



Management Science

Publication details, including instructions for authors and subscription information:
<http://pubsonline.informs.org>

Investor Inattention and the Market Impact of Summary Statistics

Thomas Gilbert, Shimon Kogan, Lars Lochstoer, Ataman Ozyildirim,

To cite this article:

Thomas Gilbert, Shimon Kogan, Lars Lochstoer, Ataman Ozyildirim, (2012) Investor Inattention and the Market Impact of Summary Statistics. *Management Science* 58(2):336-350. <http://dx.doi.org/10.1287/mnsc.1110.1475>

Full terms and conditions of use: <http://pubsonline.informs.org/page/terms-and-conditions>

This article may be used only for the purposes of research, teaching, and/or private study. Commercial use or systematic downloading (by robots or other automatic processes) is prohibited without explicit Publisher approval, unless otherwise noted. For more information, contact permissions@informs.org.

The Publisher does not warrant or guarantee the article's accuracy, completeness, merchantability, fitness for a particular purpose, or non-infringement. Descriptions of, or references to, products or publications, or inclusion of an advertisement in this article, neither constitutes nor implies a guarantee, endorsement, or support of claims made of that product, publication, or service.

Copyright © 2012, INFORMS

Please scroll down for article—it is on subsequent pages



INFORMS is the largest professional society in the world for professionals in the fields of operations research, management science, and analytics.

For more information on INFORMS, its publications, membership, or meetings visit <http://www.informs.org>

Investor Inattention and the Market Impact of Summary Statistics

Thomas Gilbert

Foster School of Business, University of Washington, Seattle, Washington 98195, gilbertt@u.washington.edu

Shimon Kogan

McCombs School of Business, University of Texas at Austin, Austin, Texas 78712,
shimon.kogan@mcombs.utexas.edu

Lars Lochstoer

Graduate School of Business, Columbia University, New York, New York 10027, ll2609@columbia.edu

Ataman Ozyildirim

The Conference Board, New York, New York 10022, ataman.ozyildirim@conference-board.org

We show that U.S. stock and Treasury futures prices respond sharply to recurring stale information releases. In particular, we identify a unique macroeconomic series—the U.S. Leading Economic Index® (LEI)—which is released monthly and constructed as a summary statistic of previously released inputs. We show that a front-running strategy that trades S&P 500 futures in the direction of the announcement a day before its release and then trades in the opposite direction of the announcement following its release generates an average annual return of close to 8%. These patterns are more pronounced for high beta stocks, for stocks that are more difficult to arbitrage, and during times when investors' sensitivity to firm-specific stale information is high. Treasury futures exhibit similar, albeit less pronounced, price patterns. Other measures of information arrival, such as price volatility and volume, spike following the release. These empirical findings suggest that some investors are inattentive to the stale nature of the information included in the LEI releases, instead interpreting it as new information, and thereby causing temporary yet significant mispricing.

Key words: capital markets; stale macroeconomic information; investor inattention

History: Received July 2, 2010; accepted August 22, 2011, by Brad Barber, Teck Ho, and Terrance Odean, special issue editors. Published online in *Articles in Advance* January 13, 2012.

1. Introduction

Markets respond rapidly to the release of new information, thereby making it stale. In this paper, we show that *aggregate* stock and bond markets respond to the release of *stale* information. The response we observe is consistent with the notion that some investors are inattentive, not to the release itself, but rather to the nature of the released information—they are unable to distinguish new from stale information. Although a growing literature links investors' limited attention with individual securities' mispricing (see literature review below), we are the first to identify a *recurring* set of stale macroeconomic information releases and document that it causes a significant mispricing of the S&P 500 Index and Treasury bonds. Testing the predictions of a limited attention model, which incorporates costly information processing, we argue that investors fail to recognize that the informational content of the releases has been priced, and they therefore respond to the releases of both new and stale information.

The stale information we study takes the form of a summary statistic—the Conference Board U.S. Leading Economic Index® (LEI), which is designed to track macroeconomic fluctuations. Like most macroeconomic announcements, the LEI is released on a predetermined schedule. What makes the LEI an important variable for our study is that the components of the LEI are publicly available or can be easily calculated using publicly available data in advance of the announcement. Furthermore, the methodology used to compile the LEI is also publicly available. These are well-known facts, publicized among other places on the Conference Board's website and Bloomberg.¹ As such, the LEI is simply a weighted average of stale macroeconomic information.

Looking at monthly announcements over a 13-year period (from 1997 to 2009), and using intraday data on S&P 500 futures returns, we show that

¹ See <http://www.conference-board.org/economics/bci/general.cfm> and <http://www.bloomberg.com/markets/ecalendar/index.html>.

positive (negative) LEI announcements are preceded by positive (negative) returns the day before, followed by strong positive (negative) announcement returns, which are fully reversed during the following day. Thus, the mispricing is of a temporary nature. A front-running strategy that trades S&P 500 futures in the direction of the LEI announcement a day before its release and then trades in the opposite direction of the announcement following its release, generates a gross return of 0.65% per event (over three trading days), or close to 8% annually. These results are robust to transaction costs and do not seem to disappear over time.

Consistent with these main results, we show that the front-running strategy for the highest quintile S&P 500 beta stocks generates a 1.50% return per event, compared with a 0.32% for the lowest quintile beta stocks. Given that the LEI is designed to forecast aggregate macroeconomic fluctuations, the difference in response suggests that (a subset of) investors view the announcement as market-level news. We also find that a similar trading strategy yields positive, albeit smaller, returns when implemented in the U.S. Treasury bond market. Finally, we show that other proxies for information arrival, such as aggregate stock return volatility and trading volume, increase following the LEI release (by 26% and 7%, respectively).

To better understand the nature of the inattention present in our empirical analysis, we develop a stylized model in which we allow for different forms of inattention.² Specifically, we show that if a subset of investors mistake the rerelease of information for actual news in addition to the information provided in the initial release, returns exhibit momentum leading to the release of the stale information and reversal after the release. However, if investors are inattentive to the initial release of information, perhaps because of the cognitive load required to process it, no return reversal is observed after the rerelease of information, as these investors do not double count the information provided. Both the momentum observed through the LEI release and the return reversal after

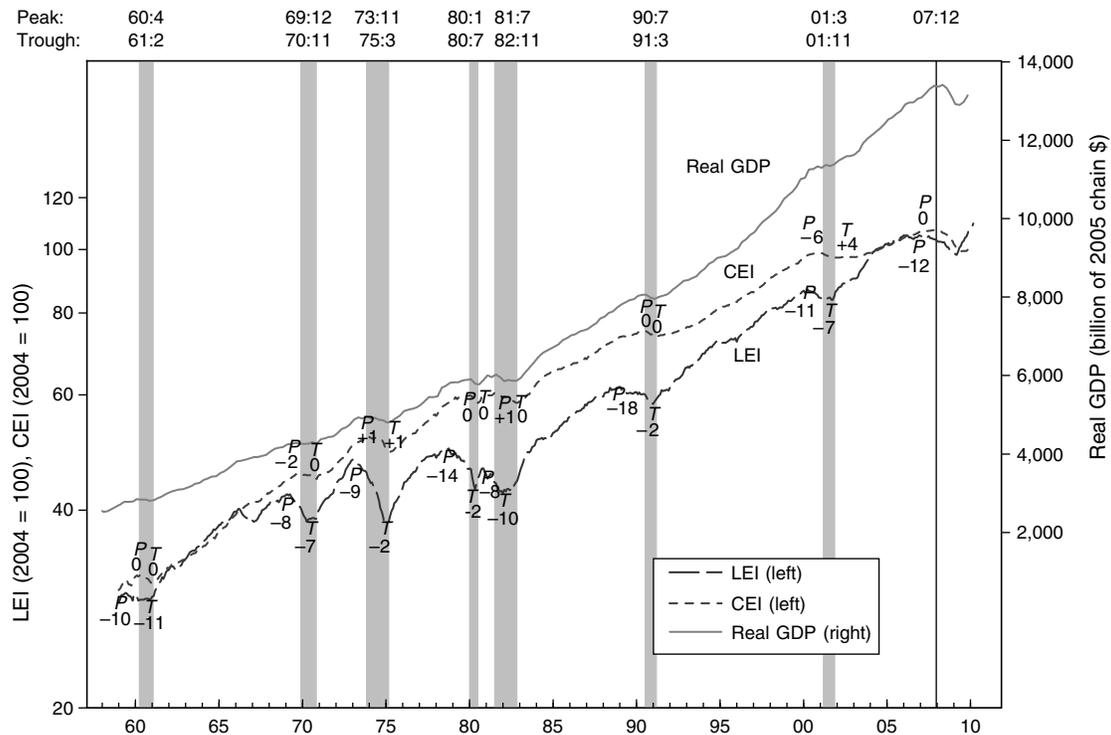
the announcement suggest that inattentive investors regard the LEI release as news, failing to account for the fact that the LEI components have been previously released and priced. As such, they exert temporary price pressure that is subsequently fully reversed. Consistent with these aggregate results, we use a measure based on the analysis in Tetlock (2011) to show that times in which investors are found to be more responsive to stale firm-specific information are also times in which the aggregate return patterns associated with the LEI release are more pronounced.

