# Short-Term Climate Cycles, Forecasts, and Operating Performance*

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**Abstract**

We study how the El Niño Southern Oscillation (ENSO)—a short-term, forecastable climate cycle with global weather impacts—affects corporate operating performance using a cross-country sample. We find that conditions favoring El Niño, the 'warm' event, have heterogeneous effects on firms' net income, whereas La Niña, the ENSO 'cold' event, tends to improve net income. However, there is heterogeneity across industries as primary sectors appear more affected than secondary and tertiary sectors. Firms and analysts partially incorporate ENSO forecasts into earnings and revenue expectations. Lastly, the forecasted component of ENSO has a generally larger effect on operating performance than the surprise component does, consistent with firms making operating adaptations based on ENSO forecasts.

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# 1. Introduction

The effects of weather anomalies and climate disasters (e.g., heat shocks, hurricanes) on businesses and the economy are significant and receive growing attention (Addoum et al., 2023; Deryugina et al., 2018; Gallagher and Hartley, 2017; Liao and Kousky, 2022; Pankratz et al., 2023). A major factor driving short-term global weather (and the likelihood of such anomalies) is the El Niño Southern Oscillation (ENSO), a periodic yet irregular variation in winds and sea surface temperatures over the tropical Pacific Ocean. The temperature and precipitation impacts of ENSO on the economy are most studied in the agriculture industry. But does ENSO meaningfully affect other sectors? This is a pressing knowledge gap because some climate scientists argue that the frequency, intensity, and duration of ENSO events will become more damaging as the planet continues on a long-run warming path (Wilcox et al., 2023).

However, firms need not be uninformed about the evolution of ENSO because scientific organizations provide informative ENSO forecasts up to nine months before realizations. Shrader (2023) shows that tuna harvesters on the Pacific Northwest coast use these forecasts to make operational adaptations. Again, however, it is unclear whether a broader set of industries will use ENSO forecasts to adapt. Studying the relationship between ENSO events, forecasts, and operating decisions can offer valuable insights into whether businesses adapt to climate variation. Low levels of adaptation could be driven by inattentiveness to ENSO forecasts or a fundamental inability to adapt.

Conceptually, climate factors like ENSO can affect firm decisions and performance through multiple channels. Shifting temperature and precipitation patterns can directly impact the demand for certain products and services or affect production processes and supply chains. If decision-relevant and available to managers, ENSO forecasts enable firms to adapt their operations in anticipation of changing conditions. However, inattention to climate factors, adjustment costs, or an inability to fully adapt can limit firms.

To illuminate these issues, we first document the impact of ENSO realizations on firms' fundamental economic performance. We then test whether firms and market participants are attentive to ENSO forecasts by studying how management earnings guidance and analyst estimates respond to forecast revisions. Then, we examine whether firms leverage ENSO forecasts to adapt their operations.

To begin our study of the impact of ENSO on firm fundamentals, we first note that ENSO cycles, including 'warm' El Niño and 'cool' La Niña phases, last between two to seven years. Thus, we focus on operational impacts: net income, operating income, revenue, and cost of goods sold (COGS). And because ENSO can have worldwide effects through atmospheric 'teleconnections', we consider a global sample of companies (Luo et al., 2010). Our ENSO data are generously provided by Columbia Climate School's International Research Institute for Climate and Society (IRI), which gathers data on realizations and forecasts of the Pacific Ocean sea surface temperature anomaly (SSTAs) from various scientific agencies. These SSTAs serve as our measure of the ENSO state.

The first empirical analysis shows that ENSO SSTAs are insignificantly negatively related to firm profits. When conditioning on the sign of the anomaly, however, we find that the relation is statistically significant—for negative SSTAs, one standard deviation more negative anomaly increases quarterly profits by 4.5%. We then consider the effects by economic sector. Significant ENSO-profit relations are largely observed in primary and secondary sectors (basic materials, consumer cyclicals, consumer non-cyclicals, energy, and industrials). They are not observed in mostly tertiary sectors (financials, healthcare, real estate, technology, and utilities). While most affected sectors do better when negative SSTAs are negative, the response when positive SSTAs are more positive is variable (e.g., consumer non-cyclicals firms do better and energy firms do worse). The negative ENSO-profit relation for negative SSTAs is observed in all continents, while an on-average negative ENSO-profit relation is also observed for positive SSTAs in North America. We also find that ENSO affects profits through revenue and COGS impacts.

Having documented that ENSO affects operating performance, we explore whether firms are attentive to ENSO forecasts and their implications for future performance. We use firm-issued guidance about earnings and revenue to capture firms‘ expectations. If firms are attentive to the performance implications of ENSO forecasts, their guidance revisions should reflect ENSO forecast updates. The evidence is spotty. Consistent with the earlier results about fundamentals, industrial firms increase their earnings guidance, and basic materials firms increase their revenue guidance when ENSO forecasts revisions indicate more negative SSTAs. However, we do not observe guidance revisions in several sectors where the results on fundamentals justify them (e.g., consumer cyclicals and consumer non-cyclicals). Similarly, while firms in North America revise their guidance upwards when ENSO forecasts revisions indicate more negative SSTAs (consistent with attentiveness), Asian firms do not seem to update their guidance. In short, the evidence suggests firms are partially attentive to ENSO forecasts.

We also consider whether capital markets appreciate the performance implications of ENSO forecasts. Specifically, we study revisions to analysts' net income and revenue estimates following ENSO forecast revisions. The approach is analogous to our study of firm attentiveness using firm guidance. Similar to the firm guidance results, analysts are partly attentive to the earnings and revenue implications of ENSO forecasts. For example, analysts covering consumer cyclicals, consumer non-cyclicals, and Asian firms appear inattentive to ENSO forecast implications.

Finally, we explore whether, in addition to being attentive to ENSO forecasts, firms use ENSO forecasts to guide operational changes/adaptations. Motivated by Shrader (2023), we argue that if firms base operational adaptations on ENSO forecasts, their performance will be affected differentially by the forecasted component of an SSTA realization vis-à-vis the shock or unexpected component. The idea is that the performance response to ENSO forecasts will reflect firms' adaptation. In contrast, the performance response to ENSO shocks will reflect the residual ENSO variation that firms have not yet adapted to, often called climate 'damages.'

Focusing on negative SSTA realizations, we find that the forecasted portion of ENSO typically has a larger effect on Net Income than the shock portion, with the difference being statistically significant when considering the lead-2 and lead-3 forecasts: the forecasted portion improves net income more than the shock portion. We observe similar and more statistically significant patterns for operating income and revenue. This evidence is suggestive of firms leveraging or adapting to ENSO forecasts to improve operating performance.

We contribute to the recent empirical literature on how firms adapt to climate impacts. Barrot and Sauvagnat (2016) and Pankratz et al. (2023) show that firms adjust their supply chain structures and surplus distribution following climate impacts. Li et al. (2024) show that firms respond to high perceived climate exposure by varying their investment, innovation, and employment activities. These papers consider climate information and impact jointly—the firm typically updates its risk assessment following an adverse event. Our setting features a lag between the production of climate information and the eventual climate realization—this allows us to isolate the operational impacts of these two items. The ENSO setting also carries importance: while ENSO is the major driver of within-year weather variation following the changing seasons, we lack broad-sample evidence of its effects on firms' operations. These effects will potentially grow if climate change intensifies ENSO (Wilcox et al., 2023).

The two papers closest to ours are Shrader (2023) and Patnaik (2016). Shrader (2023) builds a framework relating ENSO forecasts to how tuna harvesters in the US Northwest adapt by reducing the number of shipping expeditions and modifying expedition routes. Our paper complements Shrader (2023) by considering firms in industries and geographies less proximate to Pacific Ocean SSTAs. Patnaik (2016) shows how competition moderates the relation between ENSO forecast uncertainty and investment. Our paper considers the mean of ENSO forecasts rather than the variance and focuses on shorter-run operational impacts. We also propose firm-issued guidance to assess whether and when climate forecasts enter managers‘ information sets. Our analysis offers valuable insights into whether and how businesses adapt to climate variation.

# 2. El Niño-Southern Oscillation

## 2.1 Meteorological Overview

The El Niño-Southern Oscillation (ENSO) is a natural climate phenomenon that involves periodic fluctuations in sea surface temperatures, atmospheric pressure, and winds across the equatorial Pacific Ocean. ENSO has two opposite phases: El Niño, when the eastern Pacific becomes abnormally warm, and La Niña when the eastern Pacific becomes abnormally cold. Because of atmospheric 'teleconnections,' ENSO affects global weather patterns and can shift the probabilities of events such as floods, droughts, heat waves, storms, and wildfires in different regions of the world. Figure 1 describes some of the argued global impacts of ENSO. The figure is based on the widely-used schematic of Trenberth et al. (1998), which summarises earlier seminal work. Since then, evidence has emerged that ENSO's effects are further far-reaching and can affect even the European climate (King et al., 2023; Lin and Qian, 2019).

The state of ENSO is typically measured using sea-surface temperature data from delineated regions of the Pacific Ocean (e.g., the Niño 3.4 region spans 5N-5S and 170W-120W). Figure 2 plots the mean realizations provided by the IRI from 2002 to 2023. The red regions are El Niño phases (SSTAs consistently above 0.5°C), the black regions are neutral phases, and the blue regions are La Niña phases (SSTAs consistently below -0.5°C). El Niño events typically last between 9 to 12 months, and La Niña Events can persist for more than a year.

