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# How analysts process information: technical and financial disclosures in the microprocessor industry

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# How Analysts Process Information:
# Technical and Financial Disclosures in the Microprocessor Industry

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# How Analysts Process Information:

# Technical and Financial Disclosures in the Microprocessor Industry*


## *Abstract*

Following Bradshaw (2009, 2011), this paper examines *how* analysts process information, particularly in an information environment characterised by multiple and potentially complementary information sources. The setting is the microprocessor industry, one in which technical information is particularly significant and complex to digest. Based on 3,837 analyst earnings-forecast revisions, issued by 134 analysts, we examine quantitatively the speed, magnitude, and information content of the reactions of individual analysts and sub-groups of analysts to both periodic and timely technical disclosures, and as a complement to periodic financial disclosure. We find that analysts are much slower to react to timely technical disclosures than they are to periodic financial disclosures. We find also that technical and financial disclosures complement each other. Further, we find that there is a 'hierarchy' of analysts in this particular industry, as evidenced through the strength of reaction to timely technical disclosures. Finally, we find that lower speed in reacting to timely technical disclosures and a higher intensity in the use of timely technical disclosure (in conjunction with periodic financial disclosure) result in greater accuracy, and that more experienced analysts tend to be less accurate. We suggest that the findings may have implications for other industries such as Bio-Tech Pharma.



Keywords: technical, disclosure, timely, analysts, forecasts, microprocessors, information processing


## *1. Introduction*

Accounting researchers have paid relatively little attention to the 'how' of information processing (Bradshaw, 2009, 2011). This issue is particularly important in information environments with multiple and potentially complementary components, and where the digesting of technical information is especially significant. We start from the intuition that multiple information sources or signals may complement rather than substitute for each other (Francis et al. 2002). Amir and Lev (1996) studied such

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* Supplemental materials are available in an online Appendix.


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complementary relations in the wireless communication industry, while Gietzmann and Ireland (2005) have argued more recently that companies communicate via multiple 'message spaces'. A large body of prior research has shown the importance of non-financial information in explaining future financial performance, as well as analyst behaviour.[1] Consistent with this literature, we seek in this paper to open up the 'black box' of information processing by analysts.

As Bradshaw (2009, 2011) has suggested, the study of information processing is not easily accessed by conventional multi-firm archival studies. Accordingly, we select a single industry (microprocessor), and one in which the digesting of technical information is especially significant (Schaller, 2004; Zuckerman, 2004). This is consistent with calls for clinical studies (Jensen et al., 1989), appeals to alternative research methodologies (Bradshaw, 2009, 2011), and the growing body of accounting literature addressing by means of quantitative methods idiosyncratic situations or small numbers of cases.[2] This allows us to generate a unique hand-gathered data source. We focus on the dominant firm in the industry (Intel). Intel is one of the world's largest semiconductor chip makers when measured by sales revenue (Intel Corporation, 2013), it has long held a dominant position in microprocessor markets world-wide, and it exerts substantial influence on a wide range of complementary industries.[3]

Following Gietzmann and Ireland (2005, p. 600), we use the term 'timely' disclosure to refer to those disclosures that may be more relevant to analysts than periodic disclosures, such as those contained in annual reports. Consistent with this terminology and reasoning, we propose a tripartite distinction in this paper. First, we refer to *periodic financial disclosure*, such as contained in annual and quarterly reports. Second, we refer to *periodic technical disclosure*, defined as those disclosures of information that is not normally contained in the financial reports, but which appears at routine intervals (this includes, in the case of microprocessors, operating metrics such as

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helpful comments. We would also like to thank participants at the EFMA Conference (held at Bocconi University, June 2009).

[1] Baginski et al., 2004; Ball and Brown, 1968; Banker and Mashruwala, 2007; Barron et al., 1999; Bernard and Thomas, 1989; Bozzolan et al., 2009; Chandra et al., 1999; Clarkson et al., 1999; Espinosa et. al., 2009; Gu and Wang, 2005; Hussainey et. al., 2003; Ittner and Larcker, 1998; Rajgopal et al., 2003; Schleicher and Walker, 1999; Tellis and Johnson, 2007; Vanstraelen et. al., 2003; Xu et al., 2007. See also Sievers et al. (2013) on the incremental value relevance of non-financial metrics in the context of venture capital-backed firms.

[2] Cahan et al., 2011; Ho et al., 2009; Hunton et al., 2010; Krishnan et al., 2011; and Wang et al., 2011. Of these, Hunton et al. (2010) is the only one to study analysts, although the focus in that paper is on buy-side rather than sell-side analysts.

chip cost, die size and die cost). Third, we refer to *timely technical disclosure*, defined as non-periodic disclosures contained in web-based press releases (pertaining to such as market creation, production processes and product design). By using hand gathered technical data contained in web-based press releases, alongside non-traditional technical data contained in the reports of technical analysts, we seek to differentiate the impact of these three components of the information environment in the microprocessor industry, and also to examine their interaction. We examine 3,837 analyst earnings-forecast revisions issued by 134 analysts employed by 83 brokerage and investment firms across the period 2000 to 2007.

Our intuition is that, in knowledge-intensive industries, technical disclosures are unusually hard to digest, and this is likely to impact on information processing by analysts. This is particularly the case with timely technical disclosures, such as those contained in web-based press releases. We conduct both an association study and an event study, in order to investigate the information content of periodic technical disclosures and timely technical disclosures, and as a complement to periodic financial disclosure. We conduct an event study in order to identify the speed and magnitude of individual analysts' forecasts revisions made on the basis of such timely technical disclosure. We predict that there will be a significant lag in analysts responding to timely technical disclosures relative to periodic financial disclosures.[4] We explore how analysts use such timely technical disclosures, jointly with periodic financial disclosures, in their earnings-forecast revisions for this industry. We distinguish between analysts employed at major brokerage and investment firms and analysts at other firms, in order to see whether there is a 'hierarchy' of analysts, with a relatively small number digesting and disseminating critical technical disclosures. Finally, we examine whether analysts learn, and if so how. To address this question we study how and to what extent the speed of reaction to timely technical disclosures, the intensity in the use of such disclosures, and the extent of analyst experience affects learning (accuracy).

Section 2 presents the motivation for this study in light of the literature on analysts' forecast revisions, which to date has focussed mainly on multi-firm samples. We consider also the literature pertaining to information processing, and learning by

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[3] Also, since the early 1990s the firm has played a lead role in ensuring that innovation on the part of suppliers and complementors matches the ambitions and time-lines of leading chip makers, including Intel itself (Miller and O'Leary, 2007).

analysts. Section 3 considers the methodological issues concerning the impact of timely versus periodic technical disclosures on earnings-forecast revisions and market prices. It also presents the sample and data. Section 4 describes the empirical results. Section 5 concludes.

## *2. Literature and motivation*

A large body of existing literature, based on multi-firm studies, has examined the informational efficiency of analysts' forecast revisions,[5] as well as so-called analyst informativeness.[6] Specifically, Lys and Sohn (1990) have examined the information content of individual analysts' forecast revisions, by testing the stock price reaction to a report, and the surprise in an individual analyst's forecast. They concluded that analysts' forecast revisions contain some, but not all of the information that was reflected in security prices prior to the forecast release. Frankel et al. (2006), by estimating the absolute stock price reaction on the dates that analysts release forecast revisions, find that analysts' reports on average are significantly informative for the set of firms studied.

A related body of literature has examined the effects of technical disclosures on analysts' activity,[7] and the use of non-financial indicators by analysts.[8] Chandra et al. (1999), with reference to the semiconductor industry, do not show a significant association between analyst sales-forecast revisions and changes in the book-to-bill ratio (i.e. a forward-looking, industry-wide disclosure), but they provide evidence that analysts rely on this indicator to distinguish between permanent and transitory sales trends. Rajgopal et al. (2003) suggest that although analysts correctly incorporate order backlog information (i.e. a leading indicator) into their forecasts, the market fixates on the order backlog itself, without appreciating that forecasts already incorporate this information. Gu and Wang (2005) find a positive association between errors in analysts' forecasts and non-financial information (diversity and innovation in technology).

A further set of studies, which has produced mixed results to date, has examined whether analysts learn from their forecasting experience. Most of the evidence documents that forecast accuracy improves with firm-specific experience (Lys and Soo,

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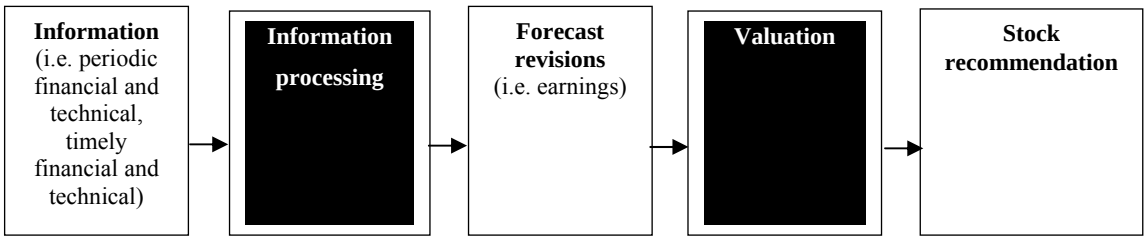
[4] While the microprocessor industry may be distinctive in this respect, it may also have similarities to the biopharmaceuticals industry, as examined by Espinosa et al. (2009).
[5] Cowen et al., 2006; Dugar and Nathan, 1995; Hong et al., 2000; Lin and McNichols, 1998.
[6] Frankel et al., 2006; Givoly and Lakonishok, 1979, 1984; Lang and Lundholm, 1996; Lys and Sohn, 1990.
[7] Barron et al., 1999; Bozzolan et al., 2009; Clarkson et al., 1999; Vanstraelen et al., 2003.

1995; Mikhail et al., 1997, 2003). However, Jacob et al. (1999) find that analysts do not learn from their forecasting experience, although situational differences (the differing demands and environment of brokerage houses) and dispositional differences (analysts' innate ability) may explain differences in forecast accuracy.

We suggest extending such enquiry, albeit in a somewhat different direction, by opening up the 'black box' of analyst information processing identified in differing ways by both Bradshaw (2009, 2011) and Zuckerman (2004). We build on the findings of Francis et al. (2002), who examined whether the news in analyst reports pre-empts, or substitutes for, the news in earnings announcements. They found instead that analyst reports can complement earnings announcements.[9] We build also on the work of Amir and Lev (1996) regarding the complementary relations between financial and non-financial information in the wireless communication industry, and Gietzmann and Ireland (2005) regarding timely disclosure, cost of capital, and accounting choice. We combine these intuitions and findings with an adapted version of Bradshaw's (2009) model of analysts' decision processes (Figure 1). He suggests that these processes should be viewed as a series of stages, and that the most interesting ones are the 'black boxes' that lead either to earnings forecasts or stock recommendations. It is the first of these black boxes that we consider here.

**Figure 1: Simple schematic of analyst information processing**




Adapted from Bradshaw (2009)

Researchers within accounting, together with those in administrative science, have suggested that decision-makers often have limited information and limited ability to retain and process the information they have, as well as limited insight into their own decision processes and future preferences.[10] We explore whether these limitations result

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[8] Chandra et al., 1999; Gu and Wang, 2005; Rajgopal et al, 2003.

[9] Consistent with Francis et al. (2002, p. 315), we use the word complement to capture the notion of a positive association between two information signals or sources, and not to indicate any particular structure or mechanism that may produce it. When we refer to 'non-complements', we mean the use of a single signal or information source.

