 basis points remains after 35 days, the return distributions no longer differ significantly.

For positive surprises, the difference between high- and low-ambiguity firms is also approximately 100 basis points shortly after the announcement. However, this difference dissipates more quickly, and the return distributions become statistically indistinguishable after approximately 20 days.

This asymmetry in persistence is notable. While one might expect the effect for negative surprises to be weaker given their generally higher informational content, the empirical results suggest that ambiguity-induced distortions for negative news are more persistent.

Using $VVIX_{t-1}$ instead of $VVIX_t$ yields similar conclusions. The return distributions of firms announcing under high versus low ambiguity differ for at least 30 days in the case of negative surprises, while for positive surprises the difference becomes statistically insignificant after approximately 15 days.

Table 4 reports cumulative long-run returns. We adopt this approach because testing abnormal long-run returns also implicitly tests the underlying asset pricing model (Roll's critique). For completeness, we provide analogous results using abnormal buy-and-hold returns in the Appendix (Table A7). We do not rely on cumulative abnormal returns, as they are poor predictors of long-run buy-and-hold abnormal returns (Barber and Lyon, 1997). Following Barber and Lyon (1997), we instead use market-value decile portfolios to construct expected returns. Our results are robust to this alternative specification.

Overall, these findings indicate that ambiguity-induced distortions in announcement returns are temporary. As ambiguity resolves, returns of firms that announced under high ambiguity converge to those of firms that announced under low ambiguity. This suggests that the market requires several days, and in some cases weeks, to adjust after periods of elevated ambiguity, consistent with the notion that ambiguity is not directly observable and must be gradually incorporated into prices.

4 Robustness tests

4.1 Alternative ambiguity measures

Thus far, we have proxied ambiguity using the VVIX index. Using the volatility of volatility as a measure of ambiguity is common in the literature (Kostopoulos et al., 2022; Meyer and Uhr, 2024). However, we acknowledge that other studies implement alternative measures of ambiguity. In this robustness section, we substantiate our findings by employing three alternative proxies for ambiguity.

The survey of professional forecasters allows us to construct a similar proxy and is also used in the literature (Ilut and Schneider, 2014). We use the quarterly survey of professional forecasters from the Philadelphia FED. This survey records probabilistic forecasts of GDP growth. Each forecaster assigns probabilities to a binned scale of GDP growth rates. We obtain our ambiguity proxy as the inter-quartile range of the standard deviations implied by the probability bins of each forecaster following the suggestion by Engelberg et al. (2009). We thereby obtain an ambiguity proxy for every quarter.

The second ambiguity proxy is the Economic Policy Uncertainty (EPU) index (Baker et al., 2016). This monthly index proxies uncertainty based on mentions of uncertainty-related terms in several US newspapers as well as US government policy documents (Baker et al., 2016). [24]

Lastly, the volatility of intra-day binned return probabilities on the S&P 500 is our third ambiguity measure (Brenner and Izhakian, 2018). We follow Brenner and Izhakian (2018) and use intra-day price data from the SPY index as a proxy for S&P 500 intra-day prices. The results are presented in Table 5.

As before, each ambiguity measure is constructed as a dummy variable with a cut-off at the median (3rd quartile) (columns (1) to (6)) or the 4th quartile (columns (7) to (12)). Overall, the alternative measures yield qualitatively similar patterns, with ambiguity attenuating responses to positive earnings surprises and, in some cases, amplifying reactions to negative surprises. However, the statistical significance of these effects is generally weaker compared to the baseline VVIX

[24] We download the national US data via the website provided by the authors.

specification.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	3rd quartile						4th quartile					
	EPU	Omega	SPF	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$	EPU	Omega	SPF	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$
Negative surprise	-0.0250***	-0.0251***	-0.0281***	-0.0250***	-0.0252***	-0.0254***	-0.0259***	-0.0268***	-0.0264***	-0.0254***	-0.0255***	-0.0256***
	(0.0026)	(0.0031)	(0.0028)	(0.0029)	(0.0029)	(0.0030)	(0.0027)	(0.0026)	(0.0027)	(0.0028)	(0.0028)	(0.0028)
Positive surprise	0.0201***	0.0208***	0.0193***	0.0220***	0.0225***	0.0223***	0.0198***	0.0200***	0.0201***	0.0211***	0.0208***	0.0210***
	(0.0020)	(0.0024)	(0.0021)	(0.0022)	(0.0022)	(0.0023)	(0.0019)	(0.0020)	(0.0019)	(0.0021)	(0.0021)	(0.0021)
Ambiguity high	0.0014	-0.0004	0.0015	0.0018	0.0009	0.0001	-0.0012	0.0003	0.0048***	0.0003	-0.0012	-0.0003
	(0.0018)	(0.0019)	(0.0016)	(0.0013)	(0.0015)	(0.0016)	(0.0026)	(0.0013)	(0.0015)	(0.0019)	(0.0020)	(0.0019)
Negative surprise & Ambiguity high	-0.0044**	-0.0019	0.0033	-0.0029*	-0.0024	-0.0019	-0.0023	0.0011	0.0003	-0.0041***	-0.0035*	-0.0033**
	(0.0019)	(0.0025)	(0.0022)	(0.0015)	(0.0019)	(0.0019)	(0.0026)	(0.0018)	(0.0020)	(0.0014)	(0.0018)	(0.0016)
Positive surprise & Ambiguity high	-0.0029	-0.0022	-0.0001	-0.0055***	-0.0063***	-0.0059***	-0.0028	-0.0021	-0.0039**	-0.0074**	-0.0057**	-0.0065***
	(0.0018)	(0.0022)	(0.0019)	(0.0020)	(0.0018)	(0.0017)	(0.0024)	(0.0019)	(0.0017)	(0.0028)	(0.0025)	(0.0022)
Constant	0.0351**	0.0354**	0.0345**	0.0345**	0.0351**	0.0354**	0.0357**	0.0351**	0.0343**	0.0350**	0.0353**	0.0351**
	(0.0149)	(0.0151)	(0.0150)	(0.0146)	(0.0147)	(0.0147)	(0.0149)	(0.0150)	(0.0150)	(0.0149)	(0.0149)	(0.0148)
R-squared	0.0801	0.0800	0.0802	0.0802	0.0804	0.0804	0.0801	0.0800	0.0802	0.0806	0.0807	0.0806
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N obs.	30302	30302	30302	30302	30302	30302	30302	30302	30302	30302	30302	30302

Year-month and industry clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5: OLS estimates for cumulative abnormal returns with alternative ambiguity measures
This table presents the coefficient estimates for VVIX ambiguity at t, $t-1$ and $t-2$ event time, as well as the Omega, EPU and SPF ambiguity proxies. The ambiguity dummy is either cut-off at the 3rd quartile (columns (1) to (6)) or at the 75th percentile (columns (7) to (12)). AEPS surprise is binned in 3 equally populated bins with neutral surprise as the reference category. Each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator.
A variable overview can be found in Table A1: Variable Overview

EPU ambiguity shows a strong and statistically significant overreaction to negative earnings-announcement news when binned at the 3rd quartile. The response to both positive and negative earnings surprises is also followed by lower returns if EPU is above its 4th quartile in the month of the announcement. However, these coefficients are not statistically significant. These findings are in line with Bai et al. (2025), who investigate the effect of EPU on earnings announcements in China.