Our paper is related to a growing empirical literature that suggests that investors' limited attention is important for asset pricing. Studying the pricing of individual securities, DellaVigna and Pollet (2007) show that publicly available demographic information related to future firm earnings is not completely impounded in stock prices. Hirshleifer et al. (2009) and DellaVigna and Pollet (2009) find that the information in earnings announcements is not completely processed when investors are more subject to limited attention (when many firms release their earnings on the same day and on Fridays), leading to weaker stock price reaction. Cohen and Frazzini (2008) show that information diffuses slowly across industries, leading to return predictability across firms linked through supplier/customer relations. Reaction to release of stale information is studied by Huberman and Regev (2001), who document an instance where a rerelease of news had a large effect on the stock price of a biotech firm. A larger set of such events is studied by Tetlock (2011). He analyzes the market reaction of S&P 500 stocks to news stories that may contain stale information. Using proxies for staleness, he finds that prices respond to stale news but that this response is partially reversed in the subsequent week. Tying these pricing results to individuals' trading behavior, Barber and Odean (2008) show that retail investors, who may be more prone to limited attention, are net buyers of attention grabbing stocks. At the aggregate market level, Hong et al. (2007) show that a large number of industries lead the stock market returns by up to two months, consistent with information diffusing slowly due to limited attention.³

We contribute to this literature in a number of ways. First, we identify a recurring set of events in which the information released is clearly stale. The power of our test comes from the fact that we do not need to measure the degree of staleness and from the fact that the announcement is prescheduled, and so there should be no surprise regarding the nature

² Our model is related to a number of theoretical models that study different features of inattention in various domains. In comparison, our model's goal is modest: study the price of an asset with stochastic dividends in an economy populated by attentive investors interacting with inattentive investors. Sims (1998, 2003) and Mankiw and Reis (2002) view agents' inattention as leading to slow information diffusion and show that it can have macroeconomic effects by creating stickiness; Ball et al. (2005) ask how this type of inattention affects macroeconomic policy. Gabaix and Laibson (2006) and Karlan et al. (2011) look at consumers' inattention regarding features of products they consume (former) and components of their future consumption (latter). Barberis and Shleifer (2003) and Peng and Xiong (2006) highlight that investors with limited attention economize on information processing by grouping stocks into categories.

³ More broadly, this paper is also related to the large body of literature on market efficiency and more specifically to studies that evaluate the impact of news about fundamentals on asset prices (see Schwert 1981, Huberman and Schwert 1985, Cutler et al. 1989, Mitchell and Mulherin 1994).

Figure 1 U.S. Leading Economic Index, Coincident Economic Index, and Real GDP

Notes. This figure shows the time series of the Leading Economic Index (LEI), the Coincident Economic Index (CEI), and real gross domestic product (GDP) from 1959 to 2009. The shaded areas represent U.S. business cycle recessions as dated by the National Bureau of Economic Research. The numbers at the *P* and *T* markings denote the leads or lags in months at the business cycle peaks and troughs, respectively.

of the announcement to all investors. Together, these factors allow us to isolate the effect of investors' limited attention. Second, we provide evidence that limited attention significantly affects *aggregate* stock and bond markets, and not just a small subset of firms or idiosyncratic firm-specific news events. Finally, our results characterize the form of limited attention that investors are subject to in our experiment, namely the confounding of old news with new information.

2. The Leading Economic Index

In this paper, the instrument for stale information that we study is the U.S. Leading Economic Index[®] (LEI). The LEI, which is calculated and published by the Conference Board (TCB) on a monthly basis, is a macroeconomic variable used primarily to predict turning points (peaks and troughs) in the business cycle. By design, the LEI should help predict changes in real economic activity and Figure 1 shows that the LEI systematically declines ahead of the recessions as dated by the National Bureau of Economic Research.⁴

The LEI is built as a composite of ten leading indicators: (1) average weekly hours (manufacturing),

(2) average weekly initial claims for unemployment insurance, (3) manufacturers' new orders (consumer goods and materials), (4) vendor performance (slower deliveries diffusion index), (5) manufacturers' new orders (nondefense capital goods), (6) building permits (new private housing units), (7) stock prices (S&P 500 Index), (8) money supply (M2), (9) interest rate spread (10-year Treasury bonds less Federal Funds rate), and (10) TCB's index of consumer expectations. These indicators are series that have an established tendency to decline before recessions and rise before recoveries.⁵

Importantly, seven of the ten above indicators used every month in the LEI calculation are directly available at least 24 hours before each release. The monthly values of the three remaining components are estimated by TCB using a simple autoregressive time-series regression.⁶ It is important to note that the procedure used in the LEI construction has been publicly available since its inception and is explained in great details on TCB's website and in their man-

⁴ Filardo (2004) provides evidence that the LEI performs well as a variable to forecast cyclical movements in the economy. McGuckin et al. (2007) also report evidence on the significant out-of-sample forecasting ability of the LEI.

⁵ For more details on the indicator approach to measuring and analyzing business cycles, see Burns and Mitchell (1946) and Zarnowitz (1992).

⁶ When the unavailable data becomes available in the next month, the LEI is revised.

ual (The Conference Board 2001), which is publicly available.

In the current indexing methodology, which changed little since the 1960s when the Department of Commerce began publishing composite indexes, the contribution of each component is weighted by its relative volatility. This adjustment is made so that relatively more volatile series do not exert undue influence on the index. The weighted average contribution of all components is the basis for the monthly change in the LEI. In the electronic companion to this paper (available at <http://faculty.washington.edu/gilbertt/research.shtml>), we provide more background information and details on the procedure used by TCB to calculate the LEI.

After TCB assumed responsibility for the Business Cycle Indicators program in 1996, it reviewed and revised the LEI. Shortly after this revision was implemented, TCB started to publish the LEI press release during market open, at 10:00 A.M. EST, to be consistent with its other macroeconomic data releases.⁷ This determines the start of our sample (February 4, 1997).

To summarize, the LEI is a widely publicized macroeconomic variable, released on a monthly basis according to a fixed schedule, which is constructed from other previously released macroeconomic variables according to a publicly available methodology. It is a pure summary statistic and its release therefore is a unique instrument of stale information.

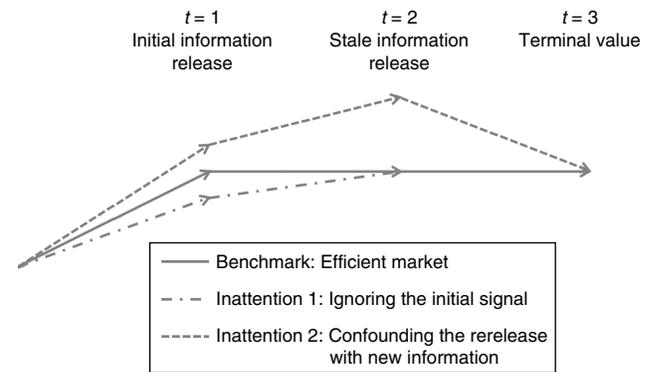
3. A Stylized Model of Investor Inattention

Because the LEI is a rerelease of already public macroeconomic information, what should we expect in terms of aggregate price response when both attentive and inattentive investors are present in the market? In this section, we present testable hypotheses that distinguish three versions of a simple equilibrium model where a subset of investors are inattentive.

All models consider a claim to a three-period dividend stream. Figure 2 shows the timeline of information events: at $t = 1$ a public signal about the terminal dividend is released along with the first dividend payment, at $t = 2$ this information is rereleased publicly along with the second dividend payment, and at $t = 3$ the terminal dividend payment is revealed to all. Both attentive and inattentive investors trade a claim to this dividend stream, and trade occurs in each period immediately after the signal is released and the current period's dividend is announced. The detailed model exposition, derivations, and proofs of claims

⁷ Previously, the LEI was released at 8:30 A.M., following the Bureau of Economic Analysis schedule.

Figure 2 Return Responses Under Different Models of Inattention



Notes. This figure shows the return responses to positive (“good news”) information releases under the three versions of the model. At $t = 1$, the initial information is released. At $t = 2$, this information, now stale, is rereleased. At $t = 3$, terminal values are realized and uncertainty is resolved. The models differ with respect to the inattentive investors’ reading of the stale signal at $t = 2$.

are available in the electronic companion.⁸ In the following, we focus on describing the economic intuition for how different assumptions about the nature of inattention give rise to different predictions about the market impact of the release of stale information. For concreteness, we assume in the following discussion that the initial information release happens to be good news in the sense that the price increases in the efficient market case.⁹

Benchmark Case: Efficient Market. The solid line in Figure 2 depicts the average price response in the efficient market case.¹⁰ Here all agents are fully attentive and therefore observe and know the marginal information content of each signal. At $t = 1$, upon the initial (good) news release, the price increases to the rational expectation of the final period payout. There is no price response to period 2’s stale information release and there is no volume of trade as all investors agree on the conditional expectation of the final dividend payout both before and after each signal is released. The market is on average correct in the prediction of terminal value, as shown at $t = 3$ in Figure 2 where the average terminal dividend is equal to the price at $t = 2$ (and $t = 1$).

