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Does Information-Processing Cost Affect Firm-Specific Information Acquisition? Evidence from XBRL Adoption

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Abstract

We examine how information-processing cost affects investors' acquisition of firm-specific information using a natural experiment resulting from a recent mandate requiring U.S. firms to adopt eXtensible Business Reporting Language (XBRL) when submitting filings to the U.S. Securities and Exchange Commission (SEC). XBRL filings make financial data standardized, tagged, and machine readable. We find that XBRL adoption reduces firms' stock return synchronicity. The reduction in synchronicity mainly applies to filings under the mandatory program as opposed to the voluntary program. Furthermore, such an effect is more pronounced for opaque and complex firms. Finally, we find that XBRL adoption also reduces price delay.

I. Introduction

The pioneering work by Grossman and Stiglitz (1980) proposes that when information is costly, share price only partially reflects the information of informed investors, and therefore information acquisition is compensated. The so called "equilibrium of disequilibrium" in the information market further implies that a reduction in the cost of information increases share price informativeness. Along this line, Sims (2003), (2006) suggests that investors' limited information-processing capacity deters information from being fully capitalized into asset prices. Building upon a rational expectation framework with costly information,

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Veldkamp (2006) argues that investors' purchase of low-price common information generates asset price comovement. Taken together, these theoretical studies predict an underinvestment in the production of expensive firm-specific information when the cost of gathering and/or processing information is high. In spite of this appealing theoretical link, little formal empirical analysis has been conducted on this issue, potentially due to the difficulty of measuring the unobservable information-processing cost. We investigate this link utilizing a recent U.S. Securities and Exchange Commission (SEC) regulation that significantly changes the format of firms' SEC filings based on technological advancement.

The adoption of eXtensible Business Reporting Language (XBRL) provides us with a natural experiment to directly examine how information-processing cost affects investors' acquisition of firm-specific information. Mandated by the SEC in 2009, the final rule of XBRL adoption requires firms to submit SEC filings (10K, 10Q, 8K, etc.) that are tagged according to standard taxonomies (SEC (2009)). Under this mandate, firms' financial statements will have the same names for items with the same economic implications. The benefit of XBRL adoption comes from the fact that this standardization makes financial statements machine readable so that market participants can be freed from the inefficiencies associated with manual data collection and hence more easily process different data items directly through computer software. Therefore, XBRL adoption helps reduce information-processing cost for market participants (SEC (2009)). We make use of this natural experiment and show how information-processing cost prevents firm-specific information from being capitalized into stock prices. We use stock return synchronicity to capture the proportion of firm-specific information contained in stock prices.

We retrieve information on firms' XBRL filings (including filing time, filing type, etc.) from the Electronic Data Gathering, Analysis, and Retrieval (EDGAR) database of Interactive Data Filings and RSS Feeds. We identify each firm's first XBRL filing date and define it as the XBRL adoption date. Exploiting the merit of a staggered XBRL adoption program, we utilize a difference-in-differences specification to estimate the causal association between information-processing cost and stock return synchronicity (Bertrand and Mullainathan (2003)). Specifically, our analysis compares the change in synchronicity of adopters with that of nonadopters and identifies the difference as the effect of XBRL adoption on stock return synchronicity. Our dependent variable is a firm-year measure of stock return synchronicity derived from a natural log transformation of R^2 from estimating a firm-year regression of weekly firm stock returns on market and industry returns. For the period 2005–2012, we find that XBRL adopters experience a significant reduction in stock return synchronicity of 0.2771. Translated into economic magnitude, this effect represents a reduction in R^2 of 2.84%, which is economically significant because the mean value of synchronicity corresponds to an R^2 value of 13.09%.

To ensure that the observed reduction in synchronicity is driven by a reduction in information-processing cost, we perform the following corroborative analyses. First, we investigate the difference between the voluntary program and the mandatory program to determine whether the effect of XBRL adoption is a function of the information quality of XBRL filings. The voluntary program was

initiated in 2005 for the purpose of assessing the feasibility of XBRL adoption. Voluntary-adopting firms were not exposed to the same set of stringent requirements associated with XBRL filings under the mandatory program. Because they lack timeliness and reliability, XBRL filings under the voluntary program are less likely to reduce information-processing cost and thus should have a limited impact on information flow and stock return synchronicity. Our results support this conjecture. In particular, the effect of voluntary adoption is insignificant during the 2005–2009 period. However, once XBRL adoption becomes mandatory, voluntary adopters also benefit because the rules guiding the mandate apply to all firms, including voluntary adopters. This evidence reinforces our argument that XBRL adoption reduces stock return synchronicity through a reduction in information-processing cost.