The SPF proxy depicts a statistically significant negative effect for positive earnings surprises when SPF uncertainty is above the 75th percentile. Negative earnings news are subject to a near-zero effect under high SPF ambiguity. Similarly, we find a negative effect for positive earnings news when using Omega as an ambiguity proxy.

As discussed previously, high ambiguity regimes are short-lived and typically persist for only a few days. This feature is best captured by ambiguity measures available at a daily frequency, such as the VVIX. In contrast, Omega, SPF, and EPU are observed at monthly or quarterly frequencies, which introduces measurement noise in an event study with a five-day event window and attenuates statistical significance. This likely explains why the effects are qualitatively consistent but statistically weaker for these lower-frequency ambiguity proxies.

4.2 Controlling for expected volatility

	(1)	(2)	(3)	(4)	(5)	(6)
	3rd quartile			4th quartile		
	VIX_t	VIX_{t-1}	VIX_{t-2}	VIX_t	VIX_{t-1}	VIX_{t-2}
Negative surprise	-0.0255***	-0.0256***	-0.0262***	-0.0259***	-0.0259***	-0.0260***
	(0.0030)	(0.0030)	(0.0029)	(0.0028)	(0.0029)	(0.0028)
Positive surprise	0.0180***	0.0184***	0.0183***	0.0183***	0.0191***	0.0185***
	(0.0023)	(0.0025)	(0.0023)	(0.0021)	(0.0020)	(0.0021)
VIX high	-0.0003	-0.0011	-0.0017	-0.0033	-0.0027	-0.0029
	(0.0015)	(0.0016)	(0.0014)	(0.0020)	(0.0023)	(0.0022)
Negative surprise & VIX high	-0.0020	-0.0015	-0.0003	-0.0021	-0.0019	-0.0016
	(0.0021)	(0.0022)	(0.0020)	(0.0027)	(0.0027)	(0.0028)
Positive surprise & VIX high	0.0023	0.0016	0.0018	0.0033	0.0005	0.0027
	(0.0021)	(0.0023)	(0.0022)	(0.0027)	(0.0029)	(0.0032)
Constant	0.0357**	0.0361**	0.0362**	0.0366**	0.0365**	0.0363**
	(0.0148)	(0.0147)	(0.0147)	(0.0149)	(0.0149)	(0.0149)
R-squared	0.0800	0.0800	0.0800	0.0802	0.0801	0.0801
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
N obs.	30302	30302	30302	30302	30302	30302

Year-month and industry clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6: OLS estimates for cumulative abnormal returns
This table presents the coefficient estimates for expected volatility (VIX) t, $t-1$ and $t-2$ event time. The VIX indicator is either cut off at the 3rd quartile (columns (1) to (3)) or at the 75th percentile (columns (4) to (6)). AEPS surprise is binned in 3 equally populated bins with neutral surprise as the reference category. Each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator.
A variable overview can be found in Table A1: Variable Overview

Expected volatility is commonly proxied by the VIX. The CBOE VIX infers the expected volatility

of market returns from the risk-neutral expectations of returns across several strike prices of 30-day S&P 500 options. The literature on option-implied measures of expected return and volatility has identified a pessimistic component in the implied measure of expected volatility (Bollerslev and Todorov, 2011; Martin, 2017). Based on these findings, one may be inclined to believe that the pessimism of a high VIX could also capture aspects of ambiguity and consequently translate into underreaction to positive and overreaction to negative surprises.

However, the ambiguity mechanism outlined in Epstein and Schneider (2008) operates through uncertainty about the precision of information signals. Signal precision is the inverse of variance and thus conceptually distinct from the expected level of market volatility. The VIX reflects uncertainty about the average market return, whereas ambiguity affects how investors interpret the informativeness of signals. Therefore, expected volatility should not give rise to the asymmetric response to earnings announcements predicted under ambiguity.

To test this distinction empirically, we repeat the analysis from Section 3.1 using expected volatility (VIX). T results are reported in Table 6. Instead of ambiguity (VVIX), we use a VIX-based dummy variable taking the value one when VIX is above its 3rd quartile (columns (1)-(3)) or 75th percentile (columns (4)-(6)). We also interact the expected volatility dummy with earnings surprises.

We find no direct effect of expected volatility on cumulative abnormal returns surrounding the earnings announcement. Furthermore, and consistent with the theoretical distinction, we find no evidence of an underreaction to positive surprises or an overreaction to negative surprises in response to expected volatility (Table 6). Pessimism in the option-implied expected volatility measure does not generate the asymmetry outlined in Epstein and Schneider (2008). Instead, the interaction between expected volatility and positive surprises is positive, suggesting that expected volatility may have the opposite effect to ambiguity. This is consistent with the notion that higher expected volatility can amplify the informational (Kim and Verrecchia, 1991) and attention-based (Barber and Odean, 2007) impact of earnings announcements, leading to larger positive market reactions. Higher volatility may also increase the liquidity provision premium around earnings announcements (Kaniel et al., 2012).

As a second empirical test, we estimate a specification that includes both VVIX and its interaction

	(1)	(2)	(3)	(4)	(5)	(6)
	3rd quartile			4th quartile		
	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$
Negative surprise	-0.0246***	-0.0247***	-0.0249***	-0.0253***	-0.0254***	-0.0254***
	(0.0030)	(0.0030)	(0.0031)	(0.0028)	(0.0029)	(0.0028)
Positive surprise	0.0204***	0.0209***	0.0208***	0.0200***	0.0197***	0.0199***
	(0.0024)	(0.0024)	(0.0025)	(0.0022)	(0.0021)	(0.0021)
Ambiguity high	0.0021	0.0011	0.0003	0.0014	-0.0004	0.0007
	(0.0014)	(0.0015)	(0.0016)	(0.0018)	(0.0020)	(0.0020)
Negative surprise & Ambiguity high	-0.0026*	-0.0021	-0.0016	-0.0038**	-0.0031*	-0.0029*
	(0.0015)	(0.0020)	(0.0020)	(0.0015)	(0.0018)	(0.0017)
Positive surprise & Ambiguity high	-0.0070***	-0.0077***	-0.0070***	-0.0101***	-0.0080***	-0.0088***
	(0.0019)	(0.0017)	(0.0016)	(0.0030)	(0.0028)	(0.0024)
VIX (50th quantile) high	-0.0010	-0.0006	-0.0005			
	(0.0015)	(0.0015)	(0.0014)			
Negative surprise & VIX (50th quantile) high	-0.0011	-0.0013	-0.0015			
	(0.0022)	(0.0022)	(0.0022)			
Positive surprise & VIX (50th quantile) high	0.0045**	0.0045**	0.0041*			
	(0.0021)	(0.0021)	(0.0020)			
VIX (75th percentile) high				-0.0035*	-0.0027	-0.0032
				(0.0019)	(0.0019)	(0.0020)
Negative surprise & VIX (75th percentile) high				-0.0006	-0.0009	-0.0010
				(0.0029)	(0.0028)	(0.0028)
Positive surprise & VIX (75th percentile) high				0.0072**	0.0064**	0.0066**
				(0.0027)	(0.0028)	(0.0026)
Constant	0.0350**	0.0354**	0.0357**	0.0359**	0.0360**	0.0359**
	(0.0146)	(0.0146)	(0.0146)	(0.0151)	(0.0150)	(0.0150)
R-squared	0.0805	0.0807	0.0807	0.0811	0.0810	0.0810
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
N obs.	30302	30302	30302	30302	30302	30302

Year-month and industry clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7: OLS estimates for cumulative abnormal returns, controlled for expected market volatility (VIX)

This table presents the coefficient estimates for several ambiguity proxies on cumulative abnormal returns from $t = -1$ to $t = 1$. The ambiguity dummies are cut off at the median and 75th quartile, respectively. VIX refers to the Chicago Board Options Exchange's Volatility Index, a measure of expected volatility. The VIX is recorded on the day of the announcement and binned at the median and 75th percentile. AEPS surprise is binned in 3 equally populated bins with neutral surprise as the reference category. As for the main analysis, each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator.