⁸ Briefly, additional model assumptions are as follows. Investors are risk averse, competitive, have a time-discounting parameter equal to one, have access to a risk-free asset with an interest rate equal to zero, and the risky asset is in zero net supply. The latter three assumptions are not important for our hypotheses and empirical tests—they simply enable us to focus the model on how traders’ expectations affect prices. Dividends are independent and identically distributed with mean zero.

⁹ The case of bad news gives exactly the opposite predictions in terms of the return response.

¹⁰ The “average price response” refers to the average *cum-dividend* price response. We focus on the average *cum-dividend* price pattern as it easily translates into predictions for the return regressions we employ in the empirical section.

Inattention 1: Ignoring the Initial Signal. We consider two forms of investor inattention. In neither case do the inattentive use prices to update their beliefs. In this first case, the inattentive investors ignore the initial signal and only update their beliefs upon the rerelease of the signal at $t = 2$. The learning delay could be due to unmodeled information processing costs in the first period (for instance, time or bandwidth constraint, as in Sims 2003). This type of inattention is documented in DellaVigna and Pollet (2009), among others, who show that investors ignore valuable pieces of information because there is too much information revealed on certain days.

At $t = 1$, only the attentive have updated their beliefs. However, because the attentive investors are risk averse and there is a risky dividend payment at $t = 2$, the price is not bid up all the way to the efficient market level.¹¹ Thus, there is underreaction to the first information release. At $t = 2$, after the rerelease, both attentive and inattentive investors have the same information and therefore prices will be as in the efficient market case, i.e., there is an additional return response at the time of the rerelease causing price momentum. The average price pattern is shown as the dash-dotted line in Figure 2. Additionally, this model implies that there is high trading volume around both announcements, as the attentive front-run the inattentive at $t = 1$ and then unwind their positions at $t = 2$.

Inattention 2: Confounding the Rerelease with New Information. In this case, the inattentive investors do not realize that the rerelease at $t = 2$ is stale and they confound it with additional new information. More precisely, they believe that it gives them new information about the terminal payout not already revealed by the first signal—they are inattentive in terms of the *content* of the second news release. This type of inattention is documented in Tetlock (2011), who presents evidence from the cross-section of stock returns consistent with the hypothesis that investors overreact to the stale component of information releases. In fact, this case of the model is almost identical to the model in Tetlock (2011), except that in our case the second signal is entirely stale.

In this model, the price increases upon the release of the initial signal, as all agents update their expectation of the final period payout. However, the attentive investors know that the inattentive will further increase their expectation of the final period payout at $t = 2$, upon the rerelease of the initial signal. Therefore, the attentive investors are in equilibrium willing to hold the risky asset at $t = 1$ at a level higher than

that of the efficient market benchmark case. At $t = 2$, the inattentive further increase their expectation of the final period payout, as predicted by the attentive, and the attentive unwind their front-running positions by selling to the inattentive at $t = 2$. Thus, there is in this case a more pronounced momentum and overreaction pattern in returns leading up to the rerelease. Because the inattentive now overestimate terminal value, the attentive will in fact take the opposite positions to profit from the subsequent price reversal that occurs at $t = 3$.

The return reversal is a testable implication that distinguishes this case, where the inattentive are inattentive to the content of the rerelease, from the form of inattention in the previous case, where investors simply ignore the information the first time around. The average price pattern is shown as the dotted line in Figure 2. In terms of volume, there is trading at both announcements, as the attentive take positions to profit from the return momentum as well as the subsequent return reversal.¹²

3.1. Empirical Implications of the Model

Based on the above model predictions, we use the LEI release and aggregate asset price data to answer the following questions:

1. *Do aggregate asset prices respond to the release of the LEI?* If so, this indicates that inattentive investors are indeed present in the market, as the LEI is a rerelease of public, macroeconomic information.

2. *Is there a preannouncement response in returns in the same direction as the LEI announcement return?* If so, this indicates that not all investors are inattentive to the fact that the LEI is a rerelease of public information. In the data, the ten components of the LEI are released at different times: from about two weeks to just over 24 hours before the LEI announcement. We use the return interval of the 24 hours before the LEI release to construct preannouncement returns. In this interval arbitrageurs have all the information needed to replicate the LEI and thus to front-run the inattentive.¹³

¹² An alternative version of the inattention model 2 has the inattentive not observing the initial signal. Instead, they use unexpected movements in lagged prices to update their beliefs, with the assumption that such price movements are due to private information about terminal value being impounded in prices. Importantly, they believe, conditional on the terminal value, that such private information is orthogonal to the public signal (re-)released at $t = 2$. In other words, the inattentive do not realize that the information in the rerelease has already been impounded in prices by the attentive investors. We show in the electronic companion that this alternative model gives the same empirical predictions as the inattention model 2.

¹³ If such arbitrageurs were risk neutral and not capital constrained, they would compete away all profits. Thus, the existence of the preannouncement and announcement return responses is consistent with the notion of limits to arbitrage.

¹¹ As an alternative to assuming risk-averse attentive investors, one could assume that these investors are capital constrained following the literature on limits to arbitrage (see Shleifer and Vishny 1997).

3. *Is there a return reversal after the announcement response?* If so, this indicates that inattentive investors confound the LEI release with additional information relative to the original component releases (inattention model 2). This double counting of information leads to an overreaction. In other words, the inattentive do not realize that the information in the LEI has already been impounded in prices and therefore believe the fair price to be above the price preceding a “good” LEI announcement. Overreaction does not occur, however, if investors are inattentive in the sense that they only update their information sets from the LEI release (inattention model 1).

4. *Is trading volume and volatility higher around the LEI announcement?* If so, this is further evidence of heterogeneous beliefs as predicted by the models with both attentive and inattentive investors. In particular, for the attentive to profit from the inattentive they have to sell to (buy from) the inattentive if the LEI release is positive (negative). In a model where all agents have homogenous beliefs (rational or not), there will be no trade even if prices move upon the LEI release.

5. *Is the return response pattern stronger when a larger fraction of investors suffer from limited attention?* This is a natural implication of the inattention models that serves as a robustness test. In particular, we ask whether the magnitude of the announcement response is related to a time-series measure of investor inattention. This measure is based on the analysis in Tetlock (2011); it is a measure of the tendency of investors to conflate stale and new information constructed using the cross-section of stock returns and firm-level announcements.

In the next section, we test these empirical hypotheses for aggregate stock and bond returns. As explained, the key to identifying the form of inattention is the existence or absence of return reversal in the period after the LEI announcement response. Somewhat outside our model, we also consider the cross-section of stock returns to determine (a) if the magnitude of the return response is related to market beta as might be expected because the (stale) information concerns aggregate growth, and (b) if the return volatility of a stock—an often used measure of costs of arbitrage—is related to the return response. The intuition for the latter test is that a stock that is more costly to arbitrage should yield larger trading revenues for arbitrageurs and therefore see a larger return response pattern.

4. Empirical Analysis

We test the predictions of the model presented in the previous section using the original LEI release data, as well as aggregate stock returns, the cross-section

of stock returns, and returns to Treasury notes and bonds.¹⁴

We consider three time intervals surrounding the LEI release that form the basis of our tests: a preannouncement interval, an announcement interval, and a postannouncement interval. The last release time of any the components that are used to calculate the LEI index is typically, and never later than, 8:30 A.M. EST the day before the announcement day. Because the stock market opens at 9:30 A.M., we set 10:00 A.M. the day before the LEI announcement as the beginning of the preannouncement interval. This gives the market sufficient time to incorporate the early morning information releases (Fleming and Remolona 1999). The preannouncement interval ends immediately before the LEI announcement at 10:00 A.M. the following day. We define the announcement interval as the five-minute interval from 10:00 A.M. to 10:05 A.M. the day of the announcement (to be exact: 9:59:59 to 10:04:59). This is similar to Andersen et al. (2007) who use five-minute return intervals to evaluate the effect of macroeconomic information announcements (such as GDP) on aggregate stock returns. They point out that a five-minute interval strikes a good balance as it is long enough for the results to not be strongly affected by market microstructure issues, and it is short enough to maintain good identification of the return response as being due to the announcement and not other, unidentified shocks to investors’ information sets. The postannouncement interval is set from 10:05 A.M. on the announcement day to the close of the day after the LEI announcement.¹⁵

4.1. Data

The monthly LEI release dates and original index series were provided by TCB, and the sample runs from February 1997 to February 2009. During this sample period, the LEI index is always reported at 10:00 A.M. The stock and bond market return data is constructed using futures prices. It is standard in the literature to use futures data because the futures are the most liquid instruments (see, e.g., Andersen et al. 2003, 2007). The futures data was purchased from Tick Data and includes five-minute interval data on open, high, low, and close prices for each of the futures contracts traded between 1997 and 2009. For each date, we determine which of the multiple contracts available are “on-the-run” and construct the intraday return

¹⁴ Like most macroeconomic series, the LEI is revised after its release based on revised data. To avoid look-ahead bias, we use the original LEI series.