Second, we examine how the effect of XBRL adoption on stock return synchronicity varies across firms with heterogeneous information-processing cost before the mandate. If information-processing cost is the driving force, the effect of XBRL adoption should be more pronounced for firms with high financial reporting opacity or firms that are complex. Specifically, opaque firms reveal less firm-level information (Hutton, Marcus, and Tehranian (2009)), rendering investors in a greater need for such information. Because firm-specific information is more costly to gather and process compared with sector-level information, a reduction in information-processing cost should affect opaque firms to a greater extent. Firm complexity is another factor that can affect the impact of XBRL adoption. Complex firms have financial information that is inherently more difficult to process (Cohen and Lou (2011)). We thus expect the effect of XBRL adoption to be stronger in complex firms. In line with these arguments, we find that the effect of XBRL adoption on stock return synchronicity is significant only for opaque or complex firms.

A methodological challenge exists in that XBRL adopters are not randomly selected. Instead, firms' adoption time largely depends on public float. Although size is observable and controlled in our specification, this concern remains because adopters and nonadopters are not perfectly comparable. To resolve this issue, we adopt a quasi-regression–discontinuity design because there are known cutoff points in size that distinguish adopters from nonadopters (Thistlethwaite and Campbell (1960)). To the extent that the assignment of firms near the cutoff points can be viewed as being random, the difference-in-differences approach using the subsample around cutoffs can generate consistent estimators. We again find evidence that XBRL adoption reduces stock return synchronicity.

Finally, we construct an alternative measure of informational efficiency. Hou and Moskowitz (2005) measure a firm's informational efficiency by capturing the delay of stock prices in absorbing market information. They argue that such a delay represents a significant market friction and inefficiency in stock prices. Following their approach, and incorporating industry information along with market information, we find that XBRL adoption significantly reduces adopters' stock price delay. Such an effect is more pronounced for firms that are affected by market and industry information to a larger extent. These results add further support to our main inference.

We make the following contributions. First, we contribute to the growing literature on the importance of information-processing cost. Sims (2003), (2006)

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argues that limited information-processing capacity reduces agents' ability in processing a complete set of information, resulting in an inertial reaction of asset prices to new information. Subsequent theoretical studies explore various roles of information-processing constraints on asset allocation or consumption decisions (Peng (2005), Luo (2008), (2010)). In spite of such a growing theoretical literature on the role of information-processing cost, empirical evidence is limited.[1] Blankespoor (2012) examines XBRL adoption and finds that a reduction in investors' information-processing cost leads firms to increase disclosures. Li, Lin, and Ni (2012) show that XBRL adoption increases analyst coverage and improves analyst forecast accuracy. Our work is important in that it provides additional and direct empirical evidence supporting the theoretical link between the information-processing cost and the incorporation of firm-specific information into stock prices.

Second, we highlight a benefit of XBRL adoption. The adoption of XBRL rules is consistent with the SEC's plan to replace the current EDGAR system with the Interactive Data Electronic Applications (IDEA) system, which will "facilitate the use and analysis of information submitted to the Commission in interactive data format" (SEC (2009), p. 7). The SEC expects that the interactive data format will help investors, analysts, and other market participants process information more quickly and at a lower cost. We provide evidence consistent with the SEC's statement that XBRL adoption helps market participants translate more firm-specific information into stock prices.

Third, we utilize a setting that is relatively free of endogeneity. Although we test a treatment effect, firms in our main empirical sample do not self-select into the treatment group because they are mandated by the SEC to adopt XBRL filings. Prior studies often suffer from endogeneity because both an agent's behavior (e.g., initiation of analyst coverage) and stock return synchronicity can be potentially related to unobservable common factors. We exploit a setting in which an exogenous shock directly affects the information-processing cost and provide a more unambiguous prediction about its effect on stock return synchronicity.

The remainder of the paper proceeds as follows: Section II reviews prior literature and develops hypotheses. Section III describes the data and empirical design. Section IV presents and discusses empirical results. Section V summarizes and concludes.