A variable overview can be found in Table A1: Variable Overview

with earnings surprises, while controlling for VIX. As discussed in Section 2.1, the two indices are positively correlated, raising the possibility that the observed asymmetry could be driven by a

common underlying factor. To address this concern, we include both VIX and its interaction with surprises in the specification from Section 3.1.

The results are reported in Table 7. We find that the asymmetric response to earnings announcements under high ambiguity is robust to controlling for expected volatility. The interaction between ambiguity and surprises remains statistically significant and of similar magnitude. In contrast, the interaction between VIX and surprises does not produce the negative asymmetry predicted by the ambiguity framework. Instead, the interaction between VIX and positive surprises is statistically significantly positive, indicating that positive surprises generate higher returns under high expected volatility.

Taken together, these findings indicate that the effects of ambiguity on earnings announcement reactions are distinct from, and not subsumed by, expected volatility.

4.3 Controlling for earnings-announcement correlation neglect

We control for the first firm announcing earnings reports in each industry and quarter by including the dummy variable *FEA* in all regression models. However, Guo and Wachter (2025) recently show that market returns in the first month of any given quarter positively predict market returns in subsequent months. The authors attribute this relation to correlation neglect. Market participants do not fully seize the joint information between earnings announcements in the first month of a quarter and announcements later during that quarter (Guo and Wachter, 2025). Due to this correlation neglect, investors overreact to earnings announcements in the second month of the quarter. This overreaction arises because the market reaction to the first announcements has already incorporated broader market implications of the earnings season. In accordance with this overreaction, the authors find that the second month's return in each quarter negatively predicts the first monthly return of the following quarter. The correlation neglect, which gives rise to the overreaction, is eventually corrected. This leads to a reversal at the beginning of the next quarter, when inflated expectations are disappointed by earnings information.

This pattern could potentially be an alternative explanation for our results if ambiguity were correlated with the timing of earnings announcements within a quarter. We therefore control for

	(1)	(2)	(3)	(4)	(5)	(6)
	3rd quartile			4th quartile		
	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$
Negative surprise	-0.0250***	-0.0252***	-0.0255***	-0.0254***	-0.0256***	-0.0256***
	(0.0029)	(0.0029)	(0.0030)	(0.0028)	(0.0028)	(0.0028)
Positive surprise	0.0219***	0.0225***	0.0223***	0.0211***	0.0207***	0.0210***
	(0.0022)	(0.0022)	(0.0023)	(0.0021)	(0.0021)	(0.0021)
Ambiguity high	0.0025*	0.0016	0.0008	0.0006	-0.0009	0.0002
	(0.0012)	(0.0014)	(0.0015)	(0.0018)	(0.0019)	(0.0018)
Negative surprise & Ambiguity high	-0.0029*	-0.0023	-0.0018	-0.0041***	-0.0035*	-0.0034**
	(0.0014)	(0.0019)	(0.0019)	(0.0014)	(0.0018)	(0.0016)
Positive surprise & Ambiguity high	-0.0053**	-0.0061***	-0.0056***	-0.0071**	-0.0054**	-0.0063***
	(0.0020)	(0.0018)	(0.0018)	(0.0028)	(0.0025)	(0.0022)
Indicator 2nd month in quarter & Return previous month	0.0653**	0.0624**	0.0612**	0.0619**	0.0606**	0.0609**
	(0.0254)	(0.0252)	(0.0248)	(0.0244)	(0.0239)	(0.0242)
Indicator 1st month in quarter & Return 2 month prior	-0.0145	-0.0152	-0.0156	-0.0143	-0.0154	-0.0146
	(0.0232)	(0.0230)	(0.0229)	(0.0224)	(0.0222)	(0.0223)
Constant	0.0337**	0.0342**	0.0346**	0.0345**	0.0348**	0.0345**
	(0.0147)	(0.0148)	(0.0148)	(0.0149)	(0.0150)	(0.0149)
R-squared	0.0809	0.0811	0.0811	0.0813	0.0814	0.0812
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
N obs.	30302	30302	30302	30302	30302	30302

Year month clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 8: OLS estimates for cumulative abnormal returns accounting for overreaction to late-season earnings announcements

This table presents the coefficient estimates for VVIX ambiguity at t, $t-1$ and $t-2$ on cumulative abnormal returns from $t=-1$ to $t=1$. Returns are obtained through a Fama-French 3-factor model. The ambiguity dummy is either cut off at the median (columns (1) to (3)) or at the 75th percentile (columns (4) to (6)). AEPS surprise is binned in 3 equally populated bins with neutral surprise as the reference category. As for the main analysis, each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator. The *Indicator 2 month in quarter & Return previous month* refers to an indicator function that takes 1 if the earnings announcement took place in the second month of a given quarter and zero otherwise. It interacts with the previous month's return and captures the positive relation between the market return of the first and second months of any given quarter (Guo and Wachter, 2025). The *Indicator 1 month in quarter & Return 2 months prior* refers to an indicator function that takes the value one when the earnings announcement took place in the first month of a given quarter. It interacts with the two months' prior market return. This interaction captures the negative relationship between the monthly return of the second month in a given quarter and the upcoming earnings season (first month of any given quarter) (Guo and Wachter, 2025).
A variable overview can be found in Table A1: Variable Overview

this effect in order to demonstrate that the asymmetric response to positive and negative news is independent of correlation neglect. For all announcements that fall into the second month of a

given quarter, we include the previous month's return, thus controlling for overreaction. Moreover, we include the 2-month lagged monthly market return for all 'earnings seasons', that is, the first month of any given quarter. This controls for the eventual disappointment of overly optimistic expectations. The results are shown in Table 8.

We find that the overreaction to earnings announcements taking place in the second month of any given quarter is positive and statistically significant. The reversal effect occurring in the first month of any given quarter is negative, but statistically insignificant from zero. Both findings are in line with Guo and Wachter (2025).

The underreaction to positive news and overreaction to negative news under high market ambiguity remain robust to the inclusion of correlation neglect. We find similar effect sizes and statistically significant coefficients in line with our initial findings from Section 3.1. These results indicate that the asymmetric response to earnings announcements under ambiguity is not driven by correlation neglect.

4.4 Controlling for firm unobservables

There are several firm-level variables that cannot be observed directly. In particular, dividend policies are highly firm-specific and may influence investors' interpretation of earnings per share. To capture such firm-specific effects, we include firm (ISIN) and year fixed effects in this robustness test instead of the industry fixed effects used in the baseline specification. This specification controls for time-invariant firm characteristics and reduces potential omitted variable bias in the estimation of the ambiguity-surprise interaction.