[10] See March, 1987, 1988. See also: Koonce and Mercer, 2005; Libby et al., 2002; Phillips and Zuckerman, 2001; Zuckerman, 2004.

in variation in information processing by analysts. In particular, we examine whether technical and financial disclosures complement each other when used by analysts, and whether variations in the speed of reaction to periodic financial and timely technical disclosures, the intensity in the use of such disclosures, and the extent of analyst experience, are significant in a setting where the processing of technical information is unusually complex. We seek to explore whether different *types of information* are processed differently and at differing speeds (including multiple information sources that may complement each other), and whether different *types of analysts* (more vs less experienced) vary in their ability to process such information.

## *3. Method*

We employ a multiple-step procedure. As a preliminary step, reported in the online supplemental material, we use two methods to test whether analysts are on average informative. We examine the information content of analyst forecasts, as in Lys and Sohn (1990), and construct an index of analyst informativeness, as in Frankel et al. (2006). In short, prior results are confirmed in the Intel case: analyst forecasts are informative, analyst informativeness varies among analysts, analyst earnings forecasts reflect at least some of the information that was available to investors prior to the release of the new forecast, and the informativeness of analyst reports increases over time. In Section 3.2, which describes the first step of the main analysis, we examine whether periodic technical disclosure is useful as a complement to periodic financial disclosure in the production of analysts' forecast revisions. We use an association study at quarterly intervals to test whether individual analysts use both periodic financial and periodic technical disclosure when revising their estimates of future earnings. In section 3.3, which describes the second step of our analysis, we employ an event study centered on the disclosure announcement date to analyse whether the information content of analyst earnings revisions depends on whether the revisions are preceded by periodic financial disclosure and/or timely technical disclosure, and also to ascertain the impact and speed of each of these forecast revisions on stock price changes. Also in section 3.3, we perform the same event study separately for analysts employed by major brokerage and investment firms, and those employed by other firms, to analyse whether there is a 'hierarchy' of analysts with a relatively small number digesting and disseminating critical technical disclosures. In section 3.4, we examine whether analysts learn, and if so whether this is a function of the use of any periodic financial and timely technical

disclosures (whether separately or as complements), the speed of reaction to such disclosures, the intensity in their use, or the extent of analyst experience.

### *3.1. Sample*

The setting is the microprocessor industry, and its leading company (Intel). We use individual analyst forecasts and revisions regarding Intel from 2000 to 2007, based on data gathered from I/B/E/S detail database.[11] In our setting, numerous analysts follow Intel and issue earnings-forecast revisions. Our sample consists of 134 distinct sell-side analysts employed by 83 brokerage and investment firms, which, during the period of our analysis, represented both major firms (i.e., Merrill Lynch, Goldman Sachs, J.P. Morgan, Morgan Stanley) and other firms. Following Phillips and Zuckerman (2001) and Hong and Kubik (2003), the measure of the brokerage and investment firm hierarchy is derived from the ranking published by *Institutional Investor* magazine. Each year *Institutional Investor* ranks 10 or so brokerage and investment firms as 'The Leaders'. We classify the firms in this annual pool as major.

The forecast revisions represent the release of new reports by individual analysts, with revisions in quarterly and annual forecasts, totalling 3,837 observations over the sample period. Each observation contains the identity of the brokerage firm, the identity of the analyst, the forecast release date, the forecast earnings per share, and the forecast period interval. Table 1 (Panel A) provides descriptive statistics of the analyst forecast revisions in our sample. The number of revisions per year is on average 479.625. The highest number of revisions in a year is 565 (2005), while the lowest number of revisions in a year is 379 (in 2007). The number of analysts issuing at least one revision during a year is on average 49.625, with a minimum of 42 (in 2001) and a maximum of 58 (in 2003). Given that many analysts issue forecasts, multiple analyst reports can be released on a given day, and thus the average number of analyst reports released per report date matters. The average number of analysts issuing a revision on a given date is 1.909, with a maximum of 2.240 (in 2005) and a minimum of 1.510 (in 2007). For most of the quarters in our sample, Intel averaged about two analyst reports on a trading day. The average number of revisions per analyst in each year over the sample period is 9.626, with a maximum of 10.870 (in 2005) and a minimum of 7.730 (in 2007).

[11] We obtained I/B/E/S data across a sequence of two downloads (in December 2006 and June 2008) for the entire sample period. Differently from Ljungqvist et al. (2009), we do not observe any change in the number of recommendations per analyst, in the value of the earnings forecasts and in the release forecast date. Data are available on request from the authors.

We obtained Intel stock prices and the Nasdaq Composite Index from Datastream for each trading day (excluding scheduled market holidays). As for periodic financial information, we obtained annual and quarterly financial data for Intel (earnings per share, gross margin, inventory, accounts receivable) from Datastream and Compustat. Financial disclosure events (and their respective dates) are either the preliminary earnings announcements collected from Compustat, or the earlier of the SEC receipt dates from 10Ks and annual reports.

The identification of both periodic and timely technical disclosures is rather more complex, as the data is not readily available in a form amenable to econometric analysis. With regard to periodic technical disclosure (used in the association study), we refer to the sources identified by Miller and O'Leary (2000), namely the reports provided by the very small group of independent technical analysts, who are separate from the sell-side analysts.[12] Here, periodic technical disclosure on Intel's products is taken to be that contained in a widely used In-Stat Report on 'Intel Manufacturing Capacity and Die Costs' (McGregor, 2005, 2007), where data on the most relevant features of microprocessors (total chip cost, average die size and average die cost) are provided on a quarterly basis from 2000 to 2007. The processor die size – a pure size measure which does not take into account die complexity – directly affects the number of dies that can be made from a single wafer, as well as affecting the yield of good chips from the wafer. [13] This yield, in turn, is a key factor in determining the cost of a processor and how rapidly new generations of processors can be introduced (McGregor, 2005, p. 9). The total cost of a processor is termed chip cost, given as the sum of the die cost (a measure of manufacturing costs that capture die complexity) and the packaging cost (a critical cost area for modern processors). Reduced die size, reduced die cost, and reduced chip cost should result in a better cost-performance ratio for a microprocessor. Table 1 (Panel B) provides descriptive statistics of the periodic financial and technical disclosures used.

Regarding the timely technical disclosure events used in the event study, the source consists of web-based press releases provided by Intel on its web site. Two of the

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[12] According to Miller and O'Leary, technical analysts 'play a pivotal role in the evaluation of products and processes in the industry… and function both as a "filter" and as a third-party evaluation and validation resource for analysts' (Miller and O'Leary, 2000, p. 2).

[13] Microprocessors are built from silicon wafers, which are thin disks. Each wafer may contain many chips of the same type. An individual chip is called a *die*. Chips are usually laid out in a grid pattern, and arranged to fit as many as possible on the wafer. A single wafer can hold more chips if they are smaller. Because chips are so small, many external factors (i.e., particle of dust or tiny impurities in the silicon) can cause defects in the die.

researchers independently identified a full set of press releases for the period July 2004-December 2007. We start the observation period in July 2004 because it was only after the introduction of the 'Global Analyst Research Settlement' (SEC, 2003) that Intel started to systematically disclose relevant press releases on a regular basis. The two researchers then collectively reviewed all events, and classified them according to impact (high/low), and according to impact on the firm or on the industry as a whole. The classification was checked separately by the third researcher. As a robustness test, we also analysed the entire sample of timely technical disclosure events (see fn 14 below). For those events that did not fit into this binary classification, a third residual category was created so as not to lose any data points. The definition of high-impact events was in terms of their anticipated effect on issues such as overall market creation, breakthrough technology innovation affecting production processes, and technology innovation affecting product design. Table 1 (Panel C) summarizes the number of timely technical disclosure events, obtained by classifying all the press releases that appeared on the Intel web site according to the year of publication and the type/relevance (industry/high relevance, firm/high relevance, industry/low relevance, firm/low relevance, others). The results shown in the paper refer to revisions preceded by highly-relevant (industry and firm) timely technical disclosure.[14]

### *3.2. Periodic financial and periodic technical disclosure as determinants of earnings-forecast revisions: an association study*

In order to address our first research question – whether periodic technical disclosure is useful as a complement to periodic financial disclosure in the production of analysts' forecast revisions – we conduct an association study to test what information analysts use when revising their estimates of future earnings. Specifically, we test here the extent to which periodic technical disclosure (limited here to chip costs, die size and die costs), when complemented by periodic financial disclosure, explains analysts' forecast revisions.

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[14] As a robustness test, we also analysed the entire sample of technical disclosure events reported on the Intel web site, without any assessment regarding the relevance of the disclosure event. These findings appear to support the classification carried out by the authors. There are 79 forecast revisions associated with low relevance technical disclosures. When we compute analyst forecast revisions preceded by these low relevance technical disclosures, the coefficient of the revision is positive (0.028) but not statistically significant (t=1.379). When we combine high-relevance technical disclosure and low-relevance technical disclosures, the analysts forecasts revisions preceded by all technical disclosures is positive (0.009) but again not statistically significant (t=0.810). However, when we focus on highly relevant technical disclosure only, the coefficient of the revisions is negative (-0.002) and significant at 10% (Table 4, Panel

The relationship between analyst earnings-forecast revisions and the bottom-line financial information represents the benchmark time-series model (named Model A in this paper):

$$\Delta FEPS_t = \alpha_0 + \alpha_1 \Delta EPS_t + \varepsilon_t \quad (1)$$

where: $\Delta FEPS_t$ = earnings-forecast revisions, measured as the *mean* of the change of the individual earnings-forecast revisions of all analysts in each quarter *t* ($\Delta FEPS_t = [FEPS_{yt} - FEPS_{y,t-\tau}]$);

$\Delta EPS_t$ = percentage quarterly change in the earnings per share (excluding extraordinary items) of Intel for each quarter *t*, where earnings per share is that available to analysts at the time of forecast revision.

To control for the use by financial analysts of a wider set of periodic financial disclosures in their forecasts, we then include three fundamental financial signals to capture information beyond earnings (named Model B). The three fundamental financial variables used here, defined according to Lev and Thiagarajan (1993) and Amir et al. (2003), are adjusted versions of gross margin, inventory and accounts receivables:

$$\Delta FEPS_t = \alpha_0 + \alpha_1 \Delta EPS_t + \alpha_2 \Delta GM'_t + \alpha_3 \Delta INV'_t + \alpha_4 \Delta AR'_t + \varepsilon_t \quad (2)$$

where: $\Delta GM'_t$ = percentage quarterly change in sales minus the percentage quarterly change in gross margin for Intel. A positive value suggests a loss in operating efficiency and cost controls;

$\Delta INV'_t$ = percentage quarterly change in inventory minus the percentage quarterly change in sales for Intel. A positive value usually suggests an inventory build-up, implying lower future earnings;

$\Delta AR'_t$ = percentage quarterly change in accounts receivable minus the percentage quarterly change in sales for Intel. A positive value may indicate difficulties in collection from customers and a deterioration in the quality of receivables.[15]

To control for the role of periodic technical disclosure in determining analysts' forecast revisions, we include the technical information for each quarter *t*, as an additional independent variable, together with earnings per share (named Model C):

$$\Delta FEPS_t = \alpha_0 + \alpha_1 \Delta EPS_t + \alpha_2 \Delta(\text{Tech info}_t) + \varepsilon_t \quad (3)$$

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A). This suggests that disclosures qualified as low-relevance by the authors are also considered to be low-relevance by analysts, who do not revise their forecast following these disclosures.