## 2.2 ENSO Forecasts

ENSO has been the subject of extensive research and monitoring by various organizations worldwide. The first ENSO forecast was produced in the mid-1980s by researchers at Columbia University. In 1989, the Climate Prediction Centre (CPC), a branch of the National Oceanic and Atmospheric Administration (NOAA), produced its own ENSO forecast. The number of ENSO forecasts produced has grown steadily since. In 2002, Columbia University's IRI began collecting publicly issued ENSO forecasts. By 2023, their data contain forecasts from 27 different models, along with ENSO SSTA realizations that are matched to those models. We consider the mean across this plume of model forecasts. The forecasts exist from month -8 to month 0 for the three-month period [0, 2]—we refer to the month -8 forecast as Forecast9 and the month 0 forecast as Forecast1.

## 3. Research Question Development

Research has demonstrated the effects of ENSO in arguably proximate sectors like agriculture, agricultural insurance, and tourism (e.g., Hansen et al., 1998). But because of its far-reaching effects on temperature and precipitation, ENSO could also impact the performance, risk, and strategies of a broader set of industries. ENSO might drive variation in input and output prices/quantities and productivity.

The impact of ENSO on firm fundamentals is not straightforward to predict ex-ante because ENSO's effects can vary substantially across geographic regions and industries. El Niño can also have negative effects like increasing the likelihood of flooding and extreme rainfall in the Southern U.S. and drought in Australia and parts of Asia (Deryugina et al., 2018). These disruptions can impede economic activity, particularly in commodity and agriculture-dependent economies. La Niña events tend to have opposing impacts, such as drier conditions in the Southern U.S.

In other cases, ENSO events may provide economic benefits. For example, El Niño years may bring milder winter weather in typically cold areas, reducing heating costs and driving higher consumer spending (Addoum et al., 2023). Similarly, in the U.S., El Niño is associated with greater winter precipitation that replenishes water supplies, benefiting agriculture (Liao and Kousky, 2022).

The net impact of ENSO on a firm will depend on the geographic footprint of its operations, customer base, and supply chain. Firms with greater exposure to ENSO-sensitive regions may experience more pronounced impacts. The effects are also likely to vary across industries based on their sensitivity to ENSO-induced changes in temperature, precipitation, and storm patterns.

Given these complexities, we do not propose a single directional hypothesis for ENSO's effect on firm fundamentals globally. Instead, we aim to provide broad-sample evidence that can inform our understanding of ENSO's impacts across different industries and regions. We expect the impacts to be more pronounced in primary and secondary sectors sensitive to weather conditions, such as energy and industrials. Our first research question is a general one:

**RQ1:** *Does ENSO meaningfully affect profitability and its components?*

A potential takeaway that could emerge from RQ1 is that firms are subject to performance shocks from the stochastic ENSO process. A sophisticated firm could obtain foresight about these impacts through ENSO forecasts. For example, in June 2023, the NOAA forecasted a moderate to strong El Niño event to peak during the fall/winter of 2023-2034. A Chicago snowplow operator could infer from the forecast (or media coverage) a milder-than-usual Chicago winter and, in turn, could update their expectations for the upcoming winter's operating performance. To study this type of 'attentiveness' more broadly, we will consider firm-issued guidance because it reflects the expectations of internal managers who have access to the firm's private information and strategy (Baginski, 1987; Waymire, 1984).

**RQ2a:** *Does firm guidance reflect ENSO forecast information?*

A natural extension is moving beyond the firm and considering the information that capital markets impound. Hutton et al. (2012) and Kadan et al. (2012) find that analysts have an information advantage over managers when forecasting the effect of macroeconomic factors such as Gross Domestic Product and energy costs. ENSO potentially falls within this category. As with managers, if analysts are attentive to the effects of ENSO, this could be useful to capital markets.

**RQ2b:** *Do analyst estimates reflect ENSO forecast information?*

There are reasons, however, to expect why firms and analysts might fail to impound ENSO forecast information into their projections of firm performance. First, they might be unaware of the forecasts available on the websites of forecasting agencies and which might be too technical to digest (Christensen et al., 2017). Second, even if intermediaries such as news outlets make ENSO forecast information more digestible, firms might struggle to connect anticipated weather patterns with performance implications, especially if the ENSO effects are more indirect (e.g., supply chain impacts).

Lastly, an important consideration is whether firms *use* the information in ENSO forecasts to adapt their operations to mitigate the adverse impact of ENSO fluctuations on their profitability. For example, the snowplow operator anticipating a milder-than-usual winter could be proactive, scale back their hiring activity, and lease their vehicles to areas with more expected snow, reducing idle capacity and improving performance come winter. More generally, firms in the energy sector could hedge their exposure to temperature fluctuations by trading in weather derivatives. Agricultural firms could adjust their planting and harvesting schedules or switch to crops that are more resilient to anticipated weather conditions. Retailers could optimize inventory management and marketing strategies based on expected regional weather patterns. As found in Shrader (2023), fisheries may adjust by sending fewer ships out to sea if they anticipate adverse weather conditions. And if capital markets provide instruments to hedge these risks, firms may use financial instruments to hedge out their risks from ENSO.

**RQ3:** *Do firms use ENSO forecast information to make operational adaptations in anticipation of ENSO realizations?*

However, several potential constraints to adaptation could bind. First, ENSO forecasts are uncertain, particularly at longer horizons. Firms may be reluctant to incur adaptation costs based on noisy information. Second, adaptation measures may be costly, especially for smaller firms or those with less flexible production functions. The costs of adaptation may exceed the expected benefits. Managers may also be inattentive to ENSO impacts, consistent with the evidence of managerial inattention to other complex climate risks (e.g., Dessaint and Matray, 2017; see RQ2). Finally, some of ENSO's impacts, such as damage from extreme weather events, may provide no opportunities for adaptation.

# 4. Empirical Setup

## 4.1 Sample Construction

We use four primary data sources for our empirical analyses: ENSO forecasts and realizations provided by Columbia University IRI, firm fundamentals from Worldscope, and managerial guidance and analyst consensus estimates from IBES.

ENSO forecast data is provided monthly for February 2002 to December 2023. The data exist as a plume of forecasts from 46 different climate models that enter and sometimes leave at different points in the sample—we consider the mean forecast across models available each month. We consider forecasts of three-month 'seasons,' such as the mean forecast for DJF (December, January, February). The earlier forecast for a season is released at the start of the season. Thus, we denote the forecast made in December for DJF as Forecast1, the forecast made in November for DJF as Forecast2, et cetera. We observe forecasts up to Forecast9. Along with the forecasts, the IRI data contains ENSO realizations over the Niño 3.4 region of the Pacific Ocean, with readings coming from the Extended Reconstructed Sea Surface Temperature v5.

We consider quarterly firm-level fundamentals from Worldscope to measure the impacts of ENSO variation within the year. We view a cross-country sample as the most relevant one, considering ENSO's global weather impacts. We winsorize firm fundamentals data at the 1

## 4.2 Descriptive Statistics

Table 1 shows that our sample has broad sectoral and continental coverage. That said, Africa and Oceania are noticeably less represented in the sample. Our industry definitions are based on 2-digit Refinitiv Business Classification (TRBC) codes. Table 2 presents descriptive statistics. Because our dependent variables are the difference of logarithms, they lack a scale. The standard deviation of the ENSO forecasts decreases in forecast horizon - longer-range forecasts tend to be less bold. Figure 3 plots the forecast errors for Forecasts1-9. Unsurprisingly, the forecast errors become less dispersed and closer to zero when moving from Forecast 9 to 1. The correlations between ForecastX and the eventual ENSO SSTA realization, where X moves from 9 to 1, are: 0.29, 0.37, 0.46, 0.54, 0.63, 0.71, 0.78, 0.84, 0.90.

To study whether ENSO affects firm performance, we consider the following model for firm performance:

$$y_{i,t} = y_{i,t-4} + \beta \cdot ENSO_t + \alpha_{i,q(t)} + \varepsilon_{i,t} \tag{1}$$

This quarter's net profit, for instance, begins with net profit from the same quarter a year ago. ENSO affects profit through $\beta$, and a firm-quarter fixed effect captures firm-specific performance growth. We take the logarithm of performance to address the issue that different firms will have different scales and reporting currencies—$\beta$ becomes the approximate percentage change in performance due to ENSO. Standard errors are clustered by year-quarter and firm as ENSO forecasts and realizations are the same for all firms within a time period, and outcome variables are likely serially correlated through time within a firm. To avoid unit root estimation issues, we estimate the equivalent model:

$$\triangle y_{i,t} = \beta \cdot ENSO_t + \alpha_{i,q(t)} + \varepsilon_{i,t} \tag{2}$$

Figure 4a presents the timeline for tests of Equation 2.