Consistent with the results in Section 3.1, we find that the asymmetric response to earnings surprises under elevated market ambiguity remains intact when including firm and year fixed effects. In particular, we continue to observe an underreaction to positive earnings surprises and an overreaction to negative earnings surprises.

Beyond time-invariant firm characteristics, firms' reporting choices (e.g., accounting conservatism) may vary over time, for example due to changes in management. Due to the short-lived nature of ambiguity, firms cannot adjust their accounting strategy in response to ambiguity at the time of

	(1)	(2)	(3)	(4)	(5)	(6)
	3rd quartile			4th quartile		
	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$
Negative surprise	-0.0252***	-0.0254***	-0.0256***	-0.0257***	-0.0257***	-0.0258***
	(0.0030)	(0.0030)	(0.0032)	(0.0029)	(0.0029)	(0.0029)
Positive surprise	0.0238***	0.0245***	0.0243***	0.0230***	0.0228***	0.0229***
	(0.0023)	(0.0023)	(0.0024)	(0.0022)	(0.0022)	(0.0022)
Ambiguity high	0.0018	0.0012	0.0006	0.0006	-0.0004	0.0002
	(0.0013)	(0.0014)	(0.0016)	(0.0018)	(0.0019)	(0.0018)
Negative surprise & Ambiguity high	-0.0031**	-0.0026	-0.0022	-0.0043***	-0.0041**	-0.0039**
	(0.0014)	(0.0019)	(0.0020)	(0.0015)	(0.0018)	(0.0016)
Positive surprise & Ambiguity high	-0.0059***	-0.0069***	-0.0064***	-0.0082***	-0.0071***	-0.0073***
	(0.0019)	(0.0018)	(0.0016)	(0.0028)	(0.0025)	(0.0022)
Constant	0.2610***	0.2612***	0.2612***	0.2622***	0.2629***	0.2625***
	(0.0388)	(0.0386)	(0.0386)	(0.0389)	(0.0388)	(0.0388)
R-squared	0.1050	0.1052	0.1052	0.1054	0.1055	0.1054
ISIN FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
N obs.	30302	30302	30302	30302	30302	30302

Year-month and industry clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 9: OLS estimates for cumulative abnormal returns including firm and year fixed effects
This table presents the coefficient estimates for VVIX ambiguity at t, $t-1$ and $t-2$ event time. The ambiguity dummy is either cut off at the median (columns (1) to (3)) or at the 75th percentile (columns (4) to (6)). AEPS surprise is binned in 3 equally populated bins with neutral surprise as the reference category. Each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator.
A variable overview can be found in Table A1: Variable Overview

the earnings announcement. Financial statements are prepared weeks in advance, while ambiguity is typically elevated only for several days. Accounting conservatism, defined as a strategic increase in negative accruals, therefore, does not arise in response to ambiguity. However, accounting conservatism may affect how investors interpret earnings announcements, as losses are generally less informative than profits (Klein and Marquardt, 2006).

While financial statements cannot be adjusted in response to ambiguity, their interpretation by investors may still vary with the level of ambiguity. We therefore include quarterly accruals and leverage as additional controls, as presented in Table A8. We find that the asymmetric response to earnings announcements remains robust to the inclusion of these accounting-related controls.

Overall, these findings indicate that the observed asymmetry in earnings announcement responses under ambiguity is not driven by firm-specific characteristics or time-varying accounting choices.

5 Conclusion

Theoretical models on information processing under ambiguity suggest that high market-level ambiguity leads to an underreaction to positive and an overreaction to negative earnings surprises (Epstein and Schneider, 2008). This is because high ambiguity increases the number of potential scenarios (and consequently the set of prior likelihoods), thereby negatively affecting the perceived precision of firm-level information for ambiguity-averse decision makers. This paper empirically tests this conjecture by investigating the effect of market-level ambiguity on market reactions to corporate earnings announcements.

We assess market responses to earnings announcements for more than 600 S&P 500 firms and combine these announcements with the VVIX as a proxy for market-level ambiguity. Using an event-study methodology, we show that investors underreact to positive earnings surprises when ambiguity is high, perceiving the news as less precise. The opposite is true for negative news: investors tend to overreact to negative surprises, perceiving their worst-case scenario as more precise. This corroborates the assumption that time-varying ambiguity affects ambiguity-averse investors' perceived precision of new information entering the market. Importantly, we show that this asymmetric response arises under ambiguity but not under expected volatility, highlighting a fundamental distinction between ambiguity and risk in information processing.

When considering post-announcement returns, we show that this effect is not persistent and reverts over time. We find that a statistically significant difference in returns between high and low ambiguity announcers persists for at least 15 days. After this period, the difference in cumulative abnormal returns approaches zero, leading to a positive correction for both positive and negative surprises. This pattern contrasts with standard post-earnings announcement drift, as ambiguity induces temporary distortions in prices that are subsequently corrected once ambiguity subsides.

We also demonstrate that our results are robust to alternative measures of market-level ambiguity, such as the EPU, the survey of professional forecasters, or the omega measure by Brenner and

Izhakian (2018), as well as to correlation neglect. Overall, our findings suggest that ambiguity plays a central role in shaping how financial markets process new information.

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Appendices

A Variable overview

Variable	Variable Name	Proxy	Frequency	Time availability	Source
Ambiguity	VVIX	Volatility of expected volatility on S&P 500 options (VVIX)	Daily	March 2006 to December 2024	CBOE
Ambiguity	Omega	Volatility of return probabilities of the SPY index fund (Omega)	Monthly	March 1993 to December 2024	TAQ
Ambiguity	EPU	Economic Policy Uncertainty Index (Baker, 2016)	Monthly	January 1985 to December 2024	www.policyuncertainty.com
Ambiguity	SPF	Standard deviation of probability forecast ranges of the Survey of Professional Forecasters, Philadelphia FED	Quarterly	October 1968 to December 2024	Philadelphia FED
Short-sales constraints	Shr. Institutional holdings	Share of institutional holdings	Bi-annual to annual depending on firm	1990 onward	Refinitiv Eikon
Earnings per share	Earnings per share (EPS)	Quarterly earnings per share issued	Quarterly	1983 onward (coverage depends on firm)	Refinitive Eikon
Analyst earnings per share expectations	Analyst earnings per share expectations (AEPS)	Market expectations of earnings per share	Quarterly	1984 onward (coverage depends on firm)	Refinitiv Eikon
Analyst earnings surprises	AEPS surprise	Percentage deviation of realised EPS from Analysts' earnings per share (AEPS)	Quarterly (at announcement date)	1990 onward	Refinitiv Eikon
Firm-level market disagreement	AEPS dispersion	Dispersion of analyst earnings per share expectations (AEPS)	Quarterly	1990 onward	Refinitiv Eikon
Firm Leverage	Total firm leverage	A firm's recorded total assets divided by total debt recorded at the beginning of the quarter preceding the earnings announcement	Quarterly to annually	1990 onward	Refinitiv Eikon
Momentum	Momentum return	The excess 12-month buy-and-hold return over the value-weighted CRSP index, ending 10 days prior to the announcement	Daily (annual moving window)	1992 onward	CRPS (WRDS) (own calculation)
Liquidity	Illiquidity (Amihud, 2002)	Average absolute return over dollar trading volume in the 250 days preceding the announcement, ending 10 days prior	Quarterly	1983 onward	Datastream (own calculation)
Accruals	Interpretation of accounting conservatism	Accruals in the previous quarterly statement divided by total assets	Quarterly	2000 onward	WRDS (CRSP)
Firm value	MV	Market valuation, shares outstanding times share price at the first trading day of the month preceding the earnings announcement	Daily	1993 onwards	Datastream (own calculation)
Book to market ratio	MB	Firm book value to market value (MV) as defined above	Quarterly	1994 onwards	Refinitiv Eikon, Datastream (own calculation)
First earnings-announcing firm in industry	FEA	Binary indicator for the first firm announcing per industry quarter	Quarterly	1960 onward	Refinitiv Eikon (own calculation)
NBER recession	Recession	NBER recession quarterly indicator	Monthly	1854 onward	https://fred.stlouisfed.org
Correlation neglect	MR2Q	Overreaction to earnings announcements in the second month of the quarter (one month prior)	Quarterly	March 2006 to December 2024	Datastream (own calculation)
Correlation neglect	MR1Q	First month in the quarter reversal of last quarter overreaction to earnings announcements in the second month of the quarter	Quarterly	March 2006 to December 2024	Datastream (own calculation)