[15] No multicollinearity problem affects the fundamental accounting variables in Eq. (2).

where: Tech info = periodic technical information proxied alternatively by chip cost (percentage quarterly change in total chip cost for Intel's microprocessors), die size (percentage quarterly change in die size for Intel's microprocessors), and die cost (percentage quarterly change in the estimated cost for each Intel's die). [16]

Finally, to control for the role of periodic technical disclosure in determining analysts' forecast revisions in addition to periodic financial disclosure, we include technical information for each quarter *t*, as an additional independent variable, together with periodic financial data (adjusted versions of gross margin, inventory and accounts receivables), named Model D:

$$\Delta FEPS_t = \alpha_0 + \alpha_1 \Delta EPS_t + \alpha_2 \Delta GM'_t + \alpha_3 \Delta INV'_t + \alpha_4 \Delta AR'_t + \alpha_4 \Delta(\text{Tech info})_t + \varepsilon_t \quad (4)$$

### *3.3. Periodic financial and timely technical disclosures and earnings-forecast revisions: an event study*

Our second research question concerns whether the information content of analyst earnings revisions depends on whether the revisions are preceded by periodic financial disclosure, and/or timely technical disclosure (concerning market creation, production processes and product design). We seek also to ascertain the impact and speed of each of these forecast revisions on stock price changes. We investigate how the information content of periodic financial disclosures compares to timely technical disclosures that result in analyst earnings-forecast revisions, and whether the information conveyed by forecast revisions depends upon whether forecast revisions are preceded by periodic financial and/or timely technical disclosure events. This allows us to differentiate between analyst forecast revisions based on complements and non-complements.

To measure the magnitude of earnings-forecast revisions preceded by either periodic financial or timely technical disclosures, we follow two steps. First, following Lys and Sohn (1990), we investigate whether the magnitude of earnings-forecast revisions that are preceded by periodic financial disclosures differs from that of revisions where no periodic financial disclosure occurred between two consecutive forecast-release dates. Second, building on Lys and Sohn (1990), we investigate whether the magnitude of earnings-forecast revisions that are preceded by timely technical disclosures differs from that of revisions where periodic financial disclosure occurred before a forecast-release date. This enables us to compare, in a non-

[16] We include the periodic technical variables one at a time because they are highly correlated (correlation coefficients above 70%), and multicollinearity problems would affect a multivariate regression.

complements setting, the magnitude of forecast revisions preceded by periodic financial disclosures with that of revisions preceded by timely technical disclosures. It addresses our second research question: are periodic financial and timely technical disclosures (on their own and as a complement to each other) relevant in the production of analysts' forecast revisions?

Furthermore, to investigate the extent to which disclosure events provide additional information to investors, we identify: a) forecast revisions where at least one periodic financial disclosure event occurred in the forecast revision period; and b) forecasts where no periodic financial disclosures were issued in the forecast revision period. We then compare the magnitude of these two types of revisions to infer the information content of periodic financial disclosure in comparison to any other disclosures that result in analysts' forecasts revisions. This can be tested as:

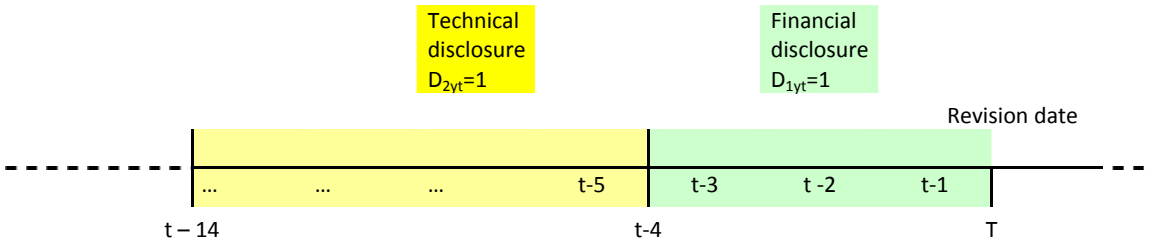
$$\Delta FEPS_{yt} = \gamma_0 + \gamma_1 R^{RP}_{yt} + \gamma_2 RM^{RP}_{yt} + \sum_{k=1}^{2} \gamma_{3k} D_{kyt} R^{AP}_{yt} + \sum_{k=1}^{2} \gamma_{4k} D_{kyt} RM^{AP}_{yt} + \varepsilon_{yt} \qquad (5)$$

where, for analyst $y$, $t$ is the forecast-release date, and $\Delta FEPS_{yt}$ is the earnings-per-share forecast revision. $R^{RP}{}_{yt}$ and $R^{AP}{}_{yt}$ are, respectively, the cumulative returns for Intel in the revision period and announcement period, $RM^{RP}{}_{yt}$ and $RM^{AP}{}_{yt}$ are, respectively, the cumulative returns on the market portfolio (Nasdaq Composite Index) in the revision and announcement periods. $D_{kyt}$ (where $k=1$) is equal to 1 for forecast revisions with at least one periodic financial disclosure in the forecast-revision period, zero otherwise; $D_{kyt}$ (where $k=2$) is equal to 1 for forecast revisions with no periodic financial events in the forecast-revision period, zero otherwise. The coefficients of $D_{kyt}R^{AP}{}_{yt}$ and $D_{kyt}RM^{AP}{}_{yt}$ indicate whether revisions (either preceded by at least one periodic financial disclosure or with no periodic financial disclosure in the forecast-revision period) are informative (i.e. whether forecast revisions are correlated with stock returns in the announcement period), while the coefficients of $R^{RP}{}_{yt}$ and $RM^{RP}{}_{yt}$ indicate whether revisions reflect information that became known to investors in the forecast revision period. Regressions are estimated with analyst fixed effects to control for any analyst-specific features that may affect their revisions.

We then compare forecast revisions where at least one periodic financial and/or one timely technical disclosure event occurred in the forecast revision period. This enables us to investigate further our second research question: does the release of forecast revisions based on periodic financial and timely technical disclosures (both on their own and as complements) provide new or incremental information to the stock

market? To avoid confusing the two types of disclosures, as shown in Figure 2, we assume that there is financial disclosure if at least one periodic financial disclosure event took place in the last four days of the forecast-revision period, and technical disclosures if any timely technical event took place in the period commencing two weeks and ending five days prior to the revision date. The length of each sub-period is based on the statistics for the minimum and maximum number of days needed to incorporate technical and financial disclosures in our sample: over the period 2004-2007, analysts needed a minimum of 0 days up to a maximum of 3 days to react to periodic financial disclosures, and a minimum of 5 days up to a maximum of 14 days to react to timely highly-relevant technical disclosures (Table 4).

**Figure 2: Sequence of events relative to financial and technical disclosure**




Specifically, to investigate the relevance of periodic financial disclosure and timely technical disclosure in providing, on their own, additional information to investors, we use panel-data techniques to estimate the following:

$$\Delta FEPS_{yt} = \gamma_0 + \gamma_1 R^{RP}_{yt} + \gamma_2 RM^{RP}_{yt} + \sum_{k=1}^{3} \gamma_{3k} D_{kyt} R^{AP}_{yt} + \sum_{k=1}^{3} \gamma_{4k} D_{kyt} RM^{AP}_{yt} + \varepsilon_{yt} \qquad (6)$$

where: $D_{kyt}$ (where $k=1$) is equal to 1 for forecast revisions with at least one periodic financial disclosure in the last four days of the forecast-revision period, zero otherwise; $D_{kyt}$ (where $k=2$) is equal to 1 for forecast revisions with timely technical disclosure events in the period commencing two weeks and ending five days prior to the revision, zero otherwise; $D_{kyt}$ (where $k=3$) is equal to 1 for forecast revisions with neither timely technical disclosure nor periodic financial disclosure, zero otherwise. The coefficients of $D_{kyt}R^{AP}_{yt}$ and $D_{kyt}RM^{AP}_{yt}$ indicate whether revisions (preceded by periodic financial disclosure, timely technical disclosure, or no disclosure in the forecast-revision period) are informative, while the coefficients of $R^{RP}_{yt}$ and $RM^{RP}_{yt}$ indicate whether revisions reflect information that became known to investors in the forecast revision period.

Next, and in order to test whether periodic financial and timely highly-relevant technical disclosure complement each other, we include in our analysis all the revisions preceded by periodic financial disclosure (both on its own, and in conjunction with

timely technical disclosure) and timely highly-relevant technical disclosure (both on its own, and in conjunction with periodic financial disclosure). This enables us to test whether these two signals complement each other, although it is possible that this is due to a confounding effect (i.e. financial disclosure that just converts information provided in prior timely technical disclosure). To avoid the confounding effect, we also test what happens when there are no potential complements, that is where revisions are preceded either by timely technical disclosure only, or by periodic financial disclosure only.

To address our third research question – whether there is a hierarchy of analysts in this particular setting, and if so whether it has any effects – we run the analyses separately for analysts employed by major brokerage and investment firms and those employed by other firms.

### *3.4. Analyst information processing and analyst forecast accuracy*

In order to investigate our fourth research question – whether analysts learn, and if so how – we investigate whether analysts use either periodic financial or timely technical disclosures (on their own or as complements) when revising their earnings forecasts, how quickly they react to such disclosures, how intense their use is, and how much experience they have. Specifically, we investigate whether analysts that react less quickly to periodic financial or timely technical disclosure are more accurate, whether analysts that make more intense use of such disclosure are more accurate, whether analysts that are more expert are more accurate (i.e. whether they learn over time), and whether more expert analysts are more accurate when they make more use of timely technical disclosure.

Our multivariate test of whether analyst information processing affects analyst forecast accuracy is based on equation (7), estimated for each analyst-quarter both in the framework of non-complements, and in the framework where complements may exist:

$$\begin{aligned} Accuracy_{yt} = \quad & \alpha_0 + \sum_{k=1}^{2} \alpha_{1k} D_{kyt} + \sum_{k=1}^{2} \alpha_{2k} D_{kyt} Speed_{kyt} \\ & + \sum_{k=1}^{2} \alpha_{3k} D_{kyt} Intensity_{kyt} + \alpha_4 Experience_{yt} + \varepsilon_{yt} \end{aligned} \tag{7}$$

where: $Accuracy_{yt}$ = absolute value of actual earnings minus the earnings forecast made by analyst *y* in quarter *t*, deflated by the end-of quarter price (i.e. higher values, lower accuracy);

$D_{kyt}$ = 1 when analyst *y* reacts in quarter *t* at least to one disclosure event *k*, which is either periodic financial disclosure (*k=1*) or timely technical disclosure (*k=2*);

$Speed_{kyt}$ = average number of days analyst *y* employs in quarter *t* to react to event *k*, which is either periodic financial disclosure or timely technical disclosure (i.e. higher values, lower speed);

$Intensity_{kyt}$ = number of disclosure events that analyst *y* employs in quarter *t*, where disclosure *k* is either periodic financial disclosure or timely technical disclosure (i.e. higher values, increased intensity);

$Experience_{yt}$ = ln of the number of previous quarters analyst *y* issued a forecast at quarter *t* (as proxied, among others, in Mikhail et al., 1997, 2003; Jacob et al., 1999).