## 5. Results: ENSO Impacts on Firm Fundamentals (RQ1)

Table 3a Column 1 shows the result of estimating Equation 2 for net income. It shows that more positive ENSO realizations are insignificantly negatively associated with net income unconditionally. However, Column 2 reveals a differential impact between negative and positive SSTAs. Interacting $ENSO$ with $NEG$ and $POS$—indicators for negative and positive values of ENSO—we find that when negative ENSO realizations become larger, net income improves. A one standard deviation larger negative ENSO realization increases profits by 3.8% ($= \exp^{0.838\times-0.046} - 1$). In contrast, positive ENSO realizations, on average, do not affect profits. This result is surprising because El Niño events, which occur when ENSO realizations are positive, tend to receive more media and academic attention than the converse La Niña (which generally produces cooler and wetter weather).

Column 3 shows the net positive impact of La Niña favoring conditions primarily comes from the basic materials, consumer cyclicals, consumer non-cyclicals, energy, and industrials sectors. These can be thought of as primary and secondary sectors (i.e., those concerned with the extraction and production of raw materials and energy and those producing finished goods). Consumer cyclical and consumer non-cyclical firms also benefit when SSTAs are more positive (i.e., they generally seem to benefit from more extreme ENSO realizations). In contrast, energy firms fare more poorly when SSTAs are more positive (warmer El Niño winters might reduce demand for heating). These contrasting effects for positive SSTAs explain the on-average non-significant result for $ENSO \times POS$ in column 2. The fact that we observe impacts largely for firms with physical production processes supports the notion that the ENSO phenomenon drives our results.

Table 3b shows the result of estimating Equation 2 for operating income. We expect and find that the results are stronger because ENSO should arguably affect operating items more than interest and tax items. Tables 3c and 3d present the results of estimating Equation 2 for revenues and COGS. The results are similar to those for net income. Because these effects offset, examining net income or operating income alone might mask the effects of ENSO on firms. For example, ENSO does not seem to affect these two profit measures for utilities firms. However, utilties firms do see revenue and COGS impacts from ENSO. Regulated monopolies that are rate regulated might be able to pass through their costs to consumers fully.

Given the results by sector, particularly for net income and operating income, from this point forward in the analysis, we limit the sample to firms in primary and secondary sectors: basic materials, consumer cyclicals, consumer non-cyclicals, energy, industrials, and utilities.

Table 3e considers the impact of ENSO realizations by continent. It shows that ENSO has a significant effect on firms in continents all over the world. Firms in most (all) continents have net (operating) income improvements when ENSO realizations are more negative. North American firms also perform worse when ENSO realizations are more positive. These results support the growing view in the climate science literature that ENSO effects are more far-reaching than previously thought.

The results in this section indicate that ENSO generally affects firms positively when SSTAs are negative (i.e., in the 'cold' region of ENSO, which favors La Nina). While the average effect of ENSO on firms is not statistically significant, considering industries separately reveals heterogeneous effects. Further, performance effects are observed in mainly primary and secondary industries (i.e., those with physical production processes). Finally, the effects of ENSO on firm operating performance are felt in countries beyond those with Pacific Ocean borders.

# 6. Results: Attentiveness to ENSO Forecasts

## 6.1 Firm Issued Guidance (RQ2a)

Given the evidence in Section 5 about ENSO's impacts on firm operating performance, we explore whether firms are attentive to ENSO forecasts and their performance implications. We study how their expectations for firm performance change as revealed through manager-issued guidance. Specifically, we estimate the following regression model:

$$\triangle Guidance_{i,t,[(Y+1),(X-1)]} = \theta(F_{t-Y}(ENSO_t) - F_{t-X}(ENSO_t)) + \alpha_{i,q(t)} + \varepsilon_{i,t} \quad (3)$$

$\triangle Guidance_{i,t,[(Y+1),(X-1)]}$ is change in firm $i$'s guidance for the year ending with year-month $t$.[1] The change is computed from the month after ENSO Forecast X ($F_{t-X}(ENSO_t)$) to the month after ENSO Forecast Y ($F_{t-Y}(ENSO_t)$). For each firm-year, we choose the largest possible value of $X$ and the smallest possible value of $Y$, which produces the largest interval over which ENSO forecasts evolve. Figure 4b presents the timeline for these tests.

Table 4a presents the results of estimating Equation 3 considering indus-

[1] Ideally, we would consider changes in quarterly guidance corresponding to the specific fiscal quarter the ENSO forecasts correspond to. However, too few firms in our sample provide repeated quarterly guidance to form a test around them.

tries with at least 1,000 observations. The sample size is considerably smaller than for Table 3 because of the requirement that firms issue guidance multiple times throughout the year. Column 1 considers the pooled forecasts of net income and EPS. It shows limited evidence of attentiveness. In particular, industrial firms appear attentive to ENSO forecasts and aware of their implications for net income. This observation comes from comparing the sign and statistical significance of the coefficients for industrials with their respective coefficients in Table 3a. Consumer non-cyclicals firms also appear attentive to the implications of ENSO forecasts for net income, at least in the case of positive SSTAs. Regarding projecting revenues, basic materials firms seem attentive to the implications of ENSO forecasts. However, when contrasting against the results in 3a and 3c, consumer cyclicals firms appear inattentive to ENSO forecasts, as do basic materials firms when it comes to net income, and as do consumer non-cylicals and industrials when it comes to revenue.

Table 4b presents the results of estimating Equation 3 considering geographies with at least 1,000 observations. This requirement produces an Asia/North America bias in the sample). When comparing the coefficient estimates to their counterparts in Table 3e, only North American firms seem attentive to the implications of ENSO for net income and revenue, and this is specifically when SSTAs are positive (i.e., El Niño favoring).

In sum, the firm guidance revisions following ENSO forecast revisions suggest that firms are partly attentive to implications for operating performance.

## 6.2 Analyst Estimates (RQ2b)

Given the results above that firm guidance partly reflects ENSO forecasts, a natural extension is to consider whether capital markets share a similar attentiveness to ENSO forecasts. Financial analysts' estimates are often used as proxies for the beliefs of sophisticated market participants. Thus, we modify the dependent variable in Equation 3 to be the change in the analyst consensus performance estimate following ENSO forecast revisions:

$$\triangle Estimate_{i,t,[(Y+1),(X-1)]} = \theta(F_{t-Y}(ENSO_t) - F_{t-X}(ENSO_t)) + \alpha_{i,q(t)} + \varepsilon_{i,t} \quad (4)$$

Table 5a presents the results of estimating Equation 4, considering sectors with at least 1,000 observations. Column 1 considers the pooled forecasts of net income and EPS. A spotty picture emerges. Analysts following energy and industrials firms revise their estimates downwards when ENSO forecasts becomes more positive in the case where SSTAs are positive (i.e., El Niño favoring). Given the results in Table 3a, this response is only consistent for the energy firm analysts. The analysts following the other sectors seem similarly inattentive to the net income implications of ENSO for the firms they follow. The results are slightly more encouraging when comparing the results for revenue estimates in column 2 with the results for revenue realizations in Table 3c. In particular, analysts following utility firms seem attentive to the revenue implications of ENSO forecasts. Considering both earnings-based and revenue estimates, the analysts following consumer cyclicals and consumer non-cylicals firms appear the most inattentive to the performance implications of ENSO forecasts. These industries might be further down in supply chains, making the ENSO-profit relation less salient and harder to discern.

Table 5a explores the attentiveness of financial analysts to ENSO forecasts by continent, considering geographies with at least 1,000 observations. When comparing the coefficient estimates to their counterparts in Table 3e, analysts covering North American firms seem the most attentive to the performance implications of ENSO forecasts, in particular when SSTAs are positive. In general, however, the signs and statistical significances of the coefficient estimates do not map well into those in Table 3e.

The results in this section suggest that managers and analysts are partly attentive to the implications of ENSO forecasts for operating performance, with this attentiveness being concentrated in particular industries and geographies. However, these results do not indicate whether attentive managers use ENSO forecasts to make operational changes. For instance, managers of adapting firms might estimate the effects of their future adaptation and update their guidance accordingly. However, managers of firms with limited opportunities to adapt might use ENSO forecasts to update their assessment of the eventual impacts of an ENSO realization. In both cases, ENSO forecasts affect management guidance, but in only the first do firms act on this information.

## 7. Results: firms‘ use of ENSO Forecasts (RQ3)

To consider the role of ENSO forecasts in driving firms to make operational adaptations to deal with ENSO realizations, we follow Shrader (2023) and assume the effect of ENSO and its forecast on performance is linear and additive. We augment Equation 2 such that there are separate impacts from the forecasted portion of ENSO ($\gamma$)) and the shock portion ($\beta$):

$$\triangle y_{i,t} = \gamma F_{t-X}(ENSO_t) + \beta \cdot (ENSO)_t - F_{t-X}(ENSO_t)) + \alpha_{i,q(t)} + \varepsilon_{i,t} \quad (5)$$

The goal is to test whether $\gamma = \beta$ for the different leads of ENSO forecasts (i.e., X $\in$ [1,9]). In an extreme hypothetical case where all firms ignore ENSO forecasts, an ENSO realization's forecasted and 'shock' components should have equal per-unit effects on operating performance. Figure 4c presents the timeline for the empirical tests.