Table A1: Variable overview: Description of variables

B Surprises conditional on ambiguity

	$VVIX_t$				
AEPS surprise	1st quartile	2nd quartile	3rd quartile	4th quartile	**Total**
Low	2925	2639	2627	2464	10655
Neutral	2941	2644	2696	2353	10634
High	2777	2404	2572	2903	10656
Total	8643	7687	7895	7720	31945

Table A2: Joint frequencies of VVIX ambiguity quartiles and three equally sized surprise categories
This table presents the conditional frequencies of positive, neutral and low surprises and VVIX ambiguity quartiles across the entire sample period. The AEPS surprise is binned in 3 equally populated bins.
A variable overview can be found in Table A1: Variable Overview

C Alternative bin cut-off points for VVIX ambiguity

	(1)	(2)	(1)	(2)	(3)	(4)	(5)	(6)	(5)	(6)
	75th percentile		80th percentile		85th percentile		90th percentile		95th percentile	
	$VVIX_t$	$VVIX_{t-1}$	$VVIX_t$	$VVIX_{t-1}$	$VVIX_t$	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-1}$	$VVIX_t$	$VVIX_{t-1}$
Negative surprise	-0.0250***	-0.0253***	-0.0249***	-0.0254***	-0.0252***	-0.0256***	-0.0256***	-0.0258***	-0.0258***	-0.0260***
	(0.0027)	(0.0026)	(0.0027)	(0.0027)	(0.0026)	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)
Positive surprise	0.0205***	0.0210***	0.0203***	0.0210***	0.0207***	0.0206***	0.0203***	0.0204***	0.0199***	0.0198***
	(0.0021)	(0.0022)	(0.0021)	(0.0021)	(0.0020)	(0.0021)	(0.0020)	(0.0020)	(0.0020)	(0.0020)
Ambiguity high	0.0017	0.0015	0.0018	0.0016	0.0025	0.0002	0.0013	0.0008	0.0022	0.0017
	(0.0012)	(0.0014)	(0.0014)	(0.0015)	(0.0016)	(0.0019)	(0.0016)	(0.0018)	(0.0020)	(0.0021)
Negative surprise & Ambiguity high	-0.0047***	-0.0036*	-0.0061***	-0.0039**	-0.0063***	-0.0037	-0.0058***	-0.0041*	-0.0066***	-0.0036
	(0.0016)	(0.0019)	(0.0018)	(0.0019)	(0.0018)	(0.0023)	(0.0014)	(0.0023)	(0.0024)	(0.0027)
Positive surprise & Ambiguity high	-0.0041**	-0.0058**	-0.0043*	-0.0070***	-0.0073***	-0.0063**	-0.0071***	-0.0073**	-0.0067**	-0.0053*
	(0.0020)	(0.0022)	(0.0024)	(0.0022)	(0.0025)	(0.0024)	(0.0022)	(0.0027)	(0.0025)	(0.0030)
ln(MB)	-0.0012**	-0.0012**	-0.0012**	-0.0012**	-0.0012**	-0.0012**	-0.0012**	-0.0012**	-0.0012**	-0.0012**
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
ln(MV)	-0.0013**	-0.0013**	-0.0013**	-0.0012**	-0.0013**	-0.0012**	-0.0012**	-0.0012**	-0.0013**	-0.0013**
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
AEPS dispersion	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Shr. of insititutional ownership	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Indicator FEA	0.0013	0.0013	0.0013	0.0014	0.0014	0.0014	0.0014	0.0013	0.0014	0.0013
	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)
Indicator Recession	0.0119***	0.0119***	0.0121***	0.0121***	0.0119***	0.0122***	0.0119***	0.0119***	0.0116***	0.0115***
	(0.0033)	(0.0031)	(0.0033)	(0.0031)	(0.0032)	(0.0030)	(0.0031)	(0.0031)	(0.0034)	(0.0034)
Momentum return	-0.0220***	-0.0221***	-0.0221***	-0.0221***	-0.0221***	-0.0221***	-0.0221***	-0.0221***	-0.0220***	-0.0221***
	(0.0034)	(0.0034)	(0.0034)	(0.0034)	(0.0034)	(0.0034)	(0.0034)	(0.0034)	(0.0034)	(0.0034)
Constant	0.0349**	0.0348**	0.0350**	0.0349**	0.0349**	0.0351**	0.0350**	0.0350**	0.0352**	0.0352**
	(0.0148)	(0.0149)	(0.0148)	(0.0149)	(0.0148)	(0.0149)	(0.0149)	(0.0149)	(0.0149)	(0.0149)
R-squared	0.0801	0.0802	0.0802	0.0803	0.0803	0.0804	0.0804	0.0804	0.0802	0.0800
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N obs.	30302	30302	30302	30302	30302	30302	30302	30302	30302	30302

Year-month and sector clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A3: OLS estimates for cumulative abnormal returns, using alternative thresholds
This table presents the coefficient estimates for several quantile thresholds of ambiguity on cumulative abnormal returns from $t = -1$ to $t = 1$. High ambiguity is defined as above the 75th, 80th, 85th, 90th, and 95th percentile of VVIX at time t and $t - 1$, respectively. AEPS surprise is binned in 3 equally populated bins with neutral surprise as the reference category. As for the main analysis, each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator. A variable overview can be found in Table A1: Variable Overview