¹⁵ The postannouncement interval was chosen ex post as a reversal pattern was found to persist even the day after the LEI announcement. Adding further days in the postannouncement interval has no qualitative effect on the measured return response.

series for each day using prices from that day’s on-the-run contract. Data for individual stock returns is constructed using a combination of the New York Stock Exchange (NYSE) Euronext Trade and Quote (TAQ) database and the Center for Research in Security Prices (CRSP) database.

We use data from the Census Bureau, Bureau of Economic Analysis, Federal Reserve Board, National Association of Purchasing Managers, and TCB to screen out all dates on which other macroeconomic announcements were released simultaneously at 10:00 A.M. The specific announcements are the releases of new home sales, factory orders, construction spending, Institute for Supply Management (ISM) manufacturing index, and the target federal funds rate.¹⁶ Out of a total of 146 announcements in our sample (February 1997–February 2009), we exclude 30 due to simultaneous macroeconomic releases.¹⁷ Thus, the final sample consists of 116 announcement days. We use analyst forecast data from Bloomberg to construct a measure of LEI surprises, as the difference between the actual LEI release and the median analyst forecast of the release. Although Bloomberg does not give the date of each analyst’s forecast, anecdotally most of the forecasts are available at least a week before the announcement. Because not all of the components of the LEI are yet released at that point, even the forecast of an analyst that is fully “rational” would not necessarily predict the index perfectly.¹⁸

Table 1 shows the main summary statistics of our sample. The table shows the mean and standard deviation for the surprises to the LEI, as well as for the three return intervals described above for the S&P 500 and 10-year Treasury bond futures. We have split the sample into two halves in order to show that there are no strong trends in terms of returns or LEI surprises over the sample. In particular, with the exception of the preannouncement return in the first half of the sample, none of the mean returns are statistically different from zero, and the return volatilities are similar across the subsamples.

4.2. Results

The generic univariate regressions we run to evaluate whether there is a return response are of the form

$$R_{t,i} = \gamma_i + \delta_i(\Delta LEI_t - E_{t-}[\Delta LEI_t]) + \varepsilon_{t,i}, \quad (1)$$

¹⁶ These announcements were identified by Andersen et al. (2007) as having a significant impact on S&P 500 futures returns.

¹⁷ All exclusions come from the first four years of the data set, after which TCB became more strategic about announcing the LEI when no other macroeconomic variables are released.

¹⁸ In the robustness section in the electronic companion, we show that alternative, naive measures of investors’ expectation of the LEI give similar results.

Table 1 Summary Statistics

| | LEI surprise | Preannouncement return | Announcement return | Preannouncement return |
|---------------------------------|--------------|------------------------|---------------------|------------------------|
| Panel A: S&P 500 | | | | |
| First half | | | | |
| Mean | 0.170 | 0.317 | -0.041 | -0.197 |
| Std. dev. | 0.812 | 1.211 | 0.170 | 1.592 |
| Second half | | | | |
| Mean | -0.170 | -0.150 | -0.015 | 0.035 |
| Std. dev. | 1.139 | 1.529 | 0.176 | 1.342 |
| Panel B: 10-year Treasury bonds | | | | |
| First half | | | | |
| Mean | 0.170 | -0.010 | -0.004 | 0.027 |
| Std. dev. | 0.812 | 0.400 | 0.055 | 0.435 |
| Second half | | | | |
| Mean | -0.170 | 0.037 | 0.008 | 0.047 |
| Std. dev. | 1.139 | 0.398 | 0.059 | 0.615 |

Notes. This table reports, for both halves of our sample separately, the average LEI surprise, the average preannouncement return (10:00 A.M. on the trading day before the announcement to 9:59 A.M. on the day of the announcement), the average announcement return (10:00 A.M.–10:04 A.M. on the day of the announcement), and the average postannouncement return (10:05 A.M. on the day of the announcement to 16:00 P.M. on the day after the announcement). The LEI surprise is standardized to have mean zero and standard deviation of one over the full sample. Panel A uses returns obtained from S&P 500 futures and panel B uses returns obtained from 10-year Treasury bonds futures. Our full sample has 116 observations, so each subsample has 58 observations.

where t refers to the announcement, i refers to the return interval, and $E_{t-}[\cdot]$ refers to the expected value of the LEI based on information available prior to the announcement and any of the relevant return intervals. For the main set of results, the term $E_{t-}[\Delta LEI_t]$ corresponds to the Bloomberg median analyst forecast of the change in the LEI. We standardize the “shock” to the change in the LEI to have unit variance to facilitate easy interpretation of the regression coefficient. All returns are in percent, so a regression coefficient (δ_i) of 0.1 implies that there is a 10 basis points return response to a one standard deviation positive LEI surprise. In the following discussion, a “x basis point return response” refers to the regression coefficient and its associated interpretation as just given.

4.2.1. The Aggregate Stock Market. Our first set of tests use the returns to the S&P 500 futures as the dependent variable. The first row of Table 2 shows that there is a significant change in the aggregate market value in the direction of the LEI surprise. In particular, the S&P 500 futures return response in the 24 hour preannouncement interval is 26 basis points (significant at the 10% level). In the five-minute announcement interval, the return response is an additional 4.5 basis points (significant at the 5% level), and the postannouncement interval sees a 35 basis point reversal (significant at the 1% level). First, the efficient-market null hypothesis of no return response is rejected. Second, per the discussion in the model

Downloaded from informs.org by [212.179.28.34] on 05 November 2015, at 08:19. For personal use only, all rights reserved.

Table 2 Return Response Around the LEI Announcement

| Log return (%) vs. Bloomberg LEI surprises | Preannouncement 10:00 A.M. on trading day before–9:59 A.M. day of LEI announcement | Announcement 10:00 A.M.–10:04 A.M. day of LEI announcement | Postannouncement 10:05 A.M. day of LEI announcement–16:00 P.M. day after LEI announcement | Net response 10:00 A.M. on trading day before–16:00 P.M. day after LEI announcement | Return response for front- running strategy |
|--|---|---|--|--|--|
| S&P 500 futures | 0.261* (0.152/3.5%) | 0.045** (0.019/6.7%) | –0.347*** (0.119/5.6%) | –0.041 (0.200/0.0%) | 0.652*** (0.205/10.5%) |
| Highest β_{mkt} -quintile | 0.613** (0.306/2.1%) | 0.101** (0.049/3.0%) | –0.681** (0.318/1.3%) | 0.007 (0.454/0.0%) | 1.505*** (0.538/3.2%) |
| Quintile 4 | 0.444** (0.213/1.1%) | 0.072* (0.037/3.1%) | –0.462*** (0.176/0.6%) | 0.069 (0.278/0.0%) | 1.060*** (0.357/3.2%) |
| Quintile 3 | 0.392** (0.186/2.6%) | 0.063** (0.032/3.3%) | –0.290** (0.136/0.6%) | 0.186 (0.254/0.2%) | 0.840*** (0.287/3.9%) |
| Quintile 2 | 0.296** (0.128/1.8%) | 0.049** (0.022/2.8%) | –0.211** (0.103/0.3%) | 0.139 (0.186/0.1%) | 0.630*** (0.198/2.3%) |
| Lowest β_{mkt} -quintile | 0.166* (0.090/0.7%) | 0.037** (0.016/1.9%) | –0.103 (0.072/0.1%) | 0.097 (0.123/0.1%) | 0.323** (0.143/0.6%) |
| 2-year Treasury bond | –0.007 (0.010/0.4%) | –0.005*** (0.002/8.0%) | 0.025 (0.016/2.3%) | 0.013 (0.017/0.4%) | 0.037* (0.021/3.3%) |
| 5-year Treasury bond | –0.013 (0.027/0.2%) | –0.013*** (0.004/10.6%) | 0.070* (0.040/3.4%) | 0.044 (0.043/0.9%) | 0.096* (0.054/4.1%) |
| 10-year Treasury bond | –0.020 (0.044/0.3%) | –0.021*** (0.006/13.5%) | 0.101* (0.059/3.7%) | 0.060 (0.068/0.9%) | 0.143* (0.082/4.3%) |
| 30-year Treasury bond | –0.039 (0.076/0.4%) | –0.032*** (0.009/12.9%) | 0.089 (0.085/1.4%) | 0.019 (0.111/0.0%) | 0.160 (0.123/2.6%) |

Notes. This table shows the regression results for different return intervals as given by the column headers. The generic regression is $R_{t,i} = \gamma_i + \delta_i(\Delta LEI_t - E_{t-1}[\Delta LEI_t]) + \varepsilon_{i,t}$, where i correspond to the return interval and t refers to the 116 announcement dates in the sample (February 1997–February 2009). The expectation of the LEI release is the median of analyst forecasts as given by Bloomberg. For brevity, we only report the δ_i coefficients. Standard errors and R^2 are given below the corresponding δ_i -estimate in parentheses. The standard errors are corrected for heteroskedasticity and, for the cross-sectional results, clustered by announcement date. The top row shows the results for S&P 500 futures returns, as defined in the main text. The next five rows use market beta quintile sorted portfolios. These betas are obtained from CRSP and the sort at each time t is done based on betas estimated using data available to investors at time t . The bottom four rows show results for Treasury bond futures returns. In the last column, the return is the return to a front-running strategy that, if the LEI surprise is positive, goes long one unit at 10:00 A.M. the day before the announcement, short two units at 10:05 A.M. the day of the announcement, and long one unit at close the day after the announcement. All returns are in percent, and the LEI surprise is normalized to have unit variance. Thus, a regression coefficient of 0.1 means that there is a 10 basis point surprise to a one standard deviation positive “shock” to the LEI announcement.