II. Literature Review and Hypothesis Development

A. XBRL and Information-Processing Cost

XBRL has a list of standard tags to which different items in financial statements are mapped (SEC (2009)). The list of tags is similar to a dictionary in which each tag is a word to define, and the definition is the economic meaning of the tag. An XBRL filing is hence a financial statement in which various

[1] One stream of literature implies that analyst coverage and analyst forecast accuracy are related to information-processing cost. For example, Barth, Kasznik, and McNichols (2001) show that analyst coverage is negatively associated with the cost of following a firm. Ghosh and Whitecotton (1997) suggest that analyst forecast accuracy is determined by information-processing capacity.

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items are defined based on these standard tags. In doing so, the filings become readable to computers. We illustrate in the Appendix how XBRL filings reduce information-processing cost using an example related to Microsoft's and Apple's 2012 quarterly reports.

The mandate for XBRL adoption lies under the long-term goal of the SEC to replace the current EDGAR disclosure system with an interactive data disclosure system. The SEC expects this disclosure system to protect investors; to maintain fair, orderly, and efficient markets; and to facilitate capital formation. The objective is reflected in the SEC's initiation of the EDGAR system in the 1990s, which makes firms' financial statements more accessible to investors through the widespread use of the Internet. It is believed that the XBRL system will further improve the accessibility and usefulness of data in financial statements (SEC (2009)).

The SEC initiated a voluntary program in 2005 to assess the feasibility of XBRL filings. Under this program, firms voluntarily chose to submit XBRL filings, and there was no requirement for submission deadline (SEC (2005)). After the trial period, the SEC initiated a mandatory program under which all firms are required to submit XBRL filings, although a phase-in period allows different firms to adopt XBRL filings in different years. Specifically, firms with public float above $5 billion are required to submit filings in interactive data format for fiscal periods ending on or after June 15, 2009. Other large accelerated filers are required to submit interactive data for fiscal periods ending on or after June 15, 2010.[2] Finally, all remaining filers are subject to the same filing requirement for fiscal periods ending on or after June 15, 2011 (SEC (2009)).

Blankespoor, Miller, and White (2014) investigate the change in information asymmetry between large and small investors due to XBRL adoption. They find that in the initial year of XBRL adoption, information asymmetry (measured by abnormal bid–ask spread) actually increases. Li et al. (2012) examine a larger sample covering all three rounds of mandatory adoptions in 2009, 2010, and 2011. They find a reduction in adopters' cost of equity capital and an improvement in their analysts' information environment and stock liquidity after XBRL adoption. They argue that a reduction in information-processing cost reduces the equity premium demanded by investors, consistent with the theoretical asset pricing literature (Peng (2005), Luo (2008), (2010)). In addition, Blankespoor (2012) finds that firms adopting XBRL increase their disclosure of quantitative footnotes because XBRL reduces investors' information-processing cost and prompts firms to disclose more. The somewhat mixed evidence on the potential benefits of XBRL adoption highlights the importance of more research into its economic consequences.

B. Information-Processing Cost and Information Flow

Grossman and Stiglitz (1980) argue that with costly information, share price only partially reflects the information of informed investors, and therefore

[2]Large accelerated filers (Rule 12-b under the Securities Exchange Act of 1934) are issuers that have common equity held by unaffiliated persons with a value of at least $700 million, have been subject to the Exchange Act's periodic reporting requirement for at least 12 months, have filed at least one annual report, and are not eligible to use the disclosure requirements available to smaller reporting companies for their periodic reports.

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information acquisition is compensated. Sims (2003), (2006) further points out that because investors' information-processing capacity is limited, information that is freely available to uninformed investors cannot be fully utilized. In particular, agents with limited information-processing capacity behave as if facing noise that changes systematically when the dynamic properties of the economy change. Thus, information-processing cost can delay the incorporation of information into asset prices or create noise in information. Subsequent studies document that information-processing constraints can result in underdiversified risk and reduce households' ability to smooth consumption (Peng (2005), Luo (2008), (2010)).

Veldkamp (2006) argues that when information production has a high fixed cost, rational investors will purchase only a subset of information, enabling only a small fraction of the expensive firm-specific information to be incorporated into stock prices. When firm-specific information becomes available to investors at a lower cost, investors will increase the demand for firm-specific information, which will be ultimately incorporated into stock prices. Therefore, lowering the information-processing cost will increase the speed as well as the amount of information being incorporated into asset prices. In a similar vein, Peng and Xiong (2006) show that the inevitability of limited attention leads investors to process more market- and sector-level information and less firm-level information. The gradual advancement of information technology will make information-processing cost less binding and reduce the return correlations.