D Ambiguity effect estimates for a market factor model

	(1)	(2)	(3)	(4)	(5)	(6)
	2nd quantile			3rd quantile		
	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$
Negative surprise	-0.0248***	-0.0250***	-0.0251***	-0.0255***	-0.0256***	-0.0256***
	(0.0028)	(0.0028)	(0.0030)	(0.0028)	(0.0028)	(0.0028)
Positive surprise	0.0217***	0.0222***	0.0221***	0.0208***	0.0205***	0.0207***
	(0.0023)	(0.0023)	(0.0024)	(0.0022)	(0.0022)	(0.0022)
Ambiguity high	0.0011	0.0001	-0.0007	-0.0009	-0.0023	-0.0008
	(0.0013)	(0.0014)	(0.0016)	(0.0019)	(0.0020)	(0.0019)
Negative surprise & Ambiguity high	-0.0032**	-0.0028	-0.0025	-0.0037**	-0.0034*	-0.0031*
	(0.0015)	(0.0019)	(0.0020)	(0.0016)	(0.0019)	(0.0017)
Positive surprise & Ambiguity high	-0.0052**	-0.0061***	-0.0058***	-0.0067**	-0.0054**	-0.0059**
	(0.0021)	(0.0020)	(0.0020)	(0.0029)	(0.0025)	(0.0022)
	(0.0037)	(0.0037)	(0.0037)	(0.0037)	(0.0037)	(0.0037)
Constant	0.0411**	0.0417**	0.0420**	0.0415**	0.0418**	0.0415**
	(0.0163)	(0.0164)	(0.0164)	(0.0166)	(0.0166)	(0.0165)
R-squared	0.0783	0.0786	0.0787	0.0789	0.0790	0.0787
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
N obs.	30302	30302	30302	30302	30302	30302

Year-month and industry clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A4: OLS estimates for cumulative abnormal returns obtained through a single-factor model
This table presents the coefficient estimates for several ambiguity proxies on cumulative abnormal returns from $t = -1$ to $t = 1$. Returns are obtained through a single-factor model, including only the market return. AEPS surprise is binned in 3 equally populated bins with neutral surprise as the reference category. As for the main analysis, each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator.
A variable overview can be found in Table A1: Variable Overview

E Ambiguity effect estimates with year-month fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)
	2nd quantile			3rd quantile		
	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$
Negative surprise	-0.0252***	-0.0254***	-0.0257***	-0.0255***	-0.0256***	-0.0257***
	(0.0028)	(0.0028)	(0.0030)	(0.0028)	(0.0028)	(0.0028)
Positive surprise	0.0219***	0.0224***	0.0223***	0.0211***	0.0207***	0.0210***
	(0.0022)	(0.0022)	(0.0023)	(0.0021)	(0.0021)	(0.0022)
Ambiguity high	0.0045***	0.0030**	0.0017	0.0027	-0.0000	0.0023
	(0.0011)	(0.0013)	(0.0013)	(0.0024)	(0.0026)	(0.0020)
Negative surprise & Ambiguity high	-0.0024*	-0.0019	-0.0014	-0.0037***	-0.0030*	-0.0027
	(0.0014)	(0.0018)	(0.0018)	(0.0013)	(0.0018)	(0.0016)
Positive surprise & Ambiguity high	-0.0051**	-0.0057***	-0.0055***	-0.0068**	-0.0050**	-0.0059**
	(0.0019)	(0.0018)	(0.0017)	(0.0028)	(0.0025)	(0.0023)
ln(MB)	-0.0012**	-0.0013**	-0.0013**	-0.0012**	-0.0012**	-0.0012**
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
ln(MV)	-0.0013**	-0.0013**	-0.0013**	-0.0013**	-0.0013**	-0.0013**
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
AEPS dispersion	0.0000***	0.0000**	0.0000**	0.0000**	0.0000***	0.0000**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Shr. of insititutional ownership	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Indicator FEA	0.0013	0.0014	0.0014	0.0015	0.0015	0.0015
	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0016)
Indicator Recession						
Momentum return	-0.0227***	-0.0227***	-0.0227***	-0.0228***	-0.0227***	-0.0228***
	(0.0032)	(0.0032)	(0.0031)	(0.0032)	(0.0032)	(0.0031)
Constant	0.0350**	0.0356**	0.0362**	0.0363**	0.0367**	0.0362**
	(0.0148)	(0.0150)	(0.0151)	(0.0149)	(0.0150)	(0.0149)
R-squared	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909
Industry FE	YES	YES	YES	YES	YES	YES
Year x Month FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
N obs.	30302	30302	30302	30302	30302	30302

Year-month and industry clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A5: OLS estimates for cumulative abnormal returns with year-month fixed effects
This table presents the coefficient estimates for VVIX ambiguity at t, $t-1$ and $t-2$ event time. The ambiguity dummy is either cut off at the median (columns (1) to (3)) or at the 75th percentile (columns (4) to (6)). AEPS surprise is binned in 3 equally populated bins with neutral surprise as the reference category. Each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator. The regression controls for year-month fixed effects. The effect estimates, therefore, draw from the intra-month difference in VVIX ambiguity.
A variable overview can be found in Table A1: Variable Overview

F Ambiguity effect estimates excluding surprises with near-zero expectations

	(1)	(2)	(3)	(4)	(5)	(6)
	3rd quartile			4th quartile		
	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$	$VVIX_t$	$VVIX_{t-1}$	$VVIX_{t-2}$
Negative surprise	-0.0252***	-0.0254***	-0.0258***	-0.0258***	-0.0260***	-0.0260***
	(0.0031)	(0.0030)	(0.0032)	(0.0031)	(0.0031)	(0.0030)
Positive surprise	0.0246***	0.0249***	0.0248***	0.0234***	0.0234***	0.0236***
	(0.0027)	(0.0027)	(0.0029)	(0.0026)	(0.0026)	(0.0025)
Ambiguity high	0.0018	0.0012	-0.0001	0.0009	-0.0010	0.0003
	(0.0013)	(0.0016)	(0.0017)	(0.0022)	(0.0025)	(0.0020)
Negative surprise & Ambiguity high	-0.0038**	-0.0033	-0.0024	-0.0052***	-0.0043**	-0.0045**
	(0.0015)	(0.0020)	(0.0020)	(0.0017)	(0.0021)	(0.0017)
Positive surprise & Ambiguity high	-0.0067***	-0.0070***	-0.0066***	-0.0081***	-0.0076***	-0.0082***
	(0.0021)	(0.0020)	(0.0022)	(0.0029)	(0.0026)	(0.0025)
Constant	0.0356**	0.0361**	0.0366**	0.0363**	0.0366**	0.0363**
	(0.0153)	(0.0153)	(0.0154)	(0.0155)	(0.0156)	(0.0155)
R-squared	0.0902	0.0903	0.0904	0.0906	0.0909	0.0906
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
N obs.	23100	23100	23100	23100	23100	23100

Year-month and industry clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A6: OLS estimates for cumulative abnormal returns excluding AEPS estimates close to zero
This table presents the coefficient estimates for VVIX ambiguity at t, $t-1$ and $t-2$ event time. The ambiguity dummy is either cut off at the median (columns (1) to (3)) or at the 75th percentile (columns (4) to (6)). AEPS surprise is binned in 3 equally populated bins with neutral surprise as the reference category. We exclude earnings surprises where assignment surprises based on dollar valued difference between earnings per share estimates and actual EPS differ from the percentage-based assignment. Each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator.
A variable overview can be found in Table A1: Variable Overview