Finally in order to investigate whether analyst learning is a function of the intensity in the use of timely technical disclosure together with analyst experience, we estimate:

$$Accuracy_{yt} = \alpha_0 + \sum_{k=1}^{2} \alpha_{1k} D_{kyt} + \sum_{k=1}^{2} \alpha_{2k} D_{kyt} Speed_{kyt} + \sum_{k=1}^{2} \alpha_{3k} D_{kyt} Intensity_{kyt} + \alpha_{4yt} Experience_{y} + \sum_{k=1}^{2} \alpha_{5k} D_{kyt} Intensity_{kyt} \times Experience_{yt} + \varepsilon_{yt} \quad (8)$$

## 4. *Results*

The investigation of our first research question (i.e. whether periodic technical disclosure is useful as a complement to periodic financial disclosure for the production of analysts' forecast revisions) is based on an association study at quarterly intervals (as formalised in equations 1-4). Technical information here is the periodic information concerning chip cost, die size and die cost. Table 2 reports the results on the relevance of periodic financial versus periodic technical disclosure as determinants of earnings-forecast revisions.[17] To highlight the association between analysts' revisions and financial variables, in columns A and B of' Table 2 we report the results of regressing earnings-forecast revisions on the changes of earnings per share and on the changes in fundamental financial information, without including any of the technical variables. We find that earnings per share have a positive (and statistically significant at 5%) coefficient of 0.145, as expected (column A). Including the fundamental financial information in the regression (column B), the coefficients of gross margin (GM) and inventory (INV) are negative as expected (and statistically significant, respectively, at 5% and 1%), indicating that disproportionate increases in inventory (relative to sales), and disproportionate decreases in gross margin, are viewed negatively by analysts.

Finally, the explanatory power of model B is much higher than the explanatory power of model A: Adj-$R^2$ increases to 40.4% from 14.1%. Such an increase indicates that fundamental financial information shows substantial incremental value-relevance over earnings changes.

In the remaining columns of Table 2 we report the results of examining the incremental explanatory power of the periodic technical variables (chip cost, die size and die cost) when complemented with periodic financial disclosure. When combined with the change in earnings per share we find, as one would expect, that positive changes (i.e. increases) in chip cost and die cost have negative (and statistically significant at 5%) coefficients, indicating that increases in chip cost and die cost are viewed negatively by analysts. When combined with periodic financial disclosure, chip cost and die cost maintain a negative coefficient (statistically significant at 1%), and also die size coefficient becomes negative and statistically significant at 10%. The magnitude of the chip and die coefficients suggests that changes in chip cost, die size and die cost have a substantial effect on analysts' earnings-forecast revisions. For instance, a 1 percent increase in chip cost implies a 0.426 percent increase in earnings-forecast revision (statistically significant at 1%). The strong explanatory power of models C and D indicates that periodic technical disclosures (especially chip cost and die cost, relative to die size, and consistent with the intuition that chip cost and die cost reflect both die size and die complexity) explain a relatively large portion of the variation in analysts' revisions. Results appear to indicate not only the incremental contribution of periodic technical disclosure in terms of increased Adj-$R^2$, but also that the contribution is substantial. When such technical disclosures are combined with earnings per share only, the value of Adj-$R^2$ increases from 0.141 in model A to 0.221 in model C1 (and to 0.233 in C3) – a substantial gain of 57% (65%). When periodic technical disclosures are combined with periodic financial disclosure, the value of Adj-$R^2$ increases, although to a lesser extent than in the previous case, from 0.405 in model B to 0.544 in model C1 (and to 0.420 in C3) – a gain of 34% (6%). Overall, and as expected, periodic disclosures pertaining to chip cost, die size and die cost is important in forecasting Intel's earnings, and this explains why there is a demand for technical information in this industry.

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[17] To control for cross-correlations in the residuals across time, we repeat our tests separated for each of the quarters ending at March, June, September, and December from 2000 to 2007.

The investigation of our second research question (i.e. the effects on both analysts and investors of timely technical disclosure and/or periodic financial disclosure) is based on event studies centered on the announcement date of each disclosure (as formalised in equations 5-6). We begin by comparing the magnitude of the revisions classified according to the type (periodic financial vs. timely technical) of disclosure preceding the revision, and the number of days needed by analysts to react to the different types (financial vs. technical) of disclosure. Table 3 reports the evidence on periodic financial disclosure relative to other non-financial disclosures (including timely technical disclosures) in analyst earnings-forecast revisions. A number of observations can be made regarding this data. The number of total revisions preceded by periodic financial disclosure (3,022) is almost four times that of revisions not preceded by periodic financial disclosure (815). Consistent with these results, the number of revisions per analyst preceded by periodic financial disclosure (22.72) is more than double the number of revisions not preceded by periodic financial disclosure (9.06). The length of the forecast-revision period is 63 calendar days for revisions with at least one periodic financial disclosure event in the forecast revision period, and 36 for revisions not preceded by any periodic financial disclosure. This is consistent with the lower frequency of periodic financial disclosures relative to the higher frequency of other disclosures, including timely technical disclosures.[18] More important, the mean absolute values of the forecast revision are very similar (0.130 and 0.134) for the two sub-samples.[19] This result indicates that, on average, the information content of periodic financial disclosures (as distinct from the speed of the reaction) is not different from the information content of other non-financial disclosure events that result in analysts' earnings-forecast revisions. This highlights the importance of investigating further the content and impact of other corporate disclosures, and particularly where complementary signals may exist. As already noted, we focus in this paper on a particular set of technical disclosures, and how they may interact with periodic financial disclosures, given the nature of the industry studied.

Table 4 reports the impact of timely technical and periodic financial disclosures (both on their own and as a complement to each other) on analyst earnings-forecast revisions. When we focus on a framework of non-complements between periodic

[18] The t-test (31.77, $p<0.01$) confirms that the length of the forecast revision period is smaller for the non-financial disclosure sub-sample.

financial and timely highly-relevant technical disclosures (Panel A), we observe that the total number of revisions preceded by periodic financial disclosure only (491) is higher than that of revisions preceded by timely highly-relevant technical disclosure only (239). Also, the number of revisions per analyst preceded by periodic financial disclosures only (7.67) is much larger than the number of revisions per analyst preceded by timely highly-relevant technical disclosures only (4.60). Moreover, less analysts issue revisions preceded by timely technical disclosures (52), rather than by periodic financial disclosures (64). Interestingly, the number of days it takes for analysts to react to periodic financial disclosures is substantially lower than for timely highly-relevant technical disclosures (1.175 days, relative to 8.902 days for the period 2004-7). This additional time required for analysts to revise forecasts in light of timely technical disclosures could be explained by the costs (primarily in terms of time) financial analysts incur when using and digesting timely technical information provided by technical analysts. Finally, the forecast revisions following timely highly-relevant technical disclosures tend to be negative, whereas the forecast revisions following periodic financial disclosures tend to be positive (-0.002 and 0.034 respectively). When we focus on a framework where complements may exist between periodic financial and timely highly-relevant technical disclosures (Panel B), the total number of revisions, the number of revisions per analyst, and the number of days it takes analysts to react to disclosure are higher than when there is periodic financial disclosure only, and higher also than when there is technical disclosure only. The magnitude of the forecast revisions following timely highly-relevant technical (also in conjunction with periodic financial disclosure) and periodic financial disclosures (also in conjunction with timely technical disclosure) are both positive (0.013 and 0.026, respectively, with the difference statistically significant). This result indicates that, on average, analysts' earnings-forecast revisions are induced more by periodic financial disclosures (or by periodic financial disclosures that just convert information provided in prior timely technical disclosures) in their upward revisions. Finally, a comparison of the number of analysts under the non-complements vs. complements framework (Table 4, Panels A & B: 52 vs. 72) reveals that many more analysts use timely technical disclosure together with periodic financial disclosure, rather than timely technical disclosure only. Similarly, the comparison of the number of revisions per analyst (Table 4, Panels A &

[19] The t-test (0.011, insignificant) suggests that the magnitude of the forecast revisions following financial disclosure is the same as the magnitude of forecast revisions with no financial disclosure in the forecast-

B: 7.67 vs. 15.56) shows that analysts produce approximately double the number of revisions when they use timely technical disclosure complemented by periodic financial disclosure, rather than timely technical disclosure only.

The information content of periodic financial disclosures only, measured by the association between analyst earnings forecasts and price changes depending upon the forecast-release date relative to periodic financial disclosure (as formalised in Eq. 5), is reported in Table 5 (Panel A). The values for the cumulative returns for Intel in the announcement period are 0.807 and 1.100, respectively, with and without any periodic financial disclosures preceding the revision (both $p<0.01$). This suggests that the correlation between analyst earnings-forecast revisions and contemporaneous stock price changes is higher when forecast revisions are not preceded by periodic financial disclosures in comparison to when forecasts are preceded by such disclosures. This indicates that the correlation between stock returns in the announcement period and earnings-forecast revisions is higher when the change in earnings expectations is caused by corporate announcements not directly related to periodic financial information in comparison to when the change in earnings expectations is driven by periodic financial disclosures. This result differs from the one in previous studies (Lys and Sohn, 1990) and warrants further research to examine what other types of corporate disclosure events (e.g., technical disclosure) occur in the sub-sample where no periodic financial releases were issued in the forecast-revision period.

Table 5 (Panel B) shows the information content of both periodic financial and timely technical disclosures, but in a setting where they are not used as complements (as formalised in Eq. 6). We offer several observations on these results. First, the relationship between analyst earnings-forecast revisions and contemporaneous changes in Intel's stock price is negative and large (-1.326) when forecast revisions are preceded by timely highly-relevant technical disclosures only, whereas it is positive and significant (0.769) when forecasts are preceded by periodic financial disclosures only. This means that revisions induced by timely technical disclosures are a surprise (even if negative) to markets, while revisions induced by periodic financial disclosures tend to be a surprise, but to a positive (and lesser) extent. A possible interpretation is that the price impact becomes negative in the presence of variables that proxy for higher information asymmetry, where this is due to particularly complex information processing that is the preserve of a small sub-set of analysts. Timely and highly-relevant

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revision period.

technical disclosures are more difficult to digest and interpret than periodic financial disclosures, therefore in the short-term prices reflect to a lesser extent timely highly-relevant technical information. Because of this higher information asymmetry, analyst forecasts following timely technical disclosure only are a surprise for the market, which reacts negatively as a result. This is consistent with Zuckerman (2004, p. 409), who suggests that it is unrealistic to assume that all investors (analysts) will interpret information in the same way. Note also that the negative market surprises due to timely technical disclosure may be explained in relation to the negative earnings-forecast revisions associated with timely technical disclosure documented in Table 4, Panel A. Second, the findings in Table 5 (Panel A) of a higher magnitude for those revisions not preceded by periodic financial disclosure (1.100), relative to those revisions preceded by periodic financial disclosures (0.807) may, we suggest, be due to the former being driven indirectly by technical disclosure. Third, periodic financial disclosure tends to be related to the state of the economy, whereas timely technical disclosure is not associated with the state of the economy (proxied by the market return in the announcement period). Finally, the explanatory power of the regression including timely technical disclosure is substantially greater than the explanatory power of the regression based on periodic financial disclosure only (Adj-$R^2$ equal to 21.53% for equation 6 and to 12.41% for equation 5). This suggests the incremental value relevance of timely technical disclosure relative to periodic financial disclosure, when each is considered separately (i.e. not as complementary signals).

In the framework where complements may exist between financial and technical disclosure (Table 5, Panel C), the evidence for periodic financial disclosure is very similar to that for the non-complements framework (i.e. a positive and significant coefficient equal respectively to 0.760 and 0.769). However, the evidence for timely technical disclosure, when complemented by periodic financial disclosure (that may also be converting timely technical disclosure), differs significantly from the one in the non-complements framework (i.e. a negative coefficient of -1.326 under no complements, and a positive coefficient of 0.452 under complements). Timely technical disclosure complemented by periodic financial disclosure induces a positive relationship between analyst earnings-forecast revisions and contemporaneous changes in Intel's stock price. When forecast revisions are preceded by timely highly-relevant technical disclosures, together with periodic financial disclosure converting timely technical disclosure, forecast revisions are positive (as documented in Table 4, Panel B), as

indicated by increases in market prices. Also, timely technical disclosure (in the complements framework) is related to the state of the economy and negatively affects analysts' revisions through market returns.