Table 6a presents the results from estimating Equation 5 for Net Income, considering Forecasts1-9. Consistent with Table 3a, negative ENSO realizations produce significant impacts on net income, whether through the forecasted or shock portions of the realization. With the exceptions of the most distant forecast, the coefficient estimates on $Fcast \times NEG$ are more negative than the estimates on $Shock \times NEG$. However, the difference is only statistically significant for Forecasts 2-3. In Table 6b, we consider operating income, which we expect to respond more strongly to ENSO related outcomes. The pattern is the same: operating income responds more the forecasted portion of ENSO realizations than to the shock portion, with the exception of the most distant forecast. Further, the differences in response are statistically significant for Forecasts 2 through to 6. These tables provides moderate evidence that firms leverage ENSO forecasts to improve net and operating income when ENSO shocks are negative.

Table 6c presents the analogous results for revenue. For all forecasts, the estimate on $Fcast \times NEG$ is larger than that on $Shock \times NEG$. Further, the difference is significant for Forecasts 2, 3, 5, and 6. The pattern is the same in Table 6d for COGS, although the difference is not statistically significant when considering any forecast. These tables provide support for firm adaptation to ENSO forecasts on the revenue side.[2] The evidence in this section provides moderate support for the idea that at least some firms use ENSO forecasts to make operational adjustments to improve profits when ENSO realizations are negative.

[2]We have thus far considered performance and adaptation from an operational perspective. In untabulated results, we also consider whether firms use ENSO forecasts when making CAPX decisions. We do not expect strong results here because PPE lasts multiple years, and thus, a single ENSO event should not have much bearing on CAPX plans. Consistent with this, in no specification is the difference between $Fcast \times NEG$ and $Shock \times NEG$ statistically significant when regressing CAPX.

## 8. Conclusion

This study explores how the El Niño Southern Oscillation (ENSO) impacts firm operations, offering insights that complement existing research on the economic consequences of weather anomalies and climate variations. We find that the effects of ENSO on corporate performance are nuanced. When negative sea surface temperature anomalies get more negative (favoring generally cooler conditions), the profits of firms are positively affected. In contrast, when positive seas surface temperature anomalies get more positive (favoring generally warmer conditions), the effect on firms is heterogeneous. These results are observed within primary and secondary sectors, that is, those concerned with extracting and working with materials.

We find that that firms and analysts partially update their earnings and revenue projections in a directionally consistent way following ENSO forecast changes. That is, firms and analysts seem partly attentive to the performance implications implied by the information in ENSO forecasts. Firm and analysts in certain sectors and geographies seem to do a better job of those. Lastly, we show that at least some firms use ENSO forecasts to make operational adjustments to improve profits when ENSO realization eventually occur.

Given that longer-run climate change might amplify the effects of ENSO, understanding the operational changes firms can make in anticipation of these events will become increasingly important for businesses and policymakers alike. Our paper takes the first steps towards this understanding for a broad, cross-industry, cross-country sample of firms. We find that at least some firms seem to pre-emptively leverage ENSO forecasts to improve net income when facing ENSO realizations. However, our finding that firms and analysts seem only partly attentive to ENSO forecast information suggests that there is room to improve attentiveness, and by extension, adaptation.

Policies aimed at making ENSO forecast information more available to, and digestible by, firms and markets are a potential prescription. Our results also suggest that public investments in ENSO forecasting efforts and infrastructure could have broader benefits that are potentially currently overlooked.

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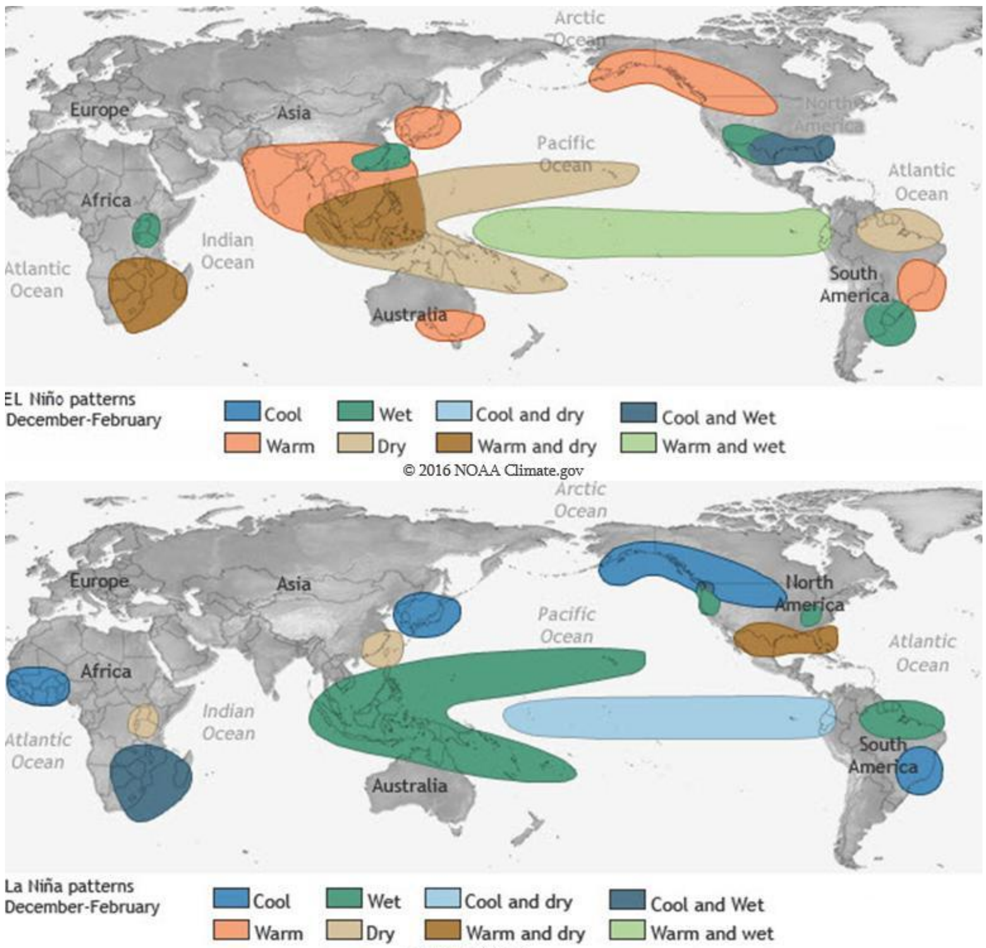
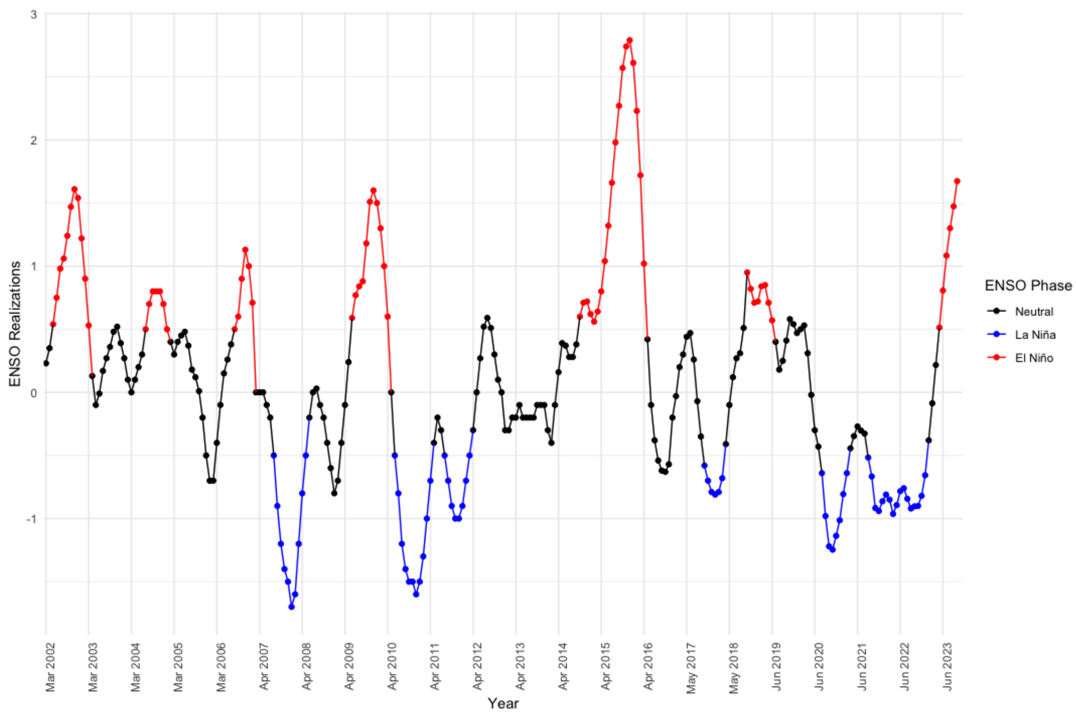
# Figures and Tables