*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.

section, the presence of a strong reversal after the run up is consistent with the interpretation of inattention as being the confounding of the rerelease of stale news as actual news (inattention model 2), but inconsistent with the interpretation of “rational inattention” where agents find it costly to update and wait for the summary statistic (inattention model 1). In the latter case, all agents’ information sets would be aligned after the LEI release, which implies that the announcement response should lead to a permanent change in prices.

The second column from the right of Table 2 gives the return response for the sum of all three intervals and shows that the overall market response over the intervals is statistically zero. The rightmost column of Table 2 shows the return response for a trading strategy that goes long (short) \$1 at 10:00 A.M. the day before the announcement if the LEI surprise is positive (negative), liquidates this position and simultaneously goes short (long) \$1 at 10:05 A.M. after the announcement, and finally liquidates the position at the close of the day after the announcement. This

strategy, ignoring transaction costs, earns 65 basis points on average—implying an annual return of 7.8%. Although we do not have data on the transaction costs in the futures market, we note that the average bid-ask spread for the S&P 500 exchange traded fund (Spider (SPY)) is seven basis points for the relevant trading times over this sample, which implies a trading cost of 14 basis points for this strategy.¹⁹ Because the futures are more liquid than the ETF, we regard this as a conservative estimate of trading costs. The net profit accounting for this level of transaction costs is then 6% per year, on par with the value spread (Fama and French 1993).

¹⁹ We use data from the NYSE TAQ database and calculate the average bid-ask spread for the Spider (SPY) exchange-traded fund (ETF) as the average over the one minute intervals 10:00 to 10:01 the day before the announcement, 10:04 to 10:05 the day of the announcement, and 15:59 to 16:00 the day after the announcement. We use the AMEX quotes, where the ETF is most heavily traded, to avoid issues with difference in the timing of quotes across exchanges. Allowing the investor to trade on additional exchanges is likely to decrease the effective trading costs.

4.2.2. The Cross-Section of Stocks. To get a sense of the cross-sectional stock return response to the LEI release, we look at the return response of portfolios created based on a quintile sort on market beta. The market beta for each stock for each year is obtained from CRSP and is calculated as the market beta from daily data the year prior to the year of a particular LEI release. Only stocks that are in the S&P 500 at the time of the release are included in these portfolios to keep the results consistent with the aggregate market results. These stocks are also fairly liquid. To get the portfolio return for a particular time interval, we equal weight the individual stock returns of all stocks in the portfolio that are traded during the first minute of the interval and the last minute of the interval. For the announcement interval, we consider the first minute as the minute from 9:58 A.M. to account for possible erroneous timing of a transaction price in the TAQ database. If there are multiple trades of a given stock in a given minute, we take the average price over the minute as the transaction price used in the return calculation. We remove observations for which prices are zero or negative.

The middle set of rows in Table 2 shows that high beta stocks respond more to the LEI announcement than low beta stocks. In particular, the highest beta quintile portfolio has a total preannouncement return of 61 basis points, an announcement return of 10 basis points, a postannouncement return of –68 basis points, and a trading strategy return ignoring transaction costs of 151 basis points. The corresponding numbers for the lowest beta quintile portfolio are 17 basis points, 3.7 basis points, –10 basis points, and 32 basis points, respectively. The difference in the return between the trading strategy return of the high beta portfolio and the low beta portfolio is 117 basis points and significant at the 1% level (not reported in the table). This indicates that (a subset of) investors consider the LEI announcement as market news and act accordingly. The effect is completely reversed (that is, the total return response over all three intervals is statistically zero) for all stocks.²⁰

4.2.3. Treasury Bonds. In the last set of rows in Table 2, we turn to the Treasury bond market. We consider the return response of futures on the 2-year, 5-year, 10-year, and 30-year Treasury notes and bonds. Unlike in the case for the stock market,

the preannouncement interval does not have significant regression coefficients, although the sign is negative as one would expect from the bond market that typically reacts opposite to the stock market when faced with macroeconomic news. The announcement returns, however, are strongly significant (at the 1% level), whereas the postannouncement returns are only marginally significant for the 5- and 10-year bonds. The magnitude of the regression coefficients are overall increasing in bond maturity, but smaller than in the stock market. The announcement return in the 30-year bond is the largest at –3.2 basis points, compared to 4.5 basis points in the stock market. Thus, the pattern in the bond market is consistent with the pattern in the equity market, although the bond market sees weaker preannouncement and postannouncement return patterns. The lower volatility of the underlying in the Treasury bond futures market makes arbitrage activity less costly, which could explain the smaller return response. These patterns are consistent with the evidence provided by Andersen et al. (2007), who analyze the response of various markets, including equity and treasuries, to the release of macroeconomic announcements.

In sum, the release of the entirely predictable LEI is associated with a return response at the aggregate stock market level and in the Treasury bond market, as well as a differential impact in the cross-section of stock returns. This indicates that the LEI is widely seen to contain actual news, despite the fact that the index is entirely stale—a fact that is published both on Bloomberg and on TCB's webpage. Consistent with the notion that some investors confound stale information with news (inattention model 2), the release of the LEI is associated with aggregate stock market prices moving in the direction of the release before and at the announcement, followed by a reversal after the announcement. These inattentive investors cause temporary, yet significant, price pressure, and transfer surplus to attentive investors via the trading process.

In the electronic companion, we perform a number of robustness tests for our main finding—that the release of the LEI is associated with a significant return response in the aggregate stock and Treasury bond markets. First, we consider different measures of LEI expectations and find they all produce announcement return responses that are consistent with the findings presented above. Second, we show that the results are similar across various subsamples of the data, such as early versus late samples. Third, we show that the announcement response cannot be explained by intraday autocorrelation in stock returns.

4.2.4. Stale Information Response Bias. To further link these price moves to a particular inattention bias, we use an instrument from Tetlock (2011).

²⁰ The reason “total” and “strategy” returns do not sum to their natural values given the other coefficients, is that there are some firms for which we have preannouncement interval returns only, some firms with postannouncement returns only, and some with announcement returns only, and combinations. All of these three returns must be present for a firm to be included in the total and strategy regressions, so the number of firms here are smaller.

In the cross-section of stock returns, Tetlock shows that the price reversal after a firm-specific news event (e.g., an earnings announcement) is larger the higher the fraction of stale information in the news release. The measure of staleness he uses is a measure of the overlap in the wording of the release relative to previous news articles/releases available in the press and from news agencies/bureaus. In particular, he runs a Fama–MacBeth cross-sectional regression of firms return on days 2–5 after the news release on the return the day of the release and the return at the time of the release interacted with this measure of the releases’ staleness (plus many additional controls). Whereas Tetlock’s analysis is unconditional, the Fama–MacBeth procedure gives a daily time series of the regression coefficient on the interaction term.²¹ We average the daily regression coefficients on this interaction term within each month to create a monthly time series of the magnitude of this particular inattention bias.²²

We postulate that the inattention bias found in the cross-section of individual firm news releases in Tetlock (2011) is also measuring a market-wide propensity of the marginal investor to suffer from the same inattention bias. This corresponds to the marginal effect of an increase in the proportion of inattentive investors in the model of the previous section. The model then predicts that the market return responds more to the LEI release when the current aggregate level of the bias is high and less when the current level of the bias is low. We therefore run the following regressions:

$$\begin{aligned}
 R_{t,i} = & \alpha_i + \beta_{0,i} \times StaleNewsReversal_XS_{t-1} \\
 & + \beta_{1,i} \times (\Delta LEI_t - E_{t-}[\Delta LEI_t]) \\
 & + \beta_{2,i} \times StaleNewsReversal_XS_{t-1} \\
 & \times (\Delta LEI_t - E_{t-}[\Delta LEI_t]) + \varepsilon_{t,i}, \quad (2)
 \end{aligned}$$

where *StaleNewsReversal_XS_{t-1}* is the negative of the cross-sectional inattention measure described above. Thus, when *StaleNewsReversal_XS_{t-1}* is high, the level of the bias is high. We use the previous month’s level of this instrument to avoid any look-ahead bias and also to ensure that this is in fact a tradable strategy, and normalize the variance of the inattention measure to be one to facilitate easy interpretation of the regression coefficients. Table 3 shows

²¹ See Equation (4), the second from the right column, and the row labeled “*AbRet_{it}*stale1_{it}*” of Table 3 in Tetlock (2011). The coefficient reported in Tetlock (2011) is the average of the daily cross-sectional regression coefficients.

²² We thank Paul Tetlock for making this data available to us. The sample in Tetlock (2011) covers our sample, except for the two last months (the two first months in 2009).