Based on these aforementioned studies, we expect that by reducing the information-processing cost, the adoption of XBRL enables new information to be incorporated into stock prices in a more timely and sufficient manner (Sims (2003), (2006), Veldkamp (2006), and Maggio and Pagano (2012)).

C. Information Flow and Return Synchronicity

Asset fundamentals are determined by a common market factor and an idiosyncratic factor. When a greater fraction of price fluctuation is caused by the idiosyncratic factor, the comovement between asset returns and the market factor decreases. Conversely, if the market factor drives the price fluctuation, asset returns will comove with the market factor to a greater extent. Roll (1988) suggests that the idiosyncratic factor would be largely determined by firm-specific information. Ferreira and Laux (2007) argue that the information-driven comovement in stock returns reflects a summary of inflow of private information about a firm. This argument that an enhancement in firm-specific information flow lowers stock return synchronicity has received ample empirical support (Morck, Yeung, and Yu (2000), Durnev, Morck, Yeung, and Zarowin (2003), Jin and Myers (2006), Fernandes and Ferreira (2008), Hutton et al. (2009), and Kim and Shi (2012)). Specifically, corporate governance mechanism (Ferreira and Laux (2007)), analyst coverage initiation (Crawford, Roulstone, and So (2012)), and the adoption of the International Financial Reporting Standards (IFRS) (Kim and Shi (2012)), among others, all impact stock return synchronicity through multiple channels of firm-specific information production. Whereas existing studies mainly focus on how the behavior of information suppliers (e.g., firms, analysts, and institutional

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investors) affects synchronicity, we go one step further by exploring the role of information-processing cost, a fundamental factor that affects the behavior of various information suppliers and acquirers, in determining the stock return synchronicity.

Given the potential that XBRL adoption reduces information-processing cost (SEC (2009), Blankespoor (2012), and Li et al. (2012)) and thereby enhances the incorporation of firm-specific information into stock prices (Sims (2003), (2006), Peng (2005), and Veldkamp (2006)), an important implication is that XBRL adoption facilitates firm-specific information production and thus reduces stock return synchronicity. This leads to our first hypothesis:

Hypothesis 1. XBRL adoption reduces stock return synchronicity.

The effect of XBRL adoption on information flow depends on the quality of information provided by XBRL filings. Timely and reliable information prompts information capitalization and reduces share price comovement. In contrast, stale and unreliable XBRL information does not produce such an impact. We examine this issue by looking into the difference between the voluntary program and the mandatory program.

The voluntary program was initiated in 2005, and firms were allowed to voluntarily provide their interactive data at any time they wanted. Voluntary-adopting firms were not exposed to the same set of stringent requirements associated with XBRL filings under the mandatory program. This flexibility made the interactive data in voluntary XBRL filings a mere supplement to official financial statements, and there were significant delays in voluntary filings (Blankespoor et al. (2014)). The SEC claimed that the voluntary program was an experiment and suggested that investors should not rely heavily on voluntary filings when making investment decisions. Due to a lack of timeliness and reliability, XBRL filings under the voluntary program are less likely to expedite firm-specific information flow.

In contrast, the mandatory program requires firms to submit financial statements and interactive data at the same time. Stringent requirements over the form, content, and legal obligations ensure the reliability of information contained in XBRL filings. Thus, interactive data in mandatory XBRL filings are more likely to affect the information capitalization process. This argument leads to our second hypothesis:

Hypothesis 2. The effect of XBRL adoption on stock return synchronicity is less pronounced when the information quality of XBRL filings is low.

The impact of XBRL adoption on stock return synchronicity varies as the cost associated with firm-specific information processing varies for different firms. Informationally opaque firms can benefit more from XBRL adoption. Specifically, financial reporting opacity reflects the fact that managers try to hide information from the capital market and obscure information about firm fundamentals (Hutton et al. (2009)). Facing ambiguous accounting numbers, investors find it difficult to understand firm performance (Fox, Durnev, Morck, and Yeung (2003)). XBRL adoption enables investors to process information in XBRL fillings at a lower cost. In addition, XBRL adoption leads to an increase in disclosures such as quantitative footnotes (Blankespoor (2012)). Given a decreasing marginal impact

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of additional information on stock return synchronicity, we expect the effect of XBRL adoption on stock return synchronicity to be more pronounced for informationally opaque firms.