Figure 1: Suggested impacts of El Niño and La Niña globally



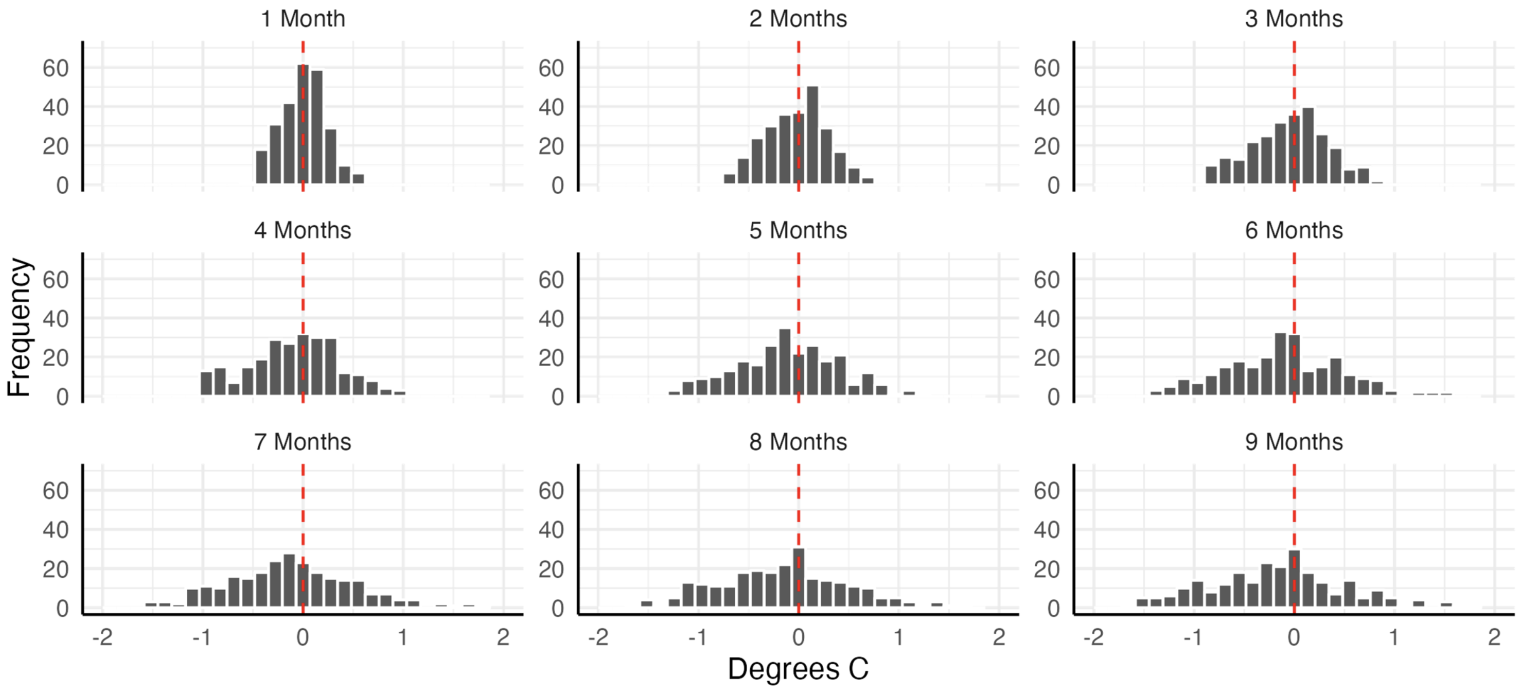

This schematic is based on the work of Trenberth et al. (1998) and summarizes the works of Ropelewski and Halpert (1986, 1987, 1989) and Halpert and Ropelewski (1992).

Figure 2: ENSO over the sample period



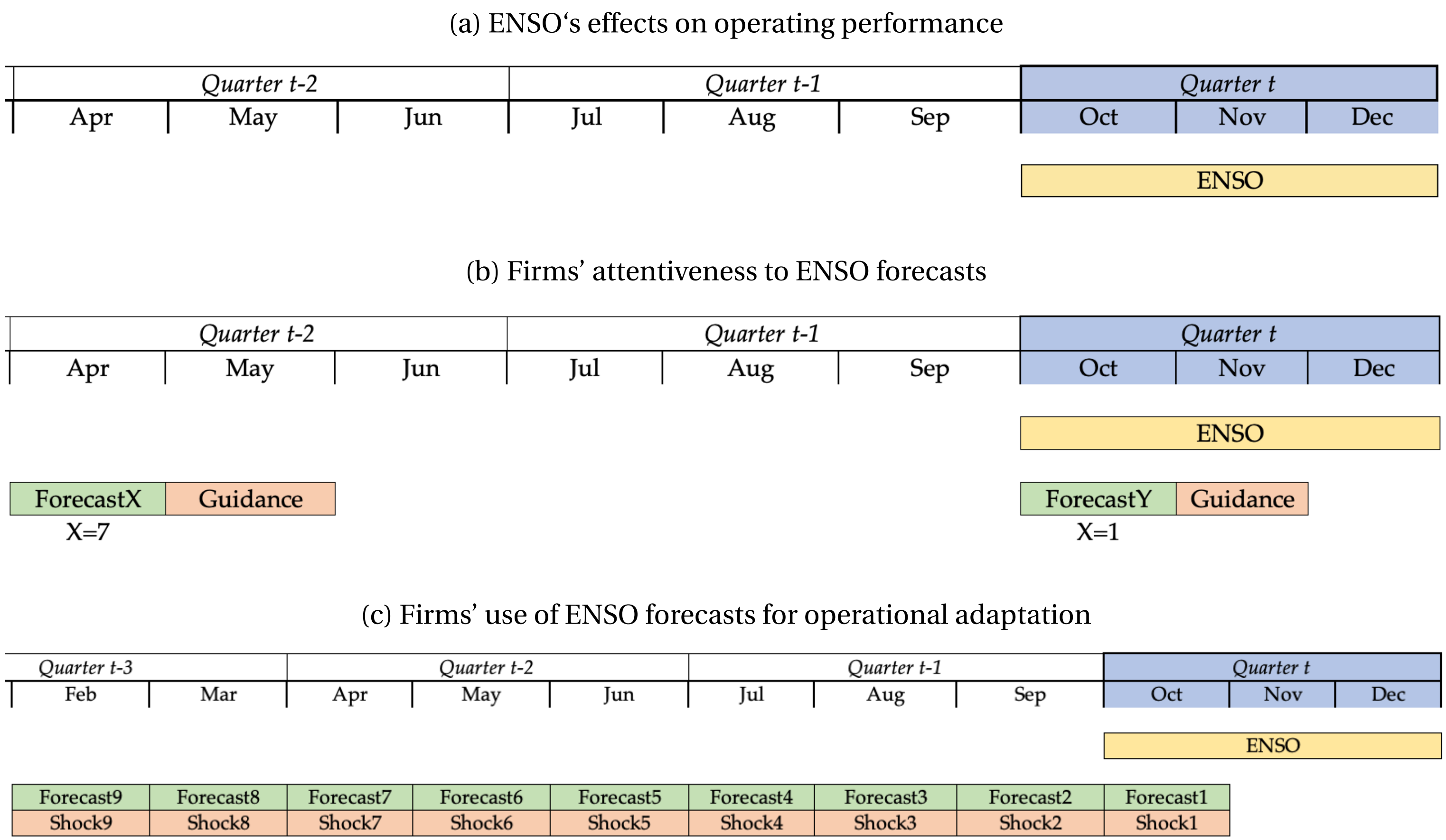

This figure plots the ENSO realization over our sample period. The data source is described in Section 2.1.

Figure 3: Plot of ENSO Forecast Errors by Time Distance from ENSO Realization




This figure contains histograms of the difference between ENSO realizations and their respective ENSO forecasts (arranged from 1 month to 9 months out).

Figure 4: Timeline for empirical tests of:




This figure visually describes the timing of the relevant items for the tests described in Sections 5-7.

Table 1: Observation Frequency by Sector and Continent

| | Africa | Asia | Central and S.A. | Europe | N.A. | Oceania | Total |
|---|---|---|---|---|---|---|---|
| Basic Materials | 4,342 | 185,180 | 12,771 | 32,892 | 44,035 | 687 | 279,907 |
| Consumer Cyclicals | 4,041 | 250,881 | 12,353 | 59,473 | 78,282 | 41 | 405,071 |
| Consumer Non-Cyclicals | 4,324 | 119,864 | 12,880 | 26,768 | 33,405 | 32 | 197,273 |
| Energy | 1,207 | 37,699 | 4,390 | 18,308 | 55,584 | 300 | 117,488 |
| Financials | 8,018 | 119,962 | 20,489 | 43,245 | 107,632 | 169 | 299,515 |
| Healthcare | 1,450 | 78,274 | 2,025 | 27,379 | 78,551 | 202 | 187,881 |
| Industrials | 3,131 | 267,114 | 11,724 | 73,608 | 80,968 | 113 | 436,658 |
| Real Estate | 2,032 | 81,398 | 4,972 | 21,724 | 31,750 | 60 | 141,936 |
| Technology | 1,079 | 214,472 | 5,300 | 54,421 | 103,452 | 147 | 378,871 |
| Utilities | 275 | 27,521 | 11,929 | 15,112 | 19,263 | 41 | 74,141 |
| Total | 29,899 | 1,382,365 | 98,833 | 372,930 | 632,922 | 1,792 | 2,518,741 |

This table presents observation counts by Refinitiv Business Classification (TRBC) sector-continent bin for the sample used in the tests of Section 5. The sample is based on the Worldscope universe spanning February 2002 to December 2023.