Table 3 Time Variation in the Response Coefficient due to Inattention

| Log return (%) S&P 500 futures | Announcement 10:00 A.M.–10:04 A.M. day of LEI announcement | Return response for front- running strategy |
|--|--|---|
| <i>StaleNewsReversal_XS_{t-1}</i> | −0.028* (0.015) | −0.113 (0.148) |
| <i>LEI_surprise_t</i> | 0.033** (0.015) | 0.574*** (0.211) |
| <i>StaleNewsReversal_XS_{t-1}</i> × <i>LEI_surprise_t</i> | 0.017 (0.020) | 0.512** (0.236) |
| <i>R²_{adj}</i> (%) | 7.5 | 9.1 |

Notes. This table shows the results from running the following regression using S&P 500 futures five-minute announcement returns as well as the front-running strategy returns (defined in the main text): $R_{t,i} = \alpha_i + \beta_{0,i} \times StaleNewsReversal_XS_{t-1} + (\beta_{1,i} + \beta_{2,i} \times StaleNewsReversal_XS_{t-1}) \times LEI_Surprise_t + \varepsilon_{t,i}$, where i correspond to the return interval and t refers to the 116 announcement dates in the sample (February 1997–February 2009). *LEI_Surprise_t* is equal to $\Delta LEI_t - E_{t-}[\Delta LEI_t]$, where the expectation of the LEI release is the median of analyst forecasts as given by Bloomberg. *StaleNewsReversal_XS* is a monthly, cross-sectional measure of the amount of individual firms’ return reversal after stale firm news announcements. This measure is constructed from monthly cross-sectional Fama–MacBeth regressions using a measure of news staleness developed in Tetlock (2011), and its $t - 1$ subscript indicates that the measure is based on return data for the month prior to the announcement month. The methodology is described in detail in the main text. A large degree of return reversal in the cross-section of stock returns leads to a high *StaleNewsReversal_XS*. Thus, if overreaction to stale news in the cross-section of stock returns is positively related to overreaction to stale aggregate news at the aggregate stock market level, the expected sign on the interaction term’s regression coefficient ($\beta_{1,2}$) is positive: high degree of overreaction to stale news leads to a higher aggregate return response to the (100% stale) LEI announcement. The standard errors of the regression coefficients are given in parentheses, and they are corrected for heteroskedasticity. All returns are in percent and *LEI_Surprise* and *StaleNewsReversal_XS* are both normalized to have unit variance.

*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.

that the regression coefficient on the interaction term is positive, as predicted, for both the announcement return and the return to the front-running strategy explained earlier. The coefficient is not statistically significant for the five-minute announcement, but the size is economically significant in that a two standard deviation increase in *StaleNewsReversal_XS* doubles the announcement return response (from 3.3 to 6.7 basis points in this regression), and a two standard deviation decrease in *StaleNewsReversal_XS* makes the announcement response zero. For the front-running strategy return regression in the rightmost column of Table 3, the regression coefficient on the interaction term is significant at the 5% level—in this case a one-standard deviation change in *StaleNewsReversal_XS* is sufficient to double the return response.

4.2.5. Constrained Arbitrageurs. Another necessary feature of the model is limited risk taking capability of the fully informed (attentive) arbitrageurs. These investors understand that the LEI release is 100% stale, so they can calculate its value before the

Table 4 Background Risk and the LEI Return Response

| Return volatility quintiles (within highest β_{mkt} quintile): | $R_t = \gamma + \delta(\Delta\text{LEI}_t - E_{t-}[\Delta\text{LEI}_t]) + \varepsilon_t$ | | | | | |
|--|--|--------------------|---------------------|---------------------|--------------------|--------------------|
| | 1 | 2 | 3 | 4 | 5 | 5 – 1 |
| $\hat{\delta}$ from announcement return regressions (s.e.) | 0.086* (0.044) | 0.101** (0.051) | 0.109* (0.057) | 0.105** (0.050) | 0.107** (0.048) | 0.021 (0.021) |
| $\hat{\delta}$ from front-running return regressions (s.e.) | 1.098** (0.447) | 1.183** (0.468) | 1.634*** (0.573) | 1.656*** (0.557) | 1.999** (0.786) | 0.891** (0.423) |

Notes. This table shows the regression results for the five-minute announcement returns, as well as the front-running strategy returns (defined in the main text) for five different portfolios. The portfolios correspond to a return standard deviation quintile sort *within* the highest market beta quintile. Both the market beta and standard deviation of each stock are taken from CRSP and are based on one-year lagged daily return data. Thus, it is available to investors at each time t . The regression for each return interval is $R_{t,i,j} = \gamma_i + \delta_i(\Delta\text{LEI}_t - E_{t-}[\Delta\text{LEI}_t]) + \varepsilon_{i,t}$, where i correspond to the portfolio, j refers to a stock in the portfolio, and t refers to the 116 announcement dates in the sample (February 1997—February 2009). The expectation of the LEI release is the median of analyst forecasts as given by Bloomberg. For brevity, we only report the δ_i coefficients. Standard errors are given below the corresponding δ_i -estimate in parentheses. The standard errors are corrected for heteroskedasticity and clustered by announcement date. All returns are in percent and the LEI surprise is normalized to have unit variance.

*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.

release, but because of background noise in the stock returns (for instance arising from liquidity traders or other news), they do not fully eliminate the profits from the front-running strategy as the efficient-market null hypothesis would predict.

Following Cohen and Lou (2012), we investigate whether such limits to arbitrage in fact are relevant for the response to the LEI. In particular, we postulate that stocks with higher idiosyncratic volatility are more difficult to arbitrage and thus should exhibit a stronger return response pattern with respect to the LEI release. To investigate this hypothesis we perform a double-sort on stocks' market beta and standard deviation of returns.²³ Both the market beta and the standard deviation of each stock are obtained from CRSP, which we estimate using daily data for the year prior to the year in which the stock is assigned its market beta and standard deviation. We sort S&P 500 stocks each month into five beta-sorted portfolios. We know from the results in Table 2 that the announcement return response is highest for the highest beta firms, so we focus on this quintile. Within the highest beta quintile we then sort on standard deviation. The portfolio returns are calculated as equal-weighted returns for the traded stocks within each portfolio, as described earlier for the beta-sorted portfolios.

Table 4 shows the result of the regressions as in Equation (1) across the five standard deviation sorted portfolios, all within the highest beta quintile. For both the announcement interval and the

front-running strategy, the return response is higher for high volatility stocks: The announcement return response increases from 8.6 basis points to 10.7 basis points, and the front-running strategy return response goes from 110 basis points to 200 basis points. The return difference is not statistically significant for the announcement return response, but it is significant at the 5% level for the front-running strategy return response.

Thus, we find evidence for two necessary ingredients of our model. First, investors suffer from inattention bias in that they view a rerelease of old news as additional news in the same direction as the original news. This leads to an overreaction to the stale news release and a subsequent reversal. Second, as generally predicted by limited risk taking capacity of arbitrageurs, stocks with higher return volatility are associated with higher returns to the arbitrageurs' front-running strategy.

4.2.6. Return Response to Initial Information Releases. In our model, the presence of attentive investors implies that there should be a return response to the initial announcements of the underlying components of the LEI. We investigate this implication here, but note that there are some severe data-driven impediments to such tests. Measuring the aggregate market response to the release of these components is complicated by the fact that most of the series are not the headline number within their release. For instance, new orders of nondefense capital goods are shown as a subitem within the Census Bureau's major release of manufacturing orders. Although the headline number may move prices, the marginal impact of subitems is hard to determine. Related, some of the releases come out at the same time as other macroeconomic statistics not included

²³ We also performed a sort on idiosyncratic volatility, which qualitatively gives the same results. This is not surprising because holding beta constant, which we are approximately doing, total volatility and idiosyncratic volatility are one to one. Standard deviations and betas are readily available from the CRSP database, however, which makes it easier to replicate our findings.

Table 5 Return Regressions of the Components of the LEI

$$R_t = \gamma + \delta \times \text{Component_Surprise}_t + \varepsilon_t$$

| LEI component | Releasing agency | Release time (EST) | <i>N</i> | $\delta_{\text{S\&P 500}}$ (s.e./ <i>R</i> ²) | $\delta_{\text{2yr bond}}$ (s.e./ <i>R</i> ²) | $\delta_{\text{5yr bond}}$ (s.e./ <i>R</i> ²) | $\delta_{\text{10yr bond}}$ (s.e./ <i>R</i> ²) | $\delta_{\text{30yr bond}}$ (s.e./ <i>R</i> ²) |
|---|------------------|--------------------|----------|--|--|--|---|---|
| Initial unemployment claims | DL | 8:30 A.M. | 623 | −0.029*** (0.009/2.1%) | 0.011*** (0.002/9.1%) | 0.019*** (0.004/5.4%) | 0.021*** (0.005/3.7%) | 0.028*** (0.006/3.3%) |
| Money supply (M2) | FRB | 4:30 P.M. | 567 | −0.007* (0.004/1.7%) | 0.001* (0.000/1.8%) | 0.002** (0.001/2.2%) | 0.004*** (0.001/2.6%) | 0.007*** (0.002/3.7%) |
| Vendor performance: deliveries diffusion index | ISM | 8:30 A.M. | 148 | 0.014 (0.019/0.2%) | −0.006 (0.004/1.1%) | −0.020** (0.009/2.5%) | −0.029** (0.012/2.9%) | −0.046*** (0.016/3.9%) |
| Average work week: manufacturing | BLS | 8:30 A.M. | 144 | 0.054 (0.039/1.3%) | −0.004 (0.010/0.1%) | 0.010 (0.022/0.1%) | 0.004 (0.030/0.0%) | 0.020 (0.036/0.2%) |
| Building permits: new private housing units | CB | 8:30 A.M. | 144 | 0.017 (0.015/1.1%) | 0.000 (0.002/0.0%) | 0.006 (0.005/0.6%) | 0.011 (0.007/1.1%) | 0.019 (0.013/1.8%) |
| Index of consumer sentiment | UM | 7:00 A.M. | 92 | 0.004 (0.006/0.5%) | −0.000 (0.001/0.3%) | −0.000 (0.001/0.0%) | 0.001 (0.001/0.2%) | 0.000 (0.002/0.0%) |
| Manufacturers new orders: consumer goods and materials | CB | 10:00 A.M. | 145 | −0.010 (0.019/0.3%) | 0.001 (0.002/0.3%) | 0.002 (0.004/0.1%) | 0.002 (0.005/0.1%) | 0.012 (0.008/1.2%) |
| Manufacturers new orders: nondefense capital goods | CB | 10:00 A.M. | 145 | 0.017 (0.015/0.7%) | 0.002 (0.002/0.5%) | 0.003 (0.004/0.3%) | 0.003 (0.005/0.1%) | 0.010 (0.008/0.8%) |