As regards our third research question, we run the analyses separately for analysts employed by major brokerage and investment firms, and those employed by other firms. Table 6 (Panel A) reports the impact of timely technical and periodic financial disclosures on earnings-forecast revisions for analysts at major firms, both where there are no complements, and where complements may exist. Table 6 (Panel B) does the same for other firms. In both the framework of complements and the framework of non-complements, we observe that the number of revisions per analyst (preceded by either periodic financial or timely highly-relevant technical disclosure) is larger for analysts employed at major firms relative to analysts at other firms. This is particularly the case for the framework of non-complements, and for timely technical disclosure only (7.33 and 4.12 respectively). This suggests that analysts at major firms follow such disclosures more closely, and that there may be a 'hierarchy' of analysts in this particular industry with respect to complex and timely technical disclosures. For both major and other firms, we find confirmation of the results observed for the overall sample: the total number of revisions preceded by periodic financial disclosure only is higher than that of revisions preceded by timely highly-relevant technical disclosure only (for major firms 146 and 88 respectively; for other firms 357 and 165 respectively); also, the number of revisions per analyst preceded by periodic financial disclosures only is larger than the number of revisions per analyst preceded by timely highly-relevant technical disclosures only, especially for analysts employed at other firms (for major firms 8.11 and 7.33 respectively; for other firms 7.60 and 4.12 respectively). When we focus on a framework of non-complements between periodic financial and timely highly-relevant technical disclosures, we observe that the forecast revisions following timely highly-relevant technical disclosure are negative for analysts employed at other brokerage and investment firms (as in the overall sample: Table 4, Panel A), whereas they are positive for analysts employed at major firms (-0.009 and 0.011 respectively). This result provides an interesting nuance to our evidence of a negative reaction for the overall sample in the framework of non-complements. When we focus on a framework of complements between periodic financial and timely highly-relevant technical disclosures, the magnitude of the forecast revisions following timely highly-relevant technical (also in conjunction with periodic financial disclosure) and

periodic financial disclosures (also in conjunction with timely technical disclosure) are positive for analysts at both major and other firms. This result confirms that of the overall sample.

Table 7 (Panels A and B) shows the specific information content of timely technical disclosures (as formalised in Eq. 6) for both analysts employed by major brokerage and investment firms and for those employed by other firms. In the no complements framework (Panel A), there is only one significant and positive (0.989) relationship between analyst earnings-forecast revisions and contemporaneous changes in Intel's stock price, which occurs when forecast revisions are issued by analysts at other firms and revisions are preceded by periodic financial disclosures. In the framework of complements (Panel B), for analysts employed by major brokerage and investment firms, the relationship between analyst earnings-forecast revisions and contemporaneous changes in Intel's stock price is positive and large (1.105) when forecast revisions are preceded by timely highly-relevant technical disclosures (that may also be converting periodic financial disclosure), whereas it is non-significant when forecasts are preceded by periodic financial disclosures (that may also be converting timely technical disclosure). Contrarily, for analysts employed by other brokerage and investment firms, the relationship between analyst earnings-forecast revisions and contemporaneous changes in Intel's stock price is positive and large (0.882) when forecast revisions are preceded by periodic financial disclosures (that may also be converting highly-relevant technical disclosure), whereas it is non-significant when forecasts are preceded by highly-relevant technical disclosures (that may also be converting periodic financial disclosure). This means that revisions induced by timely technical disclosures are a positive surprise to markets when issued by analysts at major firms, while revisions induced by periodic financial disclosures tend to be a positive surprise, but to a lesser extent, when issued by analysts at other firms. We also compute standardized coefficients to assess the relative strength of each disclosure type for different analyst types. We observe that the changes in Intel's stock price preceded by timely technical disclosure have the largest standardized coefficient (0.186) for analysts employed at major brokerage houses, whereas the changes in Intel's stock price preceded by periodic financial disclosure have the largest standardized coefficient (0.181) for analysts employed by other brokerage and investment firms.[20] This evidence further develops the result observed for the overall sample: the increase in market prices

[20] Standardized coefficients are available from the authors upon request.

documented for both financial and technical disclosure (Table 5, Panel C) can be better explained by distinguishing between analysts at major and analysts at other firms. In fact, there is an increase in market prices induced by revisions preceded by timely technical disclosures only when revisions are issued by analysts at major firms, whereas there is an increase in market prices induced by revisions preceded by periodic financial disclosures only when revisions are issued by analysts at other firms.

The investigation of our fourth research question (i.e. whether analysts learn, and if so how) focuses on the use of periodic financial and timely technical disclosures (on their own and as complements), the speed of reaction to such disclosures, the intensity in their use, and the extent of analyst experience (as formalised in equations 7-8). In the no complements framework (Table 8, Panel A, Eq. 7), we find that a lower speed in reacting to timely technical disclosure increases accuracy (coefficient equal to -0.001 significant at 5 percent level), whereas the speed in reacting to periodic financial disclosure does not influence accuracy (coefficient equal to 0.001 not significant). This result is consistent with the presence in the industry of a small number of technical analysts digesting and disseminating critical information. Financial analysts using the digested information take longer to produce their forecasts, but then produce more accurate forecasts. The speed of reaction to periodic financial disclosure has no impact on accuracy, suggesting that financial analysts do not need to wait for digested periodic financial information from others. Moreover, we find that a higher intensity in the use of either periodic financial disclosure, or timely technical disclosure, results in lower accuracy (both coefficients equal to 0.001 significant at 5 percent level). This suggests that, when analysts do not exploit the complements between technical and financial disclosures, their accuracy declines due to the increased frequency of use of timely technical disclosure only. In the non-complements framework, analysts with more experience regarding Intel tend to be less accurate (coefficient equal to 0.001 significant at 1 percent level). Further (Table 8, Panel A, Eq. 8), we find that the more intense use of this information by more experienced analysts does not impact on the learning process (coefficient equal to 0.001 not significant). This suggests that analysts do not learn over time, when controlling for other features of their information processing. This adds to the already mixed evidence on the effect of experience on learning (see Kothari, 2001; Jacob et al., 1999). Finally, to assess the economic significance of these results (in terms of relative strength of each of the predictors), we compute standardized coefficients. Interestingly, the speed of reaction to timely technical disclosure has the

largest standardized coefficient (in absolute value), -0.258, whereas experience, intensity in the use of timely technical, and intensity in the use of periodic financial disclosure fall in the middle (standardized coefficients respectively of 0.134, 0.141 and 0.179). Thus, a one standard deviation increase in the speed of reaction to timely technical disclosure leads to a 0.258 standard deviation decrease in predicted accuracy, with the other variables held constant.

In the complements framework (Table 8, Panel B, Eq. 7), we find confirmation of the result concerning speed of incorporating timely technical disclosure (also in conjunction with periodic financial disclosure): a lower speed in reacting to timely technical disclosure increases accuracy (coefficient equal to -0.001 significant at 5 percent level), consistent with financial analysts taking increased time to digest technical information. In this framework, a lower speed in reacting to periodic financial disclosure increases accuracy too (coefficient equal to -0.001 significant at 5 percent level) due also, we suggest, to the time taken to digest timely technical disclosure. Moreover, we find that a higher intensity in the use of timely technical disclosure (in conjunction with periodic financial disclosure) in a given quarter results in higher accuracy (coefficient equal to -0.001 significant at 10 percent level), whereas a higher intensity in the use of periodic financial disclosure (in conjunction with timely technical disclosure) results in lower accuracy (coefficient equal to 0.001 significant at 5 percent level). The intuition here is that, when using technical disclosure, and given the complexity of the technical information, analysts need to use more disclosure events to be more accurate, whereas an increased intensity in the use of periodic financial disclosure suggests the need for the analyst to revise their previous inaccurate forecasts. Interestingly, experience on its own continues to have a negative effect on accuracy (coefficient equal to 0.001 significant at 1 percent level): analysts do not learn over time, when controlling for other features of their information processing (Jacob et al., 1999). But, when we consider the interaction effect between experience and intensity in the use of timely technical disclosure (also in conjunction with periodic financial disclosure), we observe that experience in itself does not impact on analyst forecast accuracy, whereas an increased intensity of use of technical information by more experienced analysts impacts negatively on accuracy (coefficient equal to 0.001 significant at 10 percent level).

## *5. Conclusions*

This paper is a response to Bradshaw's (2009, 2011) call for accounting researchers to open up the 'black box' of information processing by analysts. This is particularly important in information environments with multiple and potentially complementary components, and where technical information is particularly important and hard to digest. A relatively small number of studies in accounting have examined multiple and potentially complementary information sources, including non-financial information (Amir and Lev, 1996; Francis et al., 2002; Gietzmann and Ireland, 2005). Consistent with Bradshaw's argument that the study of information processing is not easily accessed by conventional multi-firm archival studies, we have used hand gathered technical data contained in web-based press releases, alongside non-traditional technical data contained in the reports of technical analysts, to allow us to differentiate the impact of the three components of the information environment of the microprocessor industry – periodic financial information, periodic technical information, and timely technical information – and to examine their interaction.

Based on 3,837 analyst earnings-forecast revisions, issued by 134 analysts, our findings are as follows. First, and as expected, we find that periodic technical disclosure when used on its own explains a relatively large portion of the variation in analysts' forecast revisions, suggesting not only the incremental contribution of periodic technical disclosure, but also that the contribution is substantial. Second, we find that analysts take much longer (approximately one week more) to react to timely technical disclosures relative to periodic financial disclosures. We suggest that this could be explained by the time required to digest complex technical disclosures that are particularly significant within the information environment that characterises the microprocessor industry. We find also that, when analysts use timely technical disclosures jointly with periodic financial disclosures in their earnings-forecast revisions, their forecast revisions are particularly informative. This confirms our intuition that technical and financial information may be complementary sources of information for analysts in this particular industry. Third, we find evidence that there is a 'hierarchy' of analysts in this particular setting, with analysts at major firms following timely technical disclosures more closely, and such disclosures having a greater impact on market prices. Finally, we find that lower speed in reacting to timely technical disclosures increases accuracy, which is consistent with the presence in the industry of a small number of technical analysts digesting and disseminating critical information.

We find also that a higher intensity in the use of timely technical disclosure (in conjunction with periodic financial disclosure) results in greater accuracy.

More generally, and for this particular setting, these findings confirm the importance of technical disclosures, that there are complements between technical and financial disclosures, that timely technical disclosures are of particular importance in this regard, and that there exists a 'hierarchy' of analysts. Taken together, this suggests that the *how* of information processing merits much greater attention by accounting researchers. We still know relatively little about the exact nature of the relation between different types of information, how such different and potentially complementary signals are processed, how quickly, and how this is achieved by different types of analysts.

We are conscious of the limitations of a single company study, particularly given the predominant focus of the analyst literature to date on multi-firm samples. However, we contend that this approach, and the hand-gathered and non-traditional data on which it depends, offers a way of exploring questions that accounting researchers are keenly interested in, but which are not easily addressed by empirical archival research methods. In any event, the scholarly study of information processing in specific industry settings with multiple, complex, and potentially complementary sources of information can add to our understanding of the world. Finally, while noting the distinctiveness of the microprocessor industry, we suggest that our findings regarding the *how* of information processing in this industry may have relevance for other industries such as the Bio-Tech Pharma industry.