Table 2: Observation Frequency by Sector and Continent

| | N | Mean | SD | Min | p25 | p50 | p75 | Max |
|---|---|---|---|---|---|---|---|---|
| d_log(NI) | 1, 299, 264 | 0.079 | 1.010 | -3.320 | -0.322 | 0.091 | 0.484 | 3.430 |
| d_log(OPI) | 1, 330, 849 | 0.074 | 0.882 | -2.930 | -0.271 | 0.081 | 0.428 | 3.040 |
| d_log(Rev.) | 2, 199, 608 | 0.062 | 0.686 | -6.600 | -0.087 | 0.056 | 0.217 | 23.900 |
| d_log(COGS) | 1, 826, 293 | 0.098 | 0.984 | -5.880 | -0.110 | 0.057 | 0.243 | 7.060 |
| ENSO | 2, 518, 741 | 0.036 | 0.838 | -1.700 | -0.570 | -0.020 | 0.520 | 2.790 |
| Forecast1 | 2, 518, 741 | 0.034 | 0.777 | -1.780 | -0.564 | -0.052 | 0.524 | 2.530 |
| Forecast2 | 2, 517, 971 | 0.069 | 0.750 | -1.750 | -0.461 | 0.093 | 0.587 | 2.470 |
| Forecast3 | 2, 517, 313 | 0.097 | 0.695 | -1.620 | -0.418 | 0.070 | 0.542 | 2.370 |
| Forecast4 | 2, 501, 751 | 0.126 | 0.646 | -1.490 | -0.355 | 0.122 | 0.573 | 2.280 |
| Forecast5 | 2, 500, 983 | 0.152 | 0.580 | -1.270 | -0.295 | 0.098 | 0.607 | 2.090 |
| Forecast6 | 2, 500, 284 | 0.167 | 0.505 | -1.100 | -0.169 | 0.119 | 0.554 | 1.800 |
| Forecast7 | 2, 484, 867 | 0.166 | 0.474 | -0.882 | -0.175 | 0.149 | 0.506 | 1.610 |
| Forecast8 | 2, 484, 103 | 0.176 | 0.404 | -0.758 | -0.113 | 0.107 | 0.459 | 1.270 |
| Forecast9 | 2, 483, 420 | 0.188 | 0.333 | -0.714 | -0.023 | 0.171 | 0.431 | 1.030 |

This table presents descriptive statistics for the sample used in the tests of Section 5.

Table 3a: Effect of ENSO on Net Income

| | d_log(NI) | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| ENSO | −0.017 | | |
| | −1.619 | | |
| ENSO x NEG | | −0.046** | |
| | | −2.065 | |
| ENSO x POS | | 0.002 | |
| | | 0.143 | |
| ENSO x NEG x Basic Materials | | | −0.093** |
| | | | −2.261 |
| ENSO x POS x Basic Materials | | | 0.003 |
| | | | 0.110 |
| ENSO x NEG x Consumer Cyclicals | | | −0.100*** |
| | | | −3.064 |
| ENSO x POS x Consumer Cyclicals | | | 0.037* |
| | | | 1.867 |
| ENSO x NEG x Consumer Non-Cyclicals | | | −0.084*** |
| | | | −4.648 |
| ENSO x POS x Consumer Non-Cyclicals | | | 0.056*** |
| | | | 3.145 |
| ENSO x NEG x Energy | | | −0.104** |
| | | | −2.025 |
| ENSO x POS x Energy | | | −0.099*** |
| | | | −2.992 |
| ENSO x NEG x Financials | | | 0.036 |
| | | | 1.050 |
| ENSO x POS x Financials | | | −0.021 |
| | | | −1.037 |
| ENSO x NEG x Healthcare | | | −0.008 |
| | | | −0.309 |
| ENSO x POS x Healthcare | | | 0.020 |
| | | | 1.134 |
| ENSO x NEG x Industrials | | | −0.052** |
| | | | −2.077 |
| ENSO x POS x Industrials | | | −0.005 |
| | | | −0.353 |

| | d_log(NI) | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| ENSO x NEG x Real Estate | | | −0.028 |
| | | | −0.794 |
| ENSO x POS x Real Estate | | | 0.014 |
| | | | 0.770 |
| ENSO x NEG x Technology | | | −0.015 |
| | | | −0.536 |
| ENSO x POS x Technology | | | −0.019 |
| | | | −0.882 |
| ENSO x NEG x Utilities | | | −0.016 |
| | | | −0.875 |
| ENSO x POS x Utilities | | | −0.014 |
| | | | −1.262 |
| Num.Obs. | 1 299 264 | 1 299 264 | 1 299 264 |
| R2 Adj. | −0.030 | −0.030 | −0.029 |

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

Table 3b: Effect of ENSO on Operating Income

| | d_log(OPI) | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| ENSO | −0.018** | | |
| | −2.124 | | |
| ENSO x NEG | | −0.053*** | |
| | | −2.900 | |
| ENSO x POS | | 0.005 | |
| | | 0.438 | |
| ENSO x NEG x Basic Materials | | | −0.099** |
| | | | −2.560 |
| ENSO x POS x Basic Materials | | | 0.010 |
| | | | 0.439 |
| ENSO x NEG x Consumer Cyclicals | | | −0.113*** |
| | | | −3.898 |
| ENSO x POS x Consumer Cyclicals | | | 0.048*** |
| | | | 2.762 |
| ENSO x NEG x Consumer Non-Cyclicals | | | −0.071*** |
| | | | −4.882 |
| ENSO x POS x Consumer Non-Cyclicals | | | 0.042*** |
| | | | 3.155 |
| ENSO x NEG x Energy | | | −0.147** |
| | | | −2.376 |
| ENSO x POS x Energy | | | −0.096*** |
| | | | −2.688 |
| ENSO x NEG x Financials | | | 0.025 |
| | | | 0.959 |
| ENSO x POS x Financials | | | −0.019 |
| | | | −1.194 |
| ENSO x NEG x Healthcare | | | −0.009 |
| | | | −0.360 |
| ENSO x POS x Healthcare | | | 0.021 |
| | | | 1.645 |
| ENSO x NEG x Industrials | | | −0.062*** |
| | | | −2.749 |
| ENSO x POS x Industrials | | | −0.007 |
| | | | −0.538 |

| | d_log(OPI) | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| ENSO x NEG x Real Estate | | | −0.012 |
| | | | −0.542 |
| ENSO x POS x Real Estate | | | 0.004 |
| | | | 0.319 |
| ENSO x NEG x Technology | | | −0.006 |
| | | | −0.250 |
| ENSO x POS x Technology | | | −0.010 |
| | | | −0.630 |
| ENSO x NEG x Utilities | | | −0.024 |
| | | | −1.546 |
| ENSO x POS x Utilities | | | 0.003 |
| | | | 0.279 |
| Num.Obs. | 1 330 849 | 1 330 849 | 1 330 849 |
| R2 Adj. | −0.027 | −0.026 | −0.026 |

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

Table 3c: Effect of ENSO on Revenue

| | d_log(Rev.) | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| ENSO | −0.021*** | | |
| | −3.179 | | |
| ENSO x NEG | | −0.037** | |
| | | −2.135 | |
| ENSO x POS | | −0.010 | |
| | | −0.982 | |
| ENSO x NEG x Basic Materials | | | −0.081*** |
| | | | −3.602 |
| ENSO x POS x Basic Materials | | | −0.019 |
| | | | −1.185 |
| ENSO x NEG x Consumer Cyclicals | | | −0.055* |
| | | | −1.809 |
| ENSO x POS x Consumer Cyclicals | | | 0.016 |
| | | | 0.930 |
| ENSO x NEG x Consumer Non-Cyclicals | | | −0.051*** |
| | | | −3.564 |
| ENSO x POS x Consumer Non-Cyclicals | | | −0.003 |
| | | | −0.394 |
| ENSO x NEG x Energy | | | −0.060 |
| | | | −1.241 |
| ENSO x POS x Energy | | | −0.120*** |
| | | | −4.504 |
| ENSO x NEG x Financials | | | 0.011 |
| | | | 0.752 |
| ENSO x POS x Financials | | | −0.011 |
| | | | −0.987 |
| ENSO x NEG x Healthcare | | | −0.008 |
| | | | −0.553 |
| ENSO x POS x Healthcare | | | 0.002 |
| | | | 0.180 |
| ENSO x NEG x Industrials | | | −0.048** |
| | | | −2.546 |
| ENSO x POS x Industrials | | | −0.006 |
| | | | −0.600 |

| | d_log(Rev.) | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| ENSO x NEG x Real Estate | | | −0.013 |
| | | | −0.520 |
| ENSO x POS x Real Estate | | | −0.002 |
| | | | −0.133 |
| ENSO x NEG x Technology | | | −0.020 |
| | | | −1.443 |
| ENSO x POS x Technology | | | −0.003 |
| | | | −0.329 |
| ENSO x NEG x Utilities | | | −0.041** |
| | | | −2.184 |
| ENSO x POS x Utilities | | | −0.032*** |
| | | | −3.330 |
| Num.Obs. | 2 199 608 | 2 199 608 | 2 199 608 |
| R2 Adj. | 0.024 | 0.024 | 0.025 |