XBRL adoption can also facilitate the analysis of complex financial statements and thus enhances firm-specific information production. In particular, a firm with more business segments has an earnings number that comes from multiple sources, making it more difficult for investors to identify the underlying value factors. Extant literature shows that complex firms have a higher level of information-processing cost, leading to more frictions and inefficiency in their stocks' pricing process (Cohen and Lou (2011)). The XBRL adoption program requires different firms' financial statements to have the same names (taxonomies) for items with the same economic implications. As such, XBRL adoption can reduce the difficulty in analyzing complex financial statements by allowing investors to compare the value of accounting items across different firms and industries at a lower cost.

Based on these discussions, we propose the following hypotheses:

Hypothesis 3. The effect of XBRL adoption on stock return synchronicity is more pronounced in firms with opaque financial reporting.

Hypothesis 4. The effect of XBRL adoption on stock return synchronicity is more pronounced in complex firms.

III. Data and Empirical Specification

A. Data

We collect XBRL filings from EDGAR's database of Interactive Data Filings and RSS Feeds. For each XBRL filing, we obtain its filing time, form type, reporting period, and firm identity. Because our empirical design focuses on firms' XBRL adoption, we use firms' initial XBRL filings to identify their adoption time. The earliest filing time for each firm ranges from Apr. 4, 2005 to Apr. 30, 2012. Our initial XBRL sample contains 5,751 firms that are also included in the Compustat database.

Because the voluntary program of XBRL adoption started in 2005, we choose our sample period to be 2005–2012. Such a sample period also ensures two relatively balanced subperiods before and after the XBRL mandate in 2009. We obtain firm fundamental data from Compustat, stock price data from the Center for Research in Security Prices (CRSP) and analyst forecast data from the Institutional Brokers' Estimate System (IBES). In addition, we exclude from our sample firms in the financial or utility industries. Our final sample, including both voluntary and mandatory adopters, comprises 16,519 observations for 3,045 firms, with the majority (2,959 firms) being firms initiating XBRL filing under the mandatory adoption program beginning on June 15, 2009.

B. Empirical Specification

Stock return synchronicity captures the extent to which a firm's stock price comoves with the market and the industry. Specifically, we estimate the

following regression for each firm-year using weekly stock, market, and industry returns:

$$\text{RET}_{i,t} = \alpha_0 + \alpha_1 \text{RET_MKT}_t + \alpha_2 \text{RET_IND}_{i,t} + \varepsilon_{i,t}, \quad (1)$$

where $\text{RET}_{i,t}$ is the weekly stock return for firm i in week t, RET_MKT_t is the value-weighted market return in week t, and $\text{RET_IND}_{i,t}$ is the value-weighted industry return (based on 2-digit Standard Industrial Classification (SIC) codes) in week t. Equation (1) is estimated for each firm during each calendar year as long as a firm-year pair has no fewer than 40 weekly observations. The choice of equation (1) resembles the synchronicity model used by Crawford et al. (2012), with the difference being their use of daily returns because their estimation period covers only 3 months. For each firm-year estimation, we transform the adjusted R^2 into our synchronicity measure, $\text{SYNC} = \ln[R^2/(1-R^2)]$.[3]

To determine the effect of XBRL adoption on stock return synchronicity, we estimate the following regression:

$$\begin{aligned}\text{SYNC}_{i,t} = {} & b_0 + b_1 \text{POST}_{i,t} + b_2 \text{SIZE}_{i,t-1} + b_3 \text{MB}_{i,t-1} + b_4 \text{LEV}_{i,t-1} \\ & + b_5 \text{ROA}_{i,t-1} + b_6 \text{N_IND}_{i,t-1} + b_7 \text{HERF_SALE}_{i,t-1} \\ & + b_8 \text{STD_ROA}_{i,t-1} + b_9 \text{ANA_COV}_{i,t-1} \\ & + \text{FIRM_FIXED_EFFECTS} + \text{YEAR_FIXED_EFFECTS} + \varepsilon_{i,t},\end{aligned} \quad (2)$$

where $\text{SYNC}_{i,t}$ measures firm i's stock return synchronicity in year t. Our variable of interest is an indicator ($\text{POST}_{i,t}$) that equals 1 if a firm-year is after a firm's XBRL adoption, and 0 otherwise. We exclude a firm's adopting year in the analysis to ensure that an observation year is either before or after the adoption for a whole-year period.