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# Table 1
# Descriptive statistics

Panel A (on analyst earnings-forecast revisions) reports descriptive statistics (mean, standard deviation, minimum, median and maximum computed on yearly data across the sample period 2000-2007) on (1) total number per year of earnings-forecast revisions, which occur when there is a change in the value of two consecutive earnings forecasts produced by a given individual analyst, (2) total number of analysts issuing revisions, (3) total number of revisions per analysts, (4) number of revisions per trading day. Individual analyst forecasts are obtained from I/B/E/S. Over the period 2000-2007, the total number of revisions is 3,837 and the total number of analysts issuing revisions is 134. Panel B (on periodic disclosure) reports descriptive statistics (mean, standard deviation, minimum, median and maximum computed on quarterly data) for the period 2000-2007 on the percentage quarterly change of (1) earnings per share of Intel [ΔEPS], (2) gross margin for Intel [ΔGM], (3) inventory for Intel [ΔINV], (4) accounts receivable for Intel [ΔAR], (5) total chip cost for Intel's microprocessors [Δ(Chip cost)], (6) die size (i.e. size of each individual chip formed on a silicon wafer) for Intel [Δ (Die size)], (7) estimated cost for each Intel's die [Δ (Die cost)]. Panel B also reports descriptive statistics (mean, standard deviation, minimum, median and maximum computed on quarterly data) for the period 2000-2007 on the adjusted versions of gross margin, inventory and accounts receivables, defined according to Lev and Thiagarajan (1993) and Amir et al. (2003): (8) percentage quarterly change in sales minus the percentage quarterly change in gross margin [ΔGM′], (9) percentage quarterly change in inventory minus the percentage quarterly change in sales [ΔINV′], (10) percentage quarterly change in accounts receivable minus the percentage quarterly change in sales [ΔAR′]. Annual and quarterly financial data are obtained from Datastream and Compustat. Technical data (total chip cost, die size and die cost) are obtained from reports of a technical analyst firm (McGregor, 2007). Panel C (on timely technical disclosure) reports the number of disclosure events in each year classified in five categories: (1) Industry/High relevance, i.e. disclosure with high impact in terms of their anticipated industry-wide effects on issues such as overall market creation; (2) Firm/High relevance, i.e. firm-specific and product-specific disclosure with high impact (i.e. breakthrough technology innovation affecting production processes and products); (3) Industry/Low relevance; (4) Firm/Low relevance; (5) Others.

| **Panel A: Descriptive statistics on the analyst earnings-forecast revisions** | | | | | |
|---|---|---|---|---|---|
| 2000-07 | Mean | St. dev. | Min | Median | Max |
| Number of revisions | 479.625 | 84.883 | 379.000 | 503.500 | 565.000 |
| Number of analysts | 49.625 | 4.868 | 42.000 | 50.000 | 58.000 |
| Number of revisions per analyst | 9.626 | 1.095 | 7.730 | 9.645 | 10.870 |
| Number of revisions per day | 1.909 | 0.332 | 1.510 | 2.000 | 2.240 |
| **Panel B: Descriptive statistics on periodic financial and technical information** | | | | | |
| 2000-07 | Mean | St. dev. | Min | Median | Max |
| ΔEPS | 0.011 | 0.057 | -0.558 | 0.219 | 0.368 |
| ΔGM | 0.301 | 0.030 | -0.893 | 1.624 | 8.901 |
| ΔINV | 0.031 | 0.031 | -0.176 | 0.102 | 0.214 |
| ΔAR | -0.004 | 0.017 | -0.197 | 0.123 | 0.206 |
| Δ(Chip cost) | -0.001 | 0.001 | -0.196 | 0.064 | 0.156 |
| Δ(Die size) | 0.002 | 0.001 | -0.096 | 0.044 | 0.097 |
| Δ(Die cost) | -0.002 | 0.001 | -0.182 | 0.088 | 0.187 |
| ΔGM′ | -0,288 | 1,637 | -8,976 | -0,008 | 1,009 |
| ΔINV′ | 0,017 | 0,167 | -0,309 | 0,007 | 0,416 |
| ΔAR′ | -0,016 | 0,140 | -0,303 | 0,007 | 0,214 |

| **Panel C: Distribution of timely technical disclosure events by type/year** | | | | | | |
|---|---|---|---|---|---|---|
| Year | Industry/High relevance | Firm /High relevance | Industry/Low relevance | Firm/Low relevance | Others | Panel |
| 2004 | 10 | 9 | 4 | 8 | 3 | 34 |
| 2005 | 17 | 29 | 5 | 8 | 1 | 60 |
| 2006 | | 19 | 2 | 27 | 16 | 64 |
| 2007 | | 9 | | 27 | 13 | 49 |
| 2000-07 | 27 | 66 | 11 | 70 | 33 | 207 |

## Table 2
## Regression analysis: quarterly determinants of earnings-forecast revisions

The determinants of earnings-forecast revisions include periodic financial disclosures and periodic technical disclosures over each quarter (as defined in Table 1, Panel B). In the OLS regression used, the dependent variable is the analyst earnings-forecast revision. The explanatory variables (whose coefficients are $\alpha_j$) are grouped into different specifications: (A) percentage quarterly change in earnings per share only; (B) percentage quarterly change in other periodic fundamental financial information (percentage quarterly change in sales minus the percentage quarterly change in gross margin ΔGM′, percentage quarterly change in inventory minus the percentage quarterly change in sales ΔINV′, percentage quarterly change in accounts receivable minus the percentage quarterly change in sales ΔAR′) in addition to the percentage quarterly change in earnings per share; (C) percentage quarterly change in periodic technical information (total chip cost, die size and die cost respectively in C1, C2 and C3) together with the percentage quarterly change in earnings per share; (D) percentage quarterly change in periodic technical information (total chip cost, die size and die cost respectively in C1, C2 and C3) together with the percentage quarterly change in periodic financial information. The test refers to Intel in each quarter over the period 2000-2007. *, **, *** indicate two-tailed p values <0.10, <0.05 and <0.01 respectively. Standard errors are given in brackets.

| Coefficients | Variables | A (Eq. 1) | B (Eq.2) | C1 (Eq. 3) | C2 (Eq. 3) | C3 (Eq. 3) | D1 (Eq. 4) | D2 (Eq. 4) | D3 (Eq. 4) |
|---|---|---|---|---|---|---|---|---|---|
| $\alpha_j$ | CONSTANT | 0.004 (0.013) | -0.001 (0.011) | 0.004 (0.007) | 0.005 (0.007) | 0.004 (0.007) | -0.004 (0.006) | 0.002 (0.008) | 0.001 (0.007) |
| | ΔEPS | 0.145** (0.059) | 0.112** (0.049) | 0.049* (0.031) | 0.055* (0.033) | 0.035 (0.033) | 0.065** (0.028) | 0.069* (0.036) | 0.039 (0.035) |
| | ΔGM′ | | -0.018** (0.007) | | | | -0.054* (0.027) | -0.042 (0.034) | -0.030 (0.031) |
| | ΔINV′ | | -0.207*** (0.068) | | | | -0.106** (0.040) | -0.086* (0.050) | -0.98** (0.046) |
| | ΔAR′ | | 0.013 (0.086) | | | | -0.103* (0.052) | -0.054 (0.064) | -0.30 (0.057) |
| | Δ(Chip cost) | | | -0.238** (0.19) | | | -0.426*** (0.103) | | |
| | Δ(Die size) | | | | -0.209 (0.176) | | | -0.341* (0.173) | |
| | Δ(Die cost) | | | | | -0.191** (0.091) | | | -0.235*** (0.083) |
| Diagnostic statistics | N. obs | 32 | 31 | 24 | 24 | 24 | 24 | 24 | 24 |
| | F | 6.074 | 6.102 | 4.266 | 2.731 | 4.485 | 6.489 | 2.711 | 3.879 |
| | Sig. of the model | 0.020 | 0.001 | 0.028 | 0.088 | 0.024 | 0.001 | 0.054 | 0.015 |
| | Adj $R^2$ | 0.141 | 0.405 | 0.221 | 0.141 | 0.233 | 0.544 | 0.271 | 0.430 |

## Table 3
## Financial disclosure and earnings-forecast revisions

A comparison of the number of days and earnings-forecast revisions that are preceded by periodic financial disclosure (Panel A) with the number of days and earnings-forecast revisions where no periodic financial disclosure occurred between two consecutive forecast-release dates (Panel B). Days refer to the length of the forecast-revision period in calendar days (where for a given analyst, the forecast-revision period is defined as the period between consecutive forecasts). The paired sample t-test for Days is 31.77*** ($p<0.01$). ΔFEPS is the forecast revision defined as the difference in consecutive forecasts for an analyst. The paired sample t-test for ΔFEPS is -0.0078. |ΔFEPS| is the absolute value of analyst earnings-forecast revision. The paired sample t-test for |ΔFEPS| is 0.011. Periodic financial disclosure dates are taken from Compustat and SEC. The comparison refers to Intel over the period 2000-2007.

| | **Panel A: Revisions with at least one periodic financial disclosure between consecutive forecasts** | | | **Panel B: Revisions with no periodic financial disclosure between consecutive forecasts** | | |
|---|---|---|---|---|---|---|
| | Days | ΔFEPS | \|ΔFEPS\| | Days | ΔFEPS | \|ΔFEPS\| |
| Mean | 63 | 0.010 | 0.130 | 36 | -0.001 | 0.134 |
| Std. Error | 71 | 0.203 | 0.156 | 20 | 0.202 | 0.151 |
| Median | 47 | 0.014 | 0.073 | 37 | 0.012 | 0.072 |
| Number of revisions | 3022 | | | 815 | | |
| Number of analysts | 133 | | | 90 | | |
| Number of revisions per analyst | 22.72 | | | 9.06 | | |

## Table 4
## Financial and technical disclosure and analyst earnings-forecast revisions

A comparison of the number of days and earnings-forecast revisions preceded either by i) timely technical disclosure only or by ii) periodic financial disclosure only (non-complements, Panel A) and of the days and earnings-forecast revisions preceded either by iii) timely technical disclosure or timely technical disclosure in conjunction with periodic financial disclosure, or by iv) periodic financial disclosure or periodic financial disclosure in conjunction with timely technical disclosure (complements, Panel B). Days refer to the number of calendar days a disclosure takes to be reflected in a forecast revision. Timely technical disclosure are included when highly relevant. Highly-relevant technical disclosure dates are identified by the researchers from the full set of Intel's press releases (where the definition of high-relevance was in terms of their anticipated effect on issues such as overall market creation, breakthrough technology innovation affecting production processes, and technology innovation affecting product design and, therefore, capability for the industry as a whole). Periodic financial disclosure dates are taken from Compustat and SEC. The comparison refers to Intel over the period July 2004-December 2007. *, *** indicate two-tailed p values <0.10 and <0.01 respectively

| | Panel A NON-COMPLEMENTS 2004-2007 | | | | Panel B COMPLEMENTS 2004-2007 | | | |
|---|---|---|---|---|---|---|---|---|
| | i) Revisions with timely highly-relevant technical disclosure only | | ii) Revisions with periodic financial disclosure only | | iii) Revisions with timely highly-relevant technical disclosure (or with technical and financial disclosures) | | iv) Revisions with periodic financial disclosure (or with financial and technical disclosures) | |
| | Days | ΔFEPS | Days | ΔFEPS | Days | ΔFEPS | Days | ΔFEPS |
| Mean | 8.902 | -0.002 | 1.175 | 0.034 | 9.337 | 0.013 | 1.086 | 0.026 |
| T-stat of significance for mean | | -1.687* | | 3.896*** | | 2.308*** | | 4.708*** |
| Std. Error | 3.100 | 0.150 | 0.456 | 0.196 | 2.427 | 0.165 | 0.414 | 0.183 |
| Min | 5.000 | -0.535 | 0.000 | -0.783 | 5.000 | -0.535 | 0.000 | -0.783 |
| Median | 9.000 | 0.001 | 1.000 | 0.026 | 9.000 | 0.017 | 1.000 | 0.026 |
| Max | 14.000 | 0.960 | 3.000 | 0.545 | 14.000 | 1.173 | 3.000 | 1.173 |
| Number of revisions | 239 | | 491 | | 822 | | 1,074 | |
| Number of analysts | 52 | | 64 | | 72 | | 69 | |
| Number of revisions per analyst | 4.60 | | 7.67 | | 11.42 | | 15.56 | |