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

Table 3d: Effect of ENSO on COGS

| | d_log(COGS) | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| ENSO | −0.022*** | | |
| | −2.699 | | |
| ENSO x NEG | | −0.049** | |
| | | −2.405 | |
| ENSO x POS | | −0.004 | |
| | | −0.369 | |
| ENSO x NEG x Basic Materials | | | −0.085*** |
| | | | −3.458 |
| ENSO x POS x Basic Materials | | | −0.028* |
| | | | −1.799 |
| ENSO x NEG x Consumer Cyclicals | | | −0.056* |
| | | | −1.903 |
| ENSO x POS x Consumer Cyclicals | | | 0.013 |
| | | | 0.798 |
| ENSO x NEG x Consumer Non-Cyclicals | | | −0.050*** |
| | | | −3.009 |
| ENSO x POS x Consumer Non-Cyclicals | | | −0.007 |
| | | | −0.770 |
| ENSO x NEG x Energy | | | −0.070 |
| | | | −1.552 |
| ENSO x POS x Energy | | | −0.082*** |
| | | | −3.650 |
| ENSO x NEG x Financials | | | −0.116* |
| | | | −1.905 |
| ENSO x POS x Financials | | | 0.089** |
| | | | 2.154 |
| ENSO x NEG x Healthcare | | | 0.003 |
| | | | 0.102 |
| ENSO x POS x Healthcare | | | 0.014 |
| | | | 0.654 |
| ENSO x NEG x Industrials | | | −0.048** |
| | | | −2.449 |
| ENSO x POS x Industrials | | | −0.005 |
| | | | −0.427 |

| | d_log(COGS) | | |
| --- | --- | --- | --- |
| | (1) | (2) | (3) |
| ENSO x NEG x Real Estate | | | −0.013 |
| | | | −0.500 |
| ENSO x POS x Real Estate | | | 0.007 |
| | | | 0.490 |
| ENSO x NEG x Technology | | | −0.029* |
| | | | −1.705 |
| ENSO x POS x Technology | | | 0.003 |
| | | | 0.232 |
| ENSO x NEG x Utilities | | | −0.065** |
| | | | −2.411 |
| ENSO x POS x Utilities | | | −0.052*** |
| | | | −3.372 |
| Num.Obs. | 1 826 293 | 1 826 293 | 1 826 293 |
| R2 Adj. | 0.109 | 0.109 | 0.110 |

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

Table 3e: Effect of ENSO by continent

| | d_log(NI) (1) | d_log(OPI) (2) | d_log(Rev.) (3) | d_log(COGS) (4) |
|---|---|---|---|---|
| ENSO x NEG x Africa | −0.119* | −0.123* | −0.053 | −0.019 |
| | −1.789 | −1.840 | −1.072 | −0.403 |
| ENSO x POS x Africa | 0.020 | 0.015 | −0.020 | −0.008 |
| | 0.527 | 0.400 | −0.846 | −0.302 |
| ENSO x NEG x Asia | −0.081*** | −0.093*** | −0.058** | −0.058** |
| | −3.131 | −4.241 | −2.490 | −2.426 |
| ENSO x POS x Asia | 0.020 | 0.029* | −0.003 | −0.009 |
| | 1.095 | 1.967 | −0.270 | −0.749 |
| ENSO x NEG x Central and S.A. | −0.090** | −0.062** | −0.064** | −0.077*** |
| | −2.500 | −2.543 | −2.594 | −3.114 |
| ENSO x POS x Central and S.A. | 0.044 | −0.003 | −0.006 | −0.002 |
| | 1.417 | −0.156 | −0.446 | −0.171 |
| ENSO x NEG x Europe | −0.087*** | −0.090*** | −0.072*** | −0.113*** |
| | −2.742 | −3.022 | −3.135 | −4.289 |
| ENSO x POS x Europe | 0.006 | −0.006 | −0.003 | 0.012 |
| | 0.286 | −0.341 | −0.262 | 0.844 |
| ENSO x NEG x N.A. | −0.047** | −0.065*** | −0.037 | −0.024 |
| | −1.982 | −2.719 | −1.576 | −0.845 |
| ENSO x POS x N.A. | −0.053*** | −0.043** | −0.058*** | −0.053*** |
| | −2.830 | −2.319 | −3.603 | −2.882 |
| ENSO x NEG x Oceania | −0.056 | −0.341*** | −0.086 | −0.422* |
| | −0.215 | −2.768 | −0.758 | −1.800 |
| ENSO x POS x Oceania | −0.151 | −0.111 | −0.041 | 0.225 |
| | −0.931 | −0.539 | −0.503 | 1.049 |
| Num.Obs. | 784 743 | 825 062 | 1 319 470 | 1 220 714 |
| R2 Adj. | −0.033 | −0.030 | 0.029 | 0.106 |

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

These tables explore whether the El Niño Southern Oscillation (ENSO) affects firms‘ operational performance. The sample is based on the Worldscope universe spanning February 2002 to December 2023. All specifications include firm-quarter (not firm-quarter-year) fixed effects, and standard errors are double clustered by firm and quarter-year.

Table 4a: Firm guidance revisions following ENSO forecast revisions (by sector)

| | d_log(Guidance) (1) | (2) |
|---|---|---|
| d_Fcast x NEG x Basic Materials | −0.038 | −0.025** |
| | −0.600 | −2.444 |
| d_Fcast x POS x Basic Materials | 0.052 | −0.021 |
| | 0.830 | −1.313 |
| d_Fcast x NEG x Consumer Cyclicals | −0.053 | −0.004 |
| | −1.616 | −0.516 |
| d_Fcast x POS x Consumer Cyclicals | 0.030 | 0.002 |
| | 0.846 | 0.336 |
| d_Fcast x NEG x Consumer Non-Cyclicals | 0.008 | 0.011 |
| | 0.327 | 1.142 |
| d_Fcast x POS x Consumer Non-Cyclicals | 0.039* | 0.013 |
| | 1.942 | 0.864 |
| d_Fcast x NEG x Industrials | −0.046** | −0.001 |
| | −2.436 | −0.157 |
| d_Fcast x POS x Industrials | −0.027 | −0.008 |
| | −1.564 | −1.307 |
| Estimated Item | NI, EPS | Revenue |
| Num.Obs. | 19 560 | 16 096 |
| R2 Adj. | 0.238 | 0.135 |

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

Table 4b: Firm guidance revisions following ENSO forecast revisions (by continent)

| | d_log(Guidance) | |
|---|---|---|
| | (1) | (2) |
| d_Fcast x NEG x Asia | −0.046 | 0.000 |
| | −0.911 | 0.047 |
| d_Fcast x POS x Asia | 0.012 | 0.004 |
| | 0.143 | 0.440 |
| d_Fcast x NEG x N.A. | −0.030*** | −0.011** |
| | −3.327 | −2.556 |
| d_Fcast x POS x N.A. | 0.000 | −0.009 |
| | 0.043 | −1.461 |
| Estimated Item | NI, EPS | Revenue |
| Num.Obs. | 21 096 | 15 591 |
| R2 Adj. | 0.237 | 0.161 |

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

This table explore whether firms update their guidance about future performance given changes in ENSO forecasts . The sample is based on the intersection of Worldscope with IBES, and spans February 2002 to December 2023. All specifications include firm-quarter (not firm-quarter-year) fixed effects, and standard errors are double clustered by firm and quarter-year.

Table 5a: Analyst estimate revisions following ENSO forecast revisions (by sector)

| | d_log(Estimate) | |
|---|---|---|
| | (1) | (2) |
| d_Fcast x NEG x Basic Materials | −0.040 | −0.021* |
| | −1.334 | −1.658 |
| d_Fcast x POS x Basic Materials | −0.043 | −0.035*** |
| | −1.382 | −3.054 |
| d_Fcast x NEG x Consumer Cyclicals | 0.013 | 0.017 |
| | 0.406 | 1.106 |
| d_Fcast x POS x Consumer Cyclicals | −0.004 | −0.005 |
| | −0.247 | −0.942 |
| d_Fcast x NEG x Consumer Non-Cyclicals | 0.028 | 0.007 |
| | 1.478 | 1.279 |
| d_Fcast x POS x Consumer Non-Cyclicals | −0.015 | −0.008 |
| | −1.318 | −1.392 |
| d_Fcast x NEG x Energy | 0.028 | 0.023 |
| | 0.538 | 0.710 |
| d_Fcast x POS x Energy | −0.137*** | −0.101*** |
| | −3.120 | −4.343 |
| d_Fcast x NEG x Industrials | −0.016 | 0.002 |
| | −0.656 | 0.097 |
| d_Fcast x POS x Industrials | −0.044** | −0.028** |
| | −2.053 | −2.526 |
| d_Fcast x NEG x Utilities | 0.018 | 0.019** |
| | 1.483 | 2.234 |
| d_Fcast x POS x Utilities | −0.019 | −0.019** |
| | −1.356 | −2.175 |
| Estimated Item | NI, EPS | Revenue |
| Num.Obs. | 353 583 | 219 368 |
| R2 Adj. | 0.110 | 0.113 |