Notes. This table reports estimates from OLS regression of five-minute S&P 500 futures returns, as well as 2-, 5-, 10-, and 30-year Treasury note and bond futures returns on the same-day normalized announcement surprise of the eight nonprice components of the LEI. The surprise is defined relative to median analyst forecasts and variance of the surprise is normalized to be one. Initial unemployment claims and M2 are released on a weekly basis, and all other components are released on a monthly basis. The sample period is from February 1997 to February 2009, except for the Index of Consumer Sentiment where the sample starts in February 1999. The monthly releases are arranged in order of arrival across the month. The abbreviations are Institute for Supply Management (ISM), Bureau Labor Statistics (BLS), Department of Labor (DL), Census Bureau (CB), Federal Reserve Board (FRB), and University of Michigan (UM). Returns are continuously compounded and expressed as percentages. Standard errors are corrected for heteroskedasticity.

*Significant at the 10% level; **significant at the 5% level; *** significant at the 1% level (two-tailed test).

in the LEI and/or are released outside of trading hours. Although the S&P 500 futures are traded at the most common release time (8:30 A.M.) in premarket trading, volume is low. These issues notwithstanding, we test for the existence of a return response to the LEI components using returns over the five-minute interval starting immediately before each announcement to five-minutes after the announcement for all announcement dates between February 1997 and February 2009 for the S&P 500 futures and the Treasury bond futures.

Table 5 shows that the release of initial unemployment claims and money supply leads to a significant return response for both the aggregate stock market and the Treasury bond returns. These two statistics are the only ones that are headline numbers. For the releases of the other components of the LEI, we do not find a significant stock market return response, but vendor performance is associated with a significant return response for Treasury bonds. The return responses are typically between one and five basis points and thus of the same magnitude as the announcement return response of the LEI.

5. Volatility and Volume Analysis

Based on the stylized model of inattention presented in §3, we predict an increase in both volatility and

volume at the time of the release of the LEI, which would be further evidence of heterogeneous beliefs between the attentive and inattentive investors. In this section, we show that the volatility and volume in the equity market are significantly higher around the LEI announcement compared to other nonannouncement days.

5.1. Volatility Analysis

If the LEI announcement constitutes news to a set of investors, we should expect volatility to be higher at the announcement interval on announcement days compared to the nonannouncement days. We test whether five-minute stock return volatility is higher on announcement days compared to nonannouncement days in each of the five-minute intervals in the half hour around the announcement. We designate the day one week after each announcement date as the nonannouncement date, unless there is another important macroeconomic news release on that date, in which case we pick the date following the LEI release.²⁴

It is well documented that aggregate stock return volatility is time-varying. To control for this, we employ a matching study. First, we calculate the

²⁴ We experimented with other matching rules, without any qualitative changes in the results.

volatility of five-minute returns for each non-announcement day for the relevant trading hour. Next, we divide the five-minute returns on both the corresponding announcement day and the nonannouncement day by this volatility measure.²⁵ We use only the nonannouncement days' volatility in order to capture any overall higher levels of volatility on announcement days in the subsequent volatility tests. This normalization is valid under the null hypothesis that the volatility over matched announcement and nonannouncement days are equal.

Next, we calculate the volatility of five-minute (normalized) announcement and nonannouncement day returns for each interval as follows. Let $\tilde{R}_{i,t}$ be the normalized five-minute log return for the interval i , where $i \in \{9:45-9:50, 9:50-9:55, \dots, 10:15-10:20\}$. Interval i 's variance estimate is then

$$\hat{\sigma}_i^2 = \frac{1}{T} \sum_{t=1}^T \tilde{R}_{i,t}^2, \quad (3)$$

where the subscript t corresponds to the announcement or nonannouncement days in our sample, which are indexed 1 to 116. To test whether the variance on announcement days is different than on nonannouncement days, we apply a Levene F -test for each interval i .²⁶

Column 2 in Table 6 shows the results. The ratios of announcement versus nonannouncement days' volatility exhibit a significant spike for the interval 10:00–10:05, which corresponds to the time the LEI is announced. The increase is not only statistically significant (at the 5% level), but also economically sizable—volatility increases by an average of 25%. Before 10:00, there appears to be no overall pattern in the volatility ratio: volatility is about the same on announcement versus nonannouncement days. After 10:00, the volatility ratios are all above zero, indicating that volatility is overall higher on announcement days in the half hour following the LEI release.

5.2. Volume Analysis

Following a similar methodology, we test whether volume is higher on announcement days compared

²⁵ We calculate standard deviations assuming the expected five-minute returns are equal to zero. This is a standard assumption given the short time interval and yields more robust volatility estimates. Using the residuals of a regression of intraday returns on their lagged value (to capture any bid-ask bounce, which we do not find significant) does not produce qualitatively different results.

²⁶ It is common in empirical work to use modified Levene F -tests (for example, the Brown–Forsythe modified Levene test), as these are generally more robust to departures from normality of returns. We assume that the expected five-minute return is equal to zero, which is neither the sample mean, median, nor the 10% trimmed mean, but which empirically turns out to be very close to the median.

Table 6 Return Volatility and Volume Tests

| $t_0 - t_1$ | Volatility ratio (s.e.) | Volatility ratio–shocks (s.e.) | Volume ratio (s.e.) | Volume ratio–shocks (s.e.) |
|-------------|-------------------------|--------------------------------|---------------------|----------------------------|
| 9:45–9:50 | −0.009 (0.067) | 0.035 (0.121) | 0.012 (0.020) | 0.007 (0.037) |
| 9:50–9:55 | −0.084 (0.067) | −0.005 (0.131) | 0.018 (0.019) | −0.015 (0.039) |
| 9:55–10:00 | −0.006 (0.070) | −0.093 (0.110) | 0.006 (0.023) | −0.063 (0.040) |
| 10:00–10:05 | 0.261*** (0.083) | 0.387** (0.156) | 0.067*** (0.023) | 0.110** (0.044) |
| 10:05–10:10 | 0.113 (0.075) | 0.077 (0.158) | 0.034* (0.021) | 0.055 (0.044) |
| 10:10–10:15 | 0.066 (0.066) | 0.098 (0.137) | 0.040* (0.022) | 0.012 (0.043) |
| 10:15–10:20 | 0.029 (0.063) | −0.109 (0.112) | 0.038* (0.023) | −0.016 (0.040) |

Notes. This table reports estimates of mean of the log ratio of standard deviation of five-minute returns or five-minute volume on announcement days over nonannouncement days. There are 116 observations in each group in columns 2 and 4, and 34 observations in the “shocks” groups in column 3 and five where we only consider days when the LEI surprise (computed using the median consensus analyst forecasts) is at least one standard deviation away from the mean. The log ratio is for each five-minute interval regressed on a constant, and the null hypothesis is that the mean of the log ratio is equal to zero. Standard errors are corrected for heteroskedasticity (White standard errors).

*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.

to nonannouncement days in each of the five-minute intervals in the half hour around the announcement. To control for the strong increase in aggregate volume over the sample period and the well-known intraday patterns in volume (Admati and Pfleiderer 1988), we create normalized five-minute volume for each announcement day, $v_{i,t}$, by dividing the volume of the same five-minute interval on the matched nonannouncement day:

$$v_{i,t} = \ln\left[\frac{\text{(volume in five-minute interval } i \text{ on announcement day } t)}{\text{(volume in five-minute interval } i \text{ on nonannouncement day } t')}\right]. \quad (4)$$

We then regress this normalized volume on a constant for each five-minute interval from 9:45 until 10:20:

$$v_{i,t} = \alpha_i + \varepsilon_{i,t}, \quad \text{where } i \in \{9:45-9:50, 9:50-9:55, \dots, 10:15-10:20\}. \quad (5)$$

The null hypothesis we are testing is $\alpha = 0$, and column 3 of Table 6 reports the results. Although the difference in volume between announcement and nonannouncement days is insignificant prior to the 10:00 A.M. announcement, this difference markedly

increases when the LEI is released. During the announcement interval, volume is about 7% higher on announcement days compared to nonannouncement days. The difference in volume remains statistically significant for the half hour following the announcement, which supports our hypotheses of heterogeneous beliefs being present in the market and attentive investors taking advantage of the inattentive investors' lack of understanding of the stale nature of the LEI release.