G Buy-and-hold abnormal long run returns

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Negative surprise						Positive surprise					
Event time	Mean ambi low	Mean ambi high	Difference ambi high-low	Mann Whitney Test	T-test	Welch Test	Mean ambi low	Mean ambi high	Difference ambi high-low	Mann Whitney Test	T-test	Welch Test
						$VVIX_t$						
1	-0.020	-0.014	-0.005	-0.005*** (4138768.0)	-0.005*** (-2.892)	-0.005*** (-2.892)	0.021	0.015	-0.006	-0.006*** (4102102.0)	-0.006*** (-3.45)	-0.006*** (-3.461)
5	-0.019	-0.014	-0.005	-0.005** (4193292.0)	-0.005** (-2.271)	-0.005** (-2.271)	0.021	0.018	-0.003	-0.003* (4206415.0)	-0.003 (-1.682)	-0.003* (-1.687)
10	-0.019	-0.012	-0.006	-0.006** (4198274.0)	-0.006*** (-2.682)	-0.006*** (-2.682)	0.022	0.021	-0.001	-0.001 (4294379.0)	-0.001 (-0.273)	-0.001 (-0.274)
15	-0.018	-0.011	-0.007	-0.007** (4206796.0)	-0.007*** (-2.754)	-0.007*** (-2.754)	0.023	0.024	0.001	0.001 (4314587.0)	0.001 (0.222)	0.001 (0.223)
20	-0.020	-0.012	-0.008	-0.008* (4225186.0)	-0.008** (-2.631)	-0.008** (-2.631)	0.021	0.023	0.002	0.002 (4360804.0)	0.002 (0.757)	0.002 (0.763)
25	-0.020	-0.013	-0.007	-0.007* (4215188.0)	-0.007** (-2.137)	-0.007** (-2.137)	0.022	0.025	0.003	0.003 (4369193.0)	0.003 (1.087)	0.003 (1.098)
30	-0.019	-0.013	-0.006	-0.006* (4220641.0)	-0.006* (-1.813)	-0.006* (-1.813)	0.022	0.027	0.005	0.005 (4367191.0)	0.005 (1.531)	0.005 (1.548)
35	-0.018	-0.011	-0.007	-0.007 (4259178.0)	-0.007** (-1.946)	-0.007* (-1.946)	0.025	0.027	0.003	0.003 (4304483.0)	0.003 (0.744)	0.003 (0.751)
						$VVIX_{t-1}$						
1	-0.020	-0.013	-0.007	-0.007*** (4152912.0)	-0.007*** (-3.727)	-0.007*** (-3.73)	0.022	0.015	-0.007	-0.007*** (4083839.0)	-0.007*** (-3.884)	-0.007*** (-3.89)
5	-0.020	-0.013	-0.007	-0.007** (4184554.0)	-0.007*** (-3.204)	-0.007*** (-3.206)	0.022	0.018	-0.004	-0.004* (4200764.0)	-0.004* (-1.87)	-0.004** (-1.875)
10	-0.019	-0.012	-0.008	-0.008** (4193410.0)	-0.008*** (-3.218)	-0.008*** (-3.226)	0.022	0.021	-0.001	-0.001 (4292227.0)	-0.001 (-0.248)	-0.001 (-0.249)
15	-0.018	-0.011	-0.007	-0.007** (4214773.0)	-0.007*** (-2.766)	-0.007*** (-2.773)	0.023	0.024	0.000	0.000 (4294781.0)	0.000 (0.122)	0.000 (0.124)
20	-0.020	-0.012	-0.008	-0.008* (4227323.0)	-0.008*** (-2.746)	-0.008*** (-2.748)	0.021	0.023	0.002	0.002 (4353352.0)	0.002 (0.741)	0.002 (0.75)
25	-0.020	-0.013	-0.007	-0.007* (4227342.0)	-0.007** (-2.336)	-0.007** (-2.338)	0.022	0.025	0.003	0.003 (4341155.0)	0.003 (0.863)	0.003 (0.876)
30	-0.018	-0.013	-0.005	-0.005 (4263230.0)	-0.005* (-1.617)	-0.005 (-1.618)	0.023	0.027	0.004	0.004 (4332478.0)	0.004 (1.213)	0.004 (1.234)
35	-0.018	-0.011	-0.006	-0.006 (4284237.0)	-0.006* (-1.753)	-0.006 (-1.751)	0.026	0.026	0.001	0.001 (4252415.0)	0.001 (0.182)	0.001 (0.185)

Test statistic parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A7: Buy-and-hold abnormal return distribution over time periods of up to 30 days
The table presents the average buy-and-hold abnormal post-announcement returns of firms announcing positive and negative surprises under low and high ambiguity, proxied by VVIX ambiguity. Expected returns are obtained from the CRSP annual market valuation decile portfolio. The abnormal buy-and-hold return is defined as the difference in cumulative returns of the firm and the matching portfolio decile for the same time period. The average difference between returns of similar surprises (split by ambiguity) is displayed in columns (3) and (9) ("Difference ambi high-low"). High ambiguity announcements are all firms announcing when the $VVIX$ is above its 50th percentile. We test the null hypothesis of both groups sharing the same distribution of buy-and-hold returns for several time periods. The different time periods always start from *t-2* but end at x, where x can range from 1 to 30 days. The final day of the respective time period is indicated in the left-most column. The null hypothesis is tested across three different tests: an independent sample t-test, the Welch test, and the Mann-Whitney test. Both the t-test and the Welch test have been conducted as permutation tests, alleviating the need for distributional assumptions. This addresses the concern of strong positive skewness in cumulative medium- or long-term concerns (Lyon et al., 1999).