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

Table 5b: Analyst estimate revisions following ENSO forecast revisions (by continent)

| | d_log(Estimate) | |
|---|---|---|
| | (1) | (2) |
| d_Fcast x NEG x Asia | 0.003 | 0.002 |
| | 0.104 | 0.125 |
| d_Fcast x POS x Asia | −0.003 | −0.003 |
| | −0.218 | −0.547 |
| d_Fcast x NEG x Central and S.A. | −0.006 | −0.011 |
| | −0.216 | −0.600 |
| d_Fcast x POS x Central and S.A. | −0.056** | −0.017 |
| | −2.426 | −1.296 |
| d_Fcast x NEG x Europe | −0.009 | 0.002 |
| | −0.369 | 0.125 |
| d_Fcast x POS x Europe | −0.031 | −0.027** |
| | −1.635 | −2.052 |
| d_Fcast x NEG x N.A. | 0.002 | 0.011 |
| | 0.096 | 0.758 |
| d_Fcast x POS x N.A. | −0.061*** | −0.048*** |
| | −2.843 | −3.994 |
| Estimated Item | NI, EPS | Revenue |
| Num.Obs. | 353 583 | 219 368 |
| R2 Adj. | 0.109 | 0.110 |

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

These tables explore whether financial analysts update their estimates about future firm performance given changes in ENSO forecasts. The sample is based on the intersection of Worldscope with IBES, and spans February 2002 to December 2023. All specifications include firm-quarter (not firm-quarter-year) fixed effects, and standard errors are double clustered by firm and quarter-year.

Table 6a: Firm's use of ENSO forecasts (Net Income)

| | d_log(NI) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Fcast x NEG | −0.082*** | −0.100*** | −0.111*** | −0.111*** | −0.119*** | −0.118*** | −0.105*** | −0.075* | −0.034 |
| | −3.437 | −3.535 | −3.370 | −3.253 | −3.534 | −3.238 | −2.855 | −1.886 | −0.696 |
| Fcast x POS | 0.008 | 0.013 | 0.022 | 0.027 | 0.027 | 0.030 | 0.017 | −0.015 | −0.039 |
| | 0.399 | 0.632 | 1.043 | 1.208 | 1.078 | 1.136 | 0.561 | −0.459 | −1.006 |
| Shock x NEG | −0.006 | 0.034 | −0.016 | −0.047 | −0.054* | −0.071*** | −0.074*** | −0.071*** | −0.066*** |
| | −0.099 | 0.658 | −0.429 | −1.543 | −1.934 | −2.923 | −3.105 | −3.099 | −2.878 |
| Shock x POS | 0.005 | −0.029 | −0.039 | −0.034 | −0.022 | −0.013 | 0.003 | 0.020 | 0.025 |
| | 0.075 | −0.685 | −1.054 | −1.153 | −0.802 | −0.519 | 0.104 | 0.941 | 1.216 |
| Forecast | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| p(Fcast x NEG = Shock x NEG) | 0.241 | 0.043 | 0.083 | 0.173 | 0.102 | 0.188 | 0.326 | 0.923 | 0.514 |
| Num.Obs. | 784 743 | 784 595 | 784 479 | 781 647 | 781 477 | 781 367 | 778 710 | 778 542 | 778 423 |
| R2 Adj. | −0.033 | −0.033 | −0.033 | −0.033 | −0.033 | −0.033 | −0.034 | −0.034 | −0.033 |

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

Table 6b: Firm's use of ENSO forecasts (Operating Income)

| | d_log(OPI) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Fcast x NEG | −0.093*** | −0.108*** | −0.120*** | −0.123*** | −0.132*** | −0.137*** | −0.126*** | −0.101*** | −0.068 |
| | −4.469 | −4.570 | −4.420 | −4.294 | −4.386 | −4.183 | −3.842 | −2.782 | −1.524 |
| Fcast x POS | 0.014 | 0.016 | 0.024 | 0.029 | 0.029 | 0.033 | 0.025 | −0.002 | −0.013 |
| | 0.752 | 0.941 | 1.328 | 1.491 | 1.281 | 1.401 | 0.939 | −0.082 | −0.371 |
| Shock x NEG | −0.014 | 0.015 | −0.024 | −0.052* | −0.059** | −0.077*** | −0.082*** | −0.082*** | −0.081*** |
| | −0.241 | 0.349 | −0.759 | −1.920 | −2.373 | −3.608 | −3.898 | −4.043 | −3.896 |
| Shock x POS | −0.009 | −0.027 | −0.035 | −0.031 | −0.019 | −0.012 | 0.001 | 0.018 | 0.020 |
| | −0.134 | −0.594 | −0.836 | −0.923 | −0.688 | −0.487 | 0.044 | 0.959 | 1.101 |
| Forecast | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| p(Fcast x NEG = Shock x NEG) | 0.195 | 0.021 | 0.03 | 0.069 | 0.042 | 0.06 | 0.124 | 0.559 | 0.747 |
| Num.Obs. | 825 062 | 824 916 | 824 795 | 822 011 | 821 871 | 821 770 | 819 117 | 818 953 | 818 828 |
| R2 Adj. | −0.030 | −0.030 | −0.029 | −0.030 | −0.030 | −0.030 | −0.030 | −0.031 | −0.030 |

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

Table 6c: Firm's use of ENSO forecasts (Revenue)

| | d_log(Rev.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Fcast x NEG | −0.065*** | −0.072*** | −0.081*** | −0.082*** | −0.094*** | −0.101*** | −0.089** | −0.084* | −0.079 |
| | −2.596 | −2.834 | −3.007 | −2.919 | −2.767 | −2.804 | −2.395 | −1.703 | −1.346 |
| Fcast x POS | −0.011 | −0.009 | −0.005 | −0.001 | −0.003 | 0.000 | 0.000 | −0.021 | −0.016 |
| | −0.771 | −0.619 | −0.341 | −0.039 | −0.142 | 0.011 | 0.013 | −0.813 | −0.494 |
| Shock x NEG | 0.053 | 0.014 | −0.009 | −0.033 | −0.031 | −0.046* | −0.053** | −0.052** | −0.057** |
| | 0.614 | 0.321 | −0.256 | −1.175 | −1.197 | −1.962 | −2.332 | −2.338 | −2.304 |
| Shock x POS | −0.042 | −0.045 | −0.046 | −0.044* | −0.035 | −0.029 | −0.024 | −0.010 | −0.012 |
| | −0.781 | −1.319 | −1.449 | −1.681 | −1.583 | −1.550 | −1.606 | −0.733 | −0.906 |
| Forecast | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| p(Fcast x NEG = Shock x NEG) | 0.22 | 0.086 | 0.07 | 0.123 | 0.087 | 0.085 | 0.219 | 0.403 | 0.596 |
| Num.Obs. | 1 319 470 | 1 319 151 | 1 318 899 | 1 313 294 | 1 312 972 | 1 312 720 | 1 307 207 | 1 306 883 | 1 306 626 |
| R2 Adj. | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.029 | 0.028 | 0.028 |

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

Table 6d: Firm's use of ENSO forecasts (COGS)

| | d_log(COGS) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Fcast x NEG | −0.066*** | −0.072*** | −0.078*** | −0.076*** | −0.087** | −0.093*** | −0.083** | −0.085* | −0.086 |
| | −2.614 | −2.775 | −2.860 | −2.663 | −2.543 | −2.597 | −2.222 | −1.706 | −1.464 |
| Fcast x POS | −0.011 | −0.009 | −0.006 | −0.003 | −0.006 | −0.004 | −0.004 | −0.027 | −0.023 |
| | −0.749 | −0.626 | −0.398 | −0.203 | −0.306 | −0.202 | −0.187 | −1.056 | −0.701 |
| Shock x NEG | 0.019 | −0.008 | −0.027 | −0.046 | −0.041 | −0.052** | −0.057** | −0.054** | −0.059** |
| | 0.224 | −0.172 | −0.757 | −1.586 | −1.554 | −2.123 | −2.415 | −2.312 | −2.314 |
| Shock x POS | −0.042 | −0.041 | −0.042 | −0.038 | −0.029 | −0.025 | −0.021 | −0.008 | −0.011 |
| | −0.824 | −1.267 | −1.367 | −1.485 | −1.337 | −1.322 | −1.417 | −0.596 | −0.825 |
| Forecast | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| p(Fcast x NEG = Shock x NEG) | 0.369 | 0.205 | 0.194 | 0.347 | 0.209 | 0.183 | 0.372 | 0.417 | 0.519 |
| Num.Obs. | 1 220 714 | 1 220 500 | 1 220 325 | 1 216 550 | 1 216 336 | 1 216 168 | 1 212 473 | 1 212 261 | 1 212 085 |
| R2 Adj. | 0.107 | 0.106 | 0.106 | 0.106 | 0.106 | 0.106 | 0.106 | 0.106 | 0.106 |

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

These tables explore whether firms use ENSO forecasts to make operational adjustments when facing ENSO realizations. The sample is based on the Worldscope universe spanning February 2002 to December 2023. All specifications include firm-quarter (not firm-quarter-year) fixed effects, and standard errors are double clustered by firm and quarter-year.