6. Conclusion

In this paper, we present evidence that investors respond to the release of summary information, failing to account for its stale nature, and their trades as a result impact the *aggregate* stock and bond markets. The paper uses a weak restriction on aggregate prices to test for the presence of limited investor attention: markets should not respond to the release of summary statistics that are based on stale information. We identify a unique stream of events, the U.S. Leading Economic Index (LEI), that is released on a monthly basis at predetermined times, consists of previously published macroeconomic data, is calculated using a publicly available methodology, and is widely followed by the mass media.

We show that the release of the LEI has a statistically and economically significant impact on proxies for information arrival such as market-level returns, return volatility, and trading volume. Prices deviate significantly, albeit temporarily, around the release of the LEI: a front-running strategy that takes into account the price momentum and reversal around announcements generates close to 8% gross annual return for S&P 500 futures. Similar price patterns, although weaker, are observed in the Treasury futures market. The presence of a return reversal after the announcement indicates that limited attention investors confound the release of the summary statistic with new macroeconomic information. Consistent with this interpretation, the price patterns are more pronounced for high beta S&P 500 stocks and during times when investors are found to be more responsive to firm-specific stale information.

Because the test pertains to macroeconomic information, the effects of limited attention on returns should be constrained by attentive investors acting as arbitrageurs and front running the trades of the inattentive agents. The fact that the price impact of the release of the summary statistics is not completely eliminated suggests that attentive agents are constrained. Consistent with this idea, we find that price deviations are more pronounced among stocks with higher idiosyncratic volatility, which subjects arbitrageurs to greater "noise risk" (De Long et al. 1990).

The documented aggregate price response to the LEI release suggests that, when it comes to information releases, more is not necessarily a good thing because some agents have difficulty distinguishing new information from old (Tetlock 2010, 2011). This misinterpretation is costly even at the market level as attentive investors front run the trades of such agents and profit from the temporary mispricing. However, aggregated macroeconomic series, such as the LEI, may help inattentive agents update their consumption and saving plans and as such be welfare enhancing. The form of inattention we document in this paper is different from that found by, e.g., Cohen and Frazzini (2008) and DellaVigna and Pollet (2009), who show examples of situations where investors ignore available price relevant information, which leads to an initial price underreaction.²⁷ Taken together, the evidence indicates that although the saliency of a news release is important for informational efficiency, the repackaging of previously released information in the form of summary statistics gives an opportunity for arbitrageurs to profit from agents that believe such statistics provide additional information beyond that already released.

Acknowledgments

The authors thank the Conference Board for providing them with the data. The authors thank Brad Barber (special issue coeditor), Francisco Gomes, Rick Green, Terry Hendershott, Rich Lyons, Chris Malloy, Miguel Palacios, Christophe Pérignon, Paul Tetlock, and four anonymous referees for helpful comments; Tanya Balsky for research assistance; and Frank Tortorici and Ken Goldstein for their help. The authors thank seminar participants at the European Financial Management Association 2006 meeting; Carnegie Mellon University; University of California, Berkeley; and Penn State. The views expressed in this paper are those of the authors and do not necessarily represent those of the Conference Board. All errors remain the authors' responsibility.

References

- Admati, A. R., P. Pfleiderer. 1988. A theory of intraday patterns: Volume and price variability. *Rev. Financial Stud.* 1(1) 3–40.
- Andersen, T. G., T. Bollerslev, F. X. Diebold, C. Vega. 2003. Micro effects of macro announcements: Real-time price discovery in foreign exchange. *Amer. Econom. Rev.* 93(1) 38–62.
- Andersen, T. G., T. Bollerslev, F. X. Diebold, C. Vega. 2007. Real-time price discovery in global stock, bond, and foreign exchange markets. *J. Internat. Econom.* 73(2) 251–277.
- Ball, L., N. G. Mankiw, R. Reis. 2005. Monetary policy for inattentive economies. *J. Monetary Econom.* 52(4) 703–725.
- Barber, B. M., T. Odean. 2008. All that glitters: The effect of attention and news on the buying behavior of individual and institutional investors. *Rev. Financial Stud.* 21(2) 785–818.

²⁷ In addition to Tetlock (2011), overreaction due to the presence of inattentive investors has been documented in the auction market (see Malmendier and Szeidl 2008).

- Barberis, N., A. Shleifer. 2003. Style investing. *J. Financial Econom.* **68**(2) 161–199.
- Burns, A. M., W. C. Mitchell. 1946. *Measuring Business Cycles*. National Bureau of Economic Research, Cambridge, MA.
- Cohen, L., A. Frazzini. 2008. Economic links and predictable returns. *J. Finance* **63**(4) 1977–2011.
- Cohen, L., D. Lou. 2012. Complicated firms. *J. Financial Econom.* Forthcoming.
- Cutler, D. M., J. M. Poterba, L. H. Summers. 1989. What moves stock prices? *J. Portfolio Management* **15**(3) 4–12.
- DellaVigna, S., J. Pollet. 2007. Demographics and industry returns. *Amer. Econom. Rev.* **97**(5) 1167–1702.
- DellaVigna, S., J. Pollet. 2009. Investor inattention and Friday earnings announcements. *J. Finance* **64**(2) 709–749.
- De Long, J. B., A. Shleifer, L. H. Summers, R. J. Waldmann. 1990. Noise trader risk in financial markets. *J. Political Econom.* **98**(4) 703–738.
- Fama, E. F., K. R. French. 1993. Common risk factors in the returns on stocks and bonds. *J. Financial Econom.* **33**(1) 3–56.
- Filardo, A. J. 2004. The 2001 U.S. recession: What did recession prediction models tell us? Working Paper 148, Bank for International Settlements, Basel, Switzerland.
- Fleming, M. J., E. M. Remolona. 1999. Price formation and liquidity in the U.S. Treasury market: The response to public information. *J. Finance* **54**(5) 1901–1915.
- Gabaix, X., D. Laibson. 2006. Shrouded attributes, consumer myopia, and information suppression in competitive markets. *Quart. J. Econom.* **121**(2) 505–540.
- Hirshleifer, D. A., S. S. Lim, S. H. Teoh. 2009. Driven to distraction: Extraneous events and underreaction to earnings news. *J. Finance* **64**(5) 2289–2325.
- Hong, H., W. Torous, R. Valkanov. 2007. Do industries lead stock markets? *J. Financial Econom.* **83**(2) 367–396.
- Huberman, G., T. Regev. 2001. Contagious speculation and a cure for cancer: A nonevent that made stock prices soar. *J. Finance* **56**(1) 387–396.
- Huberman, G., G. W. Schwert. 1985. Information aggregation, inflation, and the pricing of indexed bonds. *J. Political Econom.* **93**(1) 92–114.
- Karlan, D., M. McConnell, S. Mullainathan, J. Zinman. 2011. Getting to the top of mind: How reminders increase saving. Working paper, Yale University, New Haven, CT.
- Malmendier, U., A. Szeidl. 2008. Fishing for fools. Working paper, University of California, Berkeley, Berkeley.
- Mankiw, G. N., R. Reis. 2002. Sticky information versus sticky prices: A proposal to replace the new Keynesian Phillips curve. *Quart. J. Econom.* **117**(4) 1295–1328.
- McGuckin, R. H., A. Ozyildirim, V. Zarnowitz. 2007. A more timely and useful index of leading indicators. *J. Bus. Econom. Statist.* **25**(1) 110–120.
- Mitchell, M. L., J. H. Mulherin. 1994. The impact of public information on the stock market. *J. Finance* **49**(3) 923–950.
- Peng, L., W. Xiong. 2006. Investor attention, overconfidence and category learning. *J. Financial Econom.* **80**(3) 563–602.
- Schwert, G. W. 1981. The adjustment of stock prices to information about inflation. *J. Finance* **36**(1) 15–29.
- Shleifer, A., R. W. Vishny. 1997. The limits of arbitrage. *J. Finance* **52**(1) 35–55.
- Sims, C. A. 1998. Stickiness. *Carnegie-Rochester Conf. Ser. Public Policy* **49** 317–356.
- Sims, C. A. 2003. Implications of rational inattention. *J. Monetary Econom.* **50**(3) 665–690.
- Tetlock, P. C. 2010. Does public financial news resolve asymmetric information? *Rev. Financial Stud.* **23**(9) 3520–3557.
- Tetlock, P. C. 2011. All the news that's fit to reprint: Do investors react to stale information. *Rev. Financial Stud.* **24**(5) 1481–1512.
- The Conference Board. 2001. *Business Cycle Indicators Handbook*. The Conference Board, New York.
- Zarnowitz, V. 1992. *Business Cycles: Theory, History, Indicators, and Forecasting*. University of Chicago Press, Chicago.