## Table 5
## Information content of analyst forecasts depending upon financial and technical disclosure

The information content of analyst forecasts in the announcement period is disentangled depending upon the timing of the forecast release date relative to periodic financial disclosure only (Panel A), periodic financial disclosure, timely technical disclosure and no disclosure both in the non-complements framework (Panel B) and in the complements framework (Panel C). We identify the non-complements framework when earnings-forecast revisions are preceded either by i) timely technical disclosure only, or by ii) periodic financial disclosure only, whereas we identify the complements framework when earnings-forecast revisions are preceded either by iii) timely technical disclosure or timely technical disclosure in conjunction with periodic financial disclosure, or by iv) periodic financial disclosure or periodic financial disclosure in conjunction with timely technical disclosure. In the fixed-effects panel-data technique used, the dependent variable is the (annual and quarterly) earnings forecast revision for analyst *y* at the forecast-release date *t.* The explanatory variables are: (1) $R^{RP}_{yt}$, the cumulative returns for Intel in the revision period, (2) $RM^{RP}_{yt}$, the cumulative returns on the market portfolio (Nasdaq Composite Index) in the revision period, (3) $R^{AP}_{yt}*D_1$, where $R^{AP}_{yt}$ is the cumulative returns for Intel in the announcement period and $D_1$ is a dummy variable equal to one if periodic financial disclosure occurred in the last four days of the forecast-revision period, zero otherwise; (4) $R^{AP}_{yt}*D_2$, where $D_2$ is a dummy variable equal to one if timely technical disclosure occurred in between the last two weeks and last five days of the forecast-revision period, zero otherwise, (5) $R^{AP}_{yt}*D_3$, where $D_3$ is a dummy variable equal to one if no disclosure occurred in the forecast-revision period, zero otherwise (in Panel A, this variable indicates absence of periodic financial disclosure whereas in Panel C by definition this variable does not exist), (6) $RM^{AP}_{yt}*D_1$, the cumulative returns on the market portfolio (Nasdaq Composite Index) in the announcement period; (7) $RM^{AP}_{yt}*D_2$, (8) $RM^{AP}_{yt}*D_3$. The coefficients of $R^{AP}_{yt}*D_1$ ($\gamma_{31}$), $R^{AP}_{yt}*D_2$ ($\gamma_{32}$) and $R^{AP}_{yt}*D_3$ ($\gamma_{33}$) indicate the information content in the announcement period depending upon periodic financial disclosure, timely technical disclosure and no disclosure (in Panel A, this variable indicates absence of periodic financial disclosure whereas in Panel C by definition this variable does not exist). The test refers to Intel over the period July 2004-December 2007. *, **, *** indicate two-tailed p-values <0.10, <0.05 and <0.01 respectively.

| **Panel A: PERIODIC FINANCIAL DISCLOSURE ONLY** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Equation (5) | Constant | $R^{RP}$ | $RM^{RP}$ | $R^{AP}*D_1$ | $R^{AP}*D_2$ | $R^{AP}*D_3$ | $RM^{AP}*D_1$ | $RM^{AP}*D_2$ | $RM^{AP}*D_3$ | Analyst | F | Adj $R^2$ |
| | ($\gamma_0$) | ($\gamma_1$) | ($\gamma_2$) | ($\gamma_{31}$) | ($\gamma_{32}$) | ($\gamma_{33}$) | ($\gamma_{41}$) | ($\gamma_{42}$) | ($\gamma_{43}$) | fixed eff | | [N. obs] |
| Predicted sign | | + | - | + | n.a. | + | - | n.a. | - | | | |
| Disclosure type | | | | Financial only | | No disclosure | Financial only | | No disclosure | | | |
| Coefficient | 0.013*** | 0.218*** | 0.199*** | 0.807*** | | 1.100*** | -1.001*** | | -2.223*** | Yes | 80.837*** | 12.41% |
| Std. Error | 0.003 | 0.028 | 0.038 | 0.073 | | 0.138 | 0.190 | | 0.313 | | | [3827] |
| t-statistic | 4.044 | 7.764 | 5.260 | 11.083 | | 7.979 | -5.312 | | -7.112 | | | |
| **Panel B: PERIODIC FINANCIAL AND TIMELY TECHNICAL DISCLOSURE - NON-COMPLEMENTS** | | | | | | | | | | | | |
| Equation (6) | Constant | $R^{RP}$ | $RM^{RP}$ | $R^{AP}*D_1$ | $R^{AP}*D_2$ | $R^{AP}*D_3$ | $RM^{AP}*D_1$ | $RM^{AP}*D_2$ | $RM^{AP}*D_3$ | Analyst | F | Adj $R^2$ |
| | ($\gamma_0$) | ($\gamma_1$) | ($\gamma_2$) | ($\gamma_{31}$) | ($\gamma_{32}$) | ($\gamma_{33}$) | ($\gamma_{41}$) | ($\gamma_{42}$) | ($\gamma_{43}$) | fixed eff | | [N. obs] |
| Predicted sign | | + | - | + | - | 0 | - | - | 0 | | | |
| Disclosure type | | | | Financial only | Technical only | No disclosure | Financial only | Technical only | No disclosure | | | |
| Coefficient | 0.022*** | 0.645*** | -0.289*** | 0.769*** | -1.326* | 1.082*** | 5.538*** | 1.114 | -2.746*** | Yes | 42.93*** | 21.53% |
| Std. Error | 0.005 | 0.051 | 0.095 | 0.212 | 0.749 | 0.131 | 1.168 | 1.265 | 0.553 | | | [1503] |
| t-statistic | 4.78 | 12.57 | -3.03 | 3.62 | -1.77 | 8.24 | 4.74 | 0.88 | -4.97 | | | |
| **Panel C: PERIODIC FINANCIAL AND TIMELY TECHNICAL DISCLOSURE – COMPLEMENTS** | | | | | | | | | | | | |
| Equation (6) | Constant | $R^{RP}$ | $RM^{RP}$ | $R^{AP}*D_1$ | $R^{AP}*D_2$ | $R^{AP}*D_3$ | $RM^{AP}*D_1$ | $RM^{AP}*D_2$ | $RM^{AP}*D_3$ | Analyst | F | Adj $R^2$ |
| | ($\gamma_0$) | ($\gamma_1$) | ($\gamma_2$) | ($\gamma_{31}$) | ($\gamma_{32}$) | ($\gamma_{33}$) | ($\gamma_{41}$) | ($\gamma_{42}$) | ($\gamma_{43}$) | fixed eff | | [N. obs] |
| Predicted sign | | + | - | + | + | n.a. | - | - | n.a. | | | |
| Disclosure type | | | | Financial (or financial & technical) | Technical (or technical & financial) | No disclosure | Financial (or financial & technical) | Technical (or technical & financial) | No disclosure | | | |
| Coefficient | 0.020*** | 0.625*** | -0.217** | 0.760*** | 0.452* | - | 1.433* | -4.052*** | - | Yes | 54.86*** | 20.77% |
| Std. Error | 0.005 | 0.051 | 0.094 | 0.205 | 0.243 | | 0.879 | 0.894 | | | | [1503] |
| t-statistic | 4.37 | 12.29 | -2.31 | 3.72 | 1.86 | | 1.64 | -4.53 | | | | |

## Table 6
## Financial and technical disclosure and analyst earnings-forecast revisions: major vs. other brokerage and investment firms

A comparison of the earnings-forecast revisions provided by analysts employed by major brokerage and investment firms (Panel A), and by those employed by other firms (Panel B). Earnings-forecast revisions are preceded either by i) timely technical disclosure only, or by ii) periodic financial disclosure only (non-complements), or by iii) timely technical disclosure or timely technical disclosure in conjunction with periodic financial disclosure, or by iv) periodic financial disclosure or periodic financial disclosure in conjunction with timely technical disclosure (complements). Highly-relevant technical disclosure dates are identified by the researchers from the full set of Intel's press releases for the period (where the definition of high-relevance was in terms of their anticipated effect on issues such as overall market creation, breakthrough technology innovation affecting production processes, and technology innovation affecting product design and, therefore, capability for the industry as a whole). Periodic financial disclosure dates are taken from Compustat and SEC. The brokerage and investment firm hierarchy is derived from a ranking published by *Institutional Investor*. The comparison refers to Intel over the period July 2004-December 2007.

| PANEL A: Major brokerage and investment firms | | | | |
|---|---|---|---|---|
| | NON-COMPLEMENTS | | COMPLEMENTS | |
| | i) Revisions with timely highly-relevant technical disclosure only | ii) Revisions with periodic financial disclosure only | iii) Revisions with timely highly-relevant technical disclosure (or with technical and financial disclosures) | iv) Revisions with periodic financial disclosure (or with financial and technical disclosures) |
| | ΔFEPS | ΔFEPS | ΔFEPS | ΔFEPS |
| Mean | 0.011 | 0.058 | 0.005 | 0.028 |
| Std. Error | 0.164 | 0.203 | 0.164 | 0.185 |
| Min | -0.267 | -0.609 | -0.475 | -0.609 |
| Median | 0.007 | 0.026 | 0.017 | 0.026 |
| Max | 0.960 | 0.545 | 1.078 | 1.078 |
| Number of revisions | 88 | 146 | 253 | 311 |
| Number of analysts | 12 | 18 | 18 | 18 |
| Number of revisions per analyst | 7.33 | 8.11 | 14.06 | 17.28 |
| Number of brokerage and investment firms | 10 | 11 | 11 | 11 |
| PANEL B: Other brokerage and investment firms | | | | |
| | NON-COMPLEMENTS | | COMPLEMENTS | |
| | i) Revisions with timely highly-relevant technical disclosure only | ii) Revisions with periodic financial disclosure only | iii) Revisions with timely highly-relevant technical disclosure (or with technical and financial disclosures) | iv) Revisions with periodic financial disclosure (or with financial and technical disclosures) |
| | ΔFEPS | ΔFEPS | ΔFEPS | ΔFEPS |
| Mean | -0.009 | 0.025 | 0.017 | 0.026 |
| Std. Error | 0.142 | 0.193 | 0.166 | 0.182 |
| Min | -0.535 | -0.783 | -0.535 | -0.783 |
| Median | 0.000 | 0.026 | 0.017 | 0.026 |
| Max | 0.419 | 0.500 | 1.173 | 1.173 |
| Number of revisions | 165 | 357 | 592 | 784 |
| Number of analysts | 40 | 47 | 55 | 52 |
| Number of revisions per analyst | 4.12 | 7.60 | 10.76 | 15.08 |
| Number of brokerage and investment firms | 37 | 42 | 48 | 47 |

## Table 7
## Information content of analyst forecasts depending upon financial and technical disclosure: major vs. other brokerage and investment firms