H Controlling for illiquidity, leverage and accruals

	(1)	(2)	(3)	(4)	(5)	(6)	(4)	(5)	(6)	(4)	(5)	(6)	(4)	(5)	(6)			
	3rd quartile												4th quartile					
		$VVIX_t$			$VVIX_{t-1}$			$VVIX_{t-2}$			$VVIX_t$			$VVIX_{t-1}$			$VVIX_{t-2}$	
	Illiquidity	Leverage	Accruals	Illiquidity	Leverage	Accruals	Illiquidity	Leverage	Accruals	Illiquidity	Leverage	Accruals	Illiquidity	Leverage	Accruals	Illiquidity	Leverage	Accruals
Negative surprise	-0.0249***	-0.0248***	-0.0260***	-0.0251***	-0.0250***	-0.0263***	-0.0253***	-0.0252***	-0.0268***	-0.0256***	-0.0254***	-0.0270***	-0.0257***	-0.0254***	-0.0269***	-0.0258***	-0.0254***	-0.0267***
	(0.0029)	(0.0028)	(0.0030)	(0.0028)	(0.0027)	(0.0031)	(0.0030)	(0.0029)	(0.0033)	(0.0028)	(0.0027)	(0.0030)	(0.0028)	(0.0027)	(0.0029)	(0.0027)	(0.0027)	(0.0028)
Positive surprise	0.0216***	0.0214***	0.0214***	0.0223***	0.0219***	0.0216***	0.0221***	0.0218***	0.0213***	0.0211***	0.0205***	0.0205***	0.0205***	0.0203***	0.0205***	0.0207***	0.0206***	0.0208***
	(0.0022)	(0.0022)	(0.0018)	(0.0023)	(0.0023)	(0.0019)	(0.0024)	(0.0024)	(0.0020)	(0.0022)	(0.0021)	(0.0020)	(0.0022)	(0.0021)	(0.0019)	(0.0022)	(0.0021)	(0.0019)
Ambiguity high	0.0017	0.0016	0.0011	0.0011	0.0008	0.0001	0.0004	0.0001	-0.0004	0.0001	-0.0003	-0.0009	-0.0017	-0.0014	-0.0018	-0.0009	-0.0003	-0.0005
	(0.0014)	(0.0015)	(0.0013)	(0.0015)	(0.0017)	(0.0015)	(0.0016)	(0.0017)	(0.0017)	(0.0018)	(0.0021)	(0.0016)	(0.0019)	(0.0020)	(0.0016)	(0.0018)	(0.0021)	(0.0017)
Negative surprise & Ambiguity high	-0.0034**	-0.0031**	-0.0032*	-0.0029	-0.0026	-0.0025	-0.0024	-0.0022	-0.0014	-0.0038**	-0.0038**	-0.0025*	-0.0032	-0.0037	-0.0026	-0.0029	-0.0037*	-0.0034*
	(0.0014)	(0.0015)	(0.0017)	(0.0019)	(0.0021)	(0.0020)	(0.0020)	(0.0021)	(0.0022)	(0.0015)	(0.0016)	(0.0012)	(0.0020)	(0.0022)	(0.0018)	(0.0017)	(0.0020)	(0.0017)
Positive surprise & Ambiguity high	-0.0045**	-0.0053**	-0.0052**	-0.0056***	-0.0061***	-0.0053***	-0.0051***	-0.0058***	-0.0048**	-0.0065**	-0.0068**	-0.0063**	-0.0043*	-0.0057**	-0.0060***	-0.0047**	-0.0068***	-0.0069***
	(0.0020)	(0.0023)	(0.0019)	(0.0018)	(0.0021)	(0.0018)	(0.0017)	(0.0020)	(0.0018)	(0.0025)	(0.0028)	(0.0026)	(0.0024)	(0.0025)	(0.0020)	(0.0020)	(0.0024)	(0.0018)
ln(MB)	-0.0011*	-0.0009	-0.0015**	-0.0012*	-0.0009	-0.0015**	-0.0012*	-0.0009	-0.0015**	-0.0011*	-0.0009	-0.0015**	-0.0011*	-0.0009	-0.0015**	-0.0011*	-0.0009	-0.0015**
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
ln(MV)	-0.0011*	-0.0011*	-0.0016**	-0.0011*	-0.0011*	-0.0016**	-0.0011*	-0.0011*	-0.0016**	-0.0011*	-0.0011*	-0.0016**	-0.0011*	-0.0011*	-0.0016**	-0.0011*	-0.0011*	-0.0016**
	(0.0006)	(0.0006)	(0.0007)	(0.0006)	(0.0006)	(0.0007)	(0.0006)	(0.0006)	(0.0007)	(0.0006)	(0.0006)	(0.0007)	(0.0006)	(0.0006)	(0.0007)	(0.0006)	(0.0006)	(0.0007)
AEPS dispersion	0.0000*	0.0000*	-0.0002**	0.0000*	0.0000*	-0.0002**	0.0000*	0.0000*	-0.0002**	0.0000*	0.0000*	-0.0002**	0.0000*	0.0000*	-0.0002**	0.0000*	0.0000*	-0.0002**
	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0001)
Shr. of insititutional ownership	-0.0000	-0.0001	-0.0001	-0.0000	-0.0001	-0.0001	-0.0000	-0.0001	-0.0001	-0.0000	-0.0001	-0.0001	-0.0000	-0.0001	-0.0001	-0.0000	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Indicator FEA	0.0014	0.0013	0.0002	0.0013	0.0013	0.0002	0.0014	0.0013	0.0002	0.0014	0.0014	0.0002	0.0014	0.0014	0.0003	0.0014	0.0014	0.0003
	(0.0017)	(0.0016)	(0.0018)	(0.0017)	(0.0016)	(0.0018)	(0.0017)	(0.0016)	(0.0018)	(0.0017)	(0.0016)	(0.0018)	(0.0017)	(0.0016)	(0.0018)	(0.0017)	(0.0016)	(0.0018)
Indicator Recession	0.0111***	0.0121***	0.0127***	0.0114***	0.0124***	0.0129***	0.0115***	0.0126***	0.0129***	0.0119***	0.0130***	0.0133***	0.0123***	0.0133***	0.0137***	0.0121***	0.0131***	0.0134***
	(0.0034)	(0.0034)	(0.0037)	(0.0033)	(0.0032)	(0.0036)	(0.0032)	(0.0031)	(0.0036)	(0.0032)	(0.0030)	(0.0035)	(0.0031)	(0.0030)	(0.0033)	(0.0031)	(0.0030)	(0.0034)
Momentum return	-0.0222***	-0.0212***	-0.0223***	-0.0222***	-0.0213***	-0.0223***	-0.0222***	-0.0213***	-0.0223***	-0.0223***	-0.0214***	-0.0224***	-0.0223***	-0.0214***	-0.0224***	-0.0223***	-0.0214***	-0.0224***
	(0.0034)	(0.0035)	(0.0035)	(0.0034)	(0.0035)	(0.0035)	(0.0034)	(0.0035)	(0.0035)	(0.0034)	(0.0034)	(0.0035)	(0.0034)	(0.0035)	(0.0035)	(0.0034)	(0.0035)	(0.0035)
Illiquidity	-0.0000			-0.0000			-0.0000			-0.0000			-0.0000			-0.0000		
	(0.0000)			(0.0000)			(0.0000)			(0.0000)			(0.0000)			(0.0000)		
Total leverage		0.0041			0.0041			0.0040			0.0041			0.0040			0.0041	
		(0.0029)			(0.0029)			(0.0029)			(0.0029)			(0.0029)			(0.0029)	
Accruals to total assets			-0.0424*			-0.0425*			-0.0426*			-0.0426*			-0.0425*			-0.0426*
			(0.0229)			(0.0229)			(0.0229)			(0.0231)			(0.0230)			(0.0229)
Constant	0.0303*	0.0312**	0.0429**	0.0308**	0.0317**	0.0434**	0.0310**	0.0319**	0.0437**	0.0309*	0.0317**	0.0434**	0.0313**	0.0318**	0.0436**	0.0311**	0.0315*	0.0434**
	(0.0149)	(0.0152)	(0.0183)	(0.0150)	(0.0153)	(0.0183)	(0.0150)	(0.0152)	(0.0182)	(0.0152)	(0.0155)	(0.0186)	(0.0153)	(0.0156)	(0.0186)	(0.0151)	(0.0155)	(0.0185)
R-squared	0.0812	0.0799	0.0853	0.0814	0.0801	0.0854	0.0814	0.0801	0.0853	0.0816	0.0804	0.0856	0.0817	0.0805	0.0858	0.0815	0.0804	0.0857
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N obs.	28272	29176	25274	28272	29176	25274	28272	29176	25274	28272	29176	25274	28272	29176	25274	28272	29176	25274

Table A8: OLS estimates for cumulative abnormal returns

This table presents the coefficient estimates for VVIX ambiguity at t, $t-1$ and $t-2$ event time. The ambiguity dummy is either cut off at the median (columns (1) to (3)) or at the 75th percentile (columns (4) to (6)). AEPS surprise is binned in 3 equally populated bins with neutral surprise as the reference category. Each OLS estimate is controlled for market valuation, book-to-market ratio, AEPS dispersion, momentum returns, the share of institutional holdings in the given year, an indicator variable for the first announcing firm in each industry in each quarter and the monthly NBER recession indicator. Moreover, we control for illiquidity, firm leverage and accruals to total assets.

A variable overview can be found in Table A1: Variable Overview