The information content of analyst forecasts in the announcement period for analysts employed at major brokerage and investment firms, and for those employed at other firms. The information content is disentangled depending upon the timing of the forecast release date relative to periodic financial disclosure, timely technical disclosure and no disclosure both in the non-complements framework (Panel A) and in the complements framework (Panel B). We identify the non-complement framework when earnings-forecast revisions are preceded either by i) timely technical disclosure only, or by ii) periodic financial disclosure only, whereas we identify the complements framework when earnings-forecast revisions are preceded either by iii) timely technical disclosure or timely technical disclosure in conjunction with periodic financial disclosure, or by iv) periodic financial disclosure or periodic financial disclosure in conjunction with timely technical disclosure. In the fixed-effects panel-data technique used, the dependent variable is the (annual and quarterly) earnings forecast revision for analyst *y* at the forecast-release date *t.* The explanatory variables are: (1) $R^{RP}_{yt}$, the cumulative returns for Intel in the revision period, (2) $RM^{RP}_{yt}$, the cumulative returns on the market portfolio (Nasdaq Composite Index) in the revision period, (3) $R^{AP}_{yt}*D_1$, where $R^{AP}_{yt}$ is the cumulative returns for Intel in the announcement period and $D_1$ is a dummy variable equal to one if periodic financial disclosure occurred in the last four days of the forecast-revision period, zero otherwise; (4) $R^{AP}_{yt}*D_2$, where $D_2$ is a dummy variable equal to one if timely technical disclosure occurred in between the last two weeks and last five days of the forecast-revision period, zero otherwise, (5) $R^{AP}_{yt}*D_3$, where $D_3$ is a dummy variable equal to one if no disclosure occurred in the forecast-revision period, zero otherwise (in Panel B by definition this variable does not exist), (6) $RM^{AP}_{yt}*D_1$, the cumulative returns on the market portfolio (Nasdaq Composite Index) in the announcement period; (7) $RM^{AP}_{yt}*D_2$, (8) $RM^{AP}_{yt}*D_3$. The coefficients of $R^{AP}_{yt}*D_1$ ($\gamma_{31}$), $R^{AP}_{yt}*D_2$ ($\gamma_{32}$) and $R^{AP}_{yt}*D_3$ ($\gamma_{33}$) indicate the information content in the announcement period depending upon periodic financial disclosure, timely technical disclosure and no disclosure. The brokerage and investment firm hierarchy is derived from a ranking published by *Institutional Investor*. The test refers to Intel in each year over July 2004-December 2007. *. **, *** indicate two-tailed p-values <0.10, <0.05 and <0.01 respectively.

| **Panel A: PERIODIC FINANCIAL AND TIMELY TECHNICAL DISCLOSURE - NON-COMPLEMENTS** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Equation (6) | | Constant ($\gamma_0$) | $R^{RP}$ ($\gamma_1$) | $RM^{RP}$ ($\gamma_2$) | $R^{AP}*D_1$ ($\gamma_{31}$) | $R^{AP}*D_2$ ($\gamma_{32}$) | $R^{AP}*D_3$ ($\gamma_{33}$) | $RM^{AP}*D_1$ ($\gamma_{41}$) | $RM^{AP}*D_2$ ($\gamma_{42}$) | $RM^{AP}*D_3$ ($\gamma_{43}$) | Analyst fixed eff | F | Adj $R^2$ [N. obs] |
| Predicted sign | | | + | - | + | - | 0 | - | - | 0 | | | |
| Disclosure type | | | | | Financial only | Technical only | No disclosure | Financial only | Technical only | No disclosure | | | |
| MAJOR | Coefficient | 0.019** | 0.515*** | 0.268 | 0.214 | -1.376 | 1.348*** | 5.035** | 2.140 | -1.985** | Yes | 17.06*** | 31.20% |
| | Std. Error | 0.008 | 0.098 | 0.174 | 0.371 | 1.052 | 0.221 | 2.377 | 2.297 | 1.025 | | | [468] |
| | t-statistic | 2.40 | 5.23 | 1.54 | 0.58 | -1.31 | 6.09 | 2.12 | 0.93 | -1.94 | | | |
| OTHER | Coefficient | 0.022*** | 0.692*** | -0.519*** | 0.989*** | -1.211 | 0.937*** | 5.642*** | 0.734 | -3.037*** | Yes | 28.97*** | 20.91% |
| | Std. Error | 0.006 | 0.060 | 0.114 | 0.258 | 1.060 | 0.162 | 1.341 | 1.537 | 0.655 | | | [1035] |
| | t-statistic | 4.00 | 11.50 | -4.56 | 3.83 | -1.14 | 5.77 | 4.21 | 0.48 | -4.64 | | | |
| **Panel B: PERIODIC FINANCIAL AND TIMELY TECHNICAL DISCLOSURE – COMPLEMENTS** | | | | | | | | | | | | | |
| Equation (6) | | Constant ($\gamma_0$) | $R^{RP}$ ($\gamma_1$) | $RM^{RP}$ ($\gamma_2$) | $R^{AP}*D_1$ ($\gamma_{31}$) | $R^{AP}*D_2$ ($\gamma_{32}$) | $R^{AP}*D_3$ ($\gamma_{33}$) | $RM^{AP}*D_1$ ($\gamma_{41}$) | $RM^{AP}*D_2$ ($\gamma_{42}$) | $RM^{AP}*D_3$ ($\gamma_{43}$) | Analyst fixed eff | F | Adj $R^2$ [N.obs] |
| Predicted sign | | | + | - | + | + | n.a. | - | - | n.a. | | | |
| Disclosure type | | | | | Financial (or financial & technical) | Technical (or technical & financial) | No disclosure | Financial (or financial & technical) | Technical (or technical & financial) | No disclosure | | | |
| MAJOR | Coefficient | 0.018** | 0.519*** | 0.282 | 0.440 | 1.105*** | | 0.991 | -3.293** | | Yes | 21.73*** | 30.57% |
| | Std. Error | 0.008 | 0.096 | 0.170 | 0.351 | 0.422 | | 1.682 | 1.680 | | | | [468] |
| | t-statistic | 2.20 | 5.39 | 1.56 | 1.25 | 2.62 | | 0.59 | -1.96 | | | | |
| OTHER | Coefficient | 0.020*** | 0.668*** | -0.426*** | 0.882*** | -0.185 | | 1.151 | -4.276*** | | Yes | 36.45*** | 19.46% |
| | Std. Error | 0.005 | 0.060 | 0.112 | 0.251 | 0.296 | | 1.031 | 1.060 | | | | [1035] |
| | t-statistic | 3.69 | 11.15 | -3.80 | 3.52 | 0.63 | | 1.47 | -4.03 | | | | |

## Table 8
## The effect of analyst information processing on analyst forecast accuracy

The effect of analyst information processing on accuracy is investigated both in the non-complements framework (Panel A), and in the complements framework (Panel B). We identify the non-complements framework when earnings-forecast revisions are preceded either by i) timely technical disclosure only, or by ii) periodic financial disclosure only, whereas we identify the complements framework when earnings-forecast revisions are preceded either by iii) timely technical disclosure or timely technical disclosure in conjunction with periodic financial disclosure, or by iv) periodic financial disclosure or periodic financial disclosure in conjunction with timely technical disclosure. In the fixed-effects panel-data technique used, the dependent variable is the forecast accuracy for analyst *y* in quarter *t*. The explanatory variables are: (1) $D_1$ is a dummy variable equal to one if analyst *y* reacts in quarter *t* at least to one periodic financial disclosure, zero otherwise, (2) $D_2$ is a dummy variable equal to one if analyst *y* reacts in quarter *t* at least to one timely technical disclosure, zero otherwise, (3) $Speed_1$ is the average number of days analyst *y* employs in quarter *t* to react to periodic financial disclosure, (4) $Speed_2$ is the average number of days analyst *y* employs in quarter *t* to react to timely technical disclosure, (5) $Intensity_1$ is the number of periodic financial disclosures that analyst *y* employs in quarter *t*, (6) $Intensity_2$ is the number of timely technical disclosures that analyst *y* employs in quarter *t*, (7) Experience is the ln of the number of previous quarters analyst *y* issued a forecast at quarter *t*. The test refers to Intel over the period July 2004-December 2007. **, *** indicate two-tailed p-values <0.05 and <0.01 respectively.

**Panel A: PERIODIC FINANCIAL AND TIMELY TECHNICAL DISCLOSURE – NON-COMPLEMENTS**

| | | Constant ($\alpha_0$) | $D_1$ ($\alpha_{11}$) | $D_2$ ($\alpha_{12}$) | $Speed_1$ ($\alpha_{21}$) | $Speed_2$ ($\alpha_{22}$) | $Intensity_1$ ($\alpha_{31}$) | $Intensity_2$ ($\alpha_{32}$) | Experience ($\alpha_4$) | Experience*$Intensity_2$ ($\alpha_5$) | Analyst fixed eff | F | Adj $R^2$ [N. obs] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Predicted sign | | | - | - | - | - | - | - | +/- | - | | | |
| Disclosure type | | | Financial only | Technical only | Financial only | Technical only | Financial only | Technical only | | Technical only | | | |
| Eq. (7) | Coefficient | 0.002*** | -0.001* | -0.001 | 0.001 | -0.001** | 0.001** | 0.001** | 0.001*** | | Yes | 9.66*** | 14.72% |
| | Std. Error | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | | | | [343] |
| | t-statistic | 5.83 | -1.69 | -1.36 | 0.08 | -2.36 | 2.05 | 1.95 | 2.67 | | | | |
| Eq. (8) | Coefficient | 0.002*** | -0.001* | -0.001 | 0.001 | -0.001** | 0.001** | 0.001* | 0.001** | 0.001 | Yes | 8.52*** | 14.77% |
| | Std. Error | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | | | [343] |
| | t-statistic | 6.11 | -1.70 | -1.58 | 0.08 | -2.34 | 2.02 | 1.92 | 2.05 | 0.56 | | | |

**Panel B: PERIODIC FINANCIAL AND TIMELY TECHNICAL DISCLOSURE – COMPLEMENTS**

| | | Constant ($\alpha_0$) | $D_1$ ($\alpha_{11}$) | $D_2$ ($\alpha_{12}$) | $Speed_1$ ($\alpha_{21}$) | $Speed_2$ ($\alpha_{22}$) | $Intensity_1$ ($\alpha_{31}$) | $Intensity_2$ ($\alpha_{32}$) | Experience ($\alpha_4$) | Experience* $Intensity_2$ ($\alpha_5$) | Analyst fixed eff | F | Adj $R^2$ [N. obs] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Predicted sign | | | - | - | - | - | - | - | +/- | - | | | |
| Disclosure type | | | Financial (or financial & technical) | Technical (or technical & financial) | Financial (or financial & technical) | Technical (or technical & financial) | Financial (or financial & technical) | Technical (or technical & financial) | | Technical (or technical & financial) | | | |
| Eq. (7) | Coefficient | 0.001*** | -0.001 | 0.002*** | -0.001** | -0.001** | 0.001** | -0.001* | 0.001*** | | Yes | 11.56*** | 12.50% |
| | Std. Error | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | | | | [518] |
| | t-statistic | 2.61 | -0.19 | 5.36 | -1.99 | -1.93 | 2.43 | -1.66 | 3.62 | | | | |
| Eq. (8) | Coefficient | 0.001*** | 0.001 | 0.002*** | -0.001** | -0.001* | 0.001** | -0.001** | 0.001 | 0.001* | Yes | 10.49*** | 12.80% |
| | Std. Error | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | | | [518] |
| | t-statistic | 3.08 | 0.03 | 5.38 | -1.98 | -1.71 | 2.29 | -2.25 | 1.36 | 1.65 | | | |