We include control variables following the prior literature (Piotroski and Roulstone (2004), Hutton et al. (2009), Dasgupta, Gan, and Gao (2010), Kim and Shi (2012), and Crawford et al. (2012)). Specifically, we control for firm size ($\text{SIZE}_{i,t-1}$), measured as the natural log of a firm's market capitalization at the end of the previous fiscal year; the market-to-book ratio ($\text{MB}_{i,t-1}$), measured as market capitalization scaled by the book value of equity; leverage ($\text{LEV}_{i,t-1}$), defined as total long-term debt scaled by total assets; and profitability ($\text{ROA}_{i,t-1}$), defined as income before extraordinary items divided by total assets. We control for industry factors associated with industry size ($\text{N_IND}_{i,t-1}$) and industry competition ($\text{HERF_SALE}_{i,t-1}$). $\text{N_IND}_{i,t-1}$ is defined as the natural log of the number of firms in the industry to which firm i belongs. $\text{HERF_SALE}_{i,t-1}$ is the sum of the squared terms of the proportion of a firm's revenue to total revenue in the industry to which firm i belongs. Following Crawford et al. (2012), we also include earnings volatility ($\text{STD_ROA}_{i,t-1}$), measured as the standard deviation of the ratio between income before extraordinary items and total assets in the previous 5 years, and analyst coverage ($\text{ANA_COV}_{i,t-1}$), defined as the number of analysts issuing annual forecasts during the previous fiscal year. We control for firm fixed effects and year fixed effects. Finally, we cluster standard errors by firm to control for within-firm correlations of the residuals.

[3]Following prior literature (Crawford et al. (2012)), we use the adjusted R^2. We winsorize the adjusted R^2 at 0.0001 and 0.9999, respectively.

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IV. Empirical Results

A. Summary Statistics

Panel A of Table 1 shows the number of sample firms that adopt XBRL filings in a specific calendar year. Here we include both voluntary adopters and mandatory adopters to depict a complete picture of firms' XBRL adoption. There are a total of 3,045 firms in the sample. We observe that a majority of firms adopt XBRL filings under the mandatory program. Specifically, there are 86 voluntary adopters and 2,959 mandatory adopters. Panel B shows summary statistics for key variables in our empirical analysis. Because voluntary adopters do not follow the same rules and guidelines as specified in the mandatory adoption program, the sample here consists of only mandatory adopters, which also form the main sample for our later analyses. There are a total of 15,992 firm-year observations. The mean (median) value of our synchronicity measure SYNC is −1.893 (−1.168), corresponding to an R^2 value of 13.09% (23.72%). The standard deviation of SYNC is 2.736. For the full sample, 21.8% represent firm-years after XBRL adoptions. As for control variables, the average market-to-book ratio is 3.275, and the average leverage is 0.150. The average analyst coverage for firms with IBES data is 3.035.

TABLE 1

Summary Statistics

Panel A of Table 1 presents the number of XBRL adopters in each year. We split year 2009 into a voluntary period and a mandatory period because the XBRL mandate began on June 15, 2009. Panel B presents summary statistics of key variables used in the empirical analyses. The sample consists of mandatory adopters for the period 2005–2012. $SYNC_{i,t}$ is firm i's stock return synchronicity in year t measured as $\ln[R^2/(1 - R^2)]$, where R^2 is estimated from a regression of weekly stock returns on market and industry returns. $POST_{i,t}$ equals 1 if a firm-year is after a firm's XBRL adoption, and 0 otherwise. $SIZE_{i,t-1}$ is the natural log of a firm's market capitalization at the end of the previous fiscal year. $MB_{i,t-1}$ is market capitalization scaled by the book value of equity. $LEV_{i,t-1}$ is total long-term debt scaled by total assets. $ROA_{i,t-1}$ is income before extraordinary items divided by total assets. $N_IND_{i,t-1}$ is the natural log of the number of firms in the industry to which firm i belongs. $HERF_SALE_{i,t-1}$ is the sum of the squared terms of the proportion of a firm's revenue to total revenue in the industry to which firm i belongs. $STD_ROA_{i,t-1}$ is the standard deviation of the ratio between income before extraordinary items and total assets in the previous 5 years. $ANA_COV_{i,t-1}$ is the number of analysts issuing annual forecasts for the last fiscal year.

Panel A. Number of Adopters by Year

Year	Subperiod	Program	No. of Adopters
2005	—	Voluntary	9
2006	—	Voluntary	18
2007	—	Voluntary	14
2008	—	Voluntary	32
2009	Jan.–June	Voluntary	13
2009	July–Dec.	Mandatory	272
2010	—	Mandatory	704
2011	—	Mandatory	1,876
2012	Jan.–Apr.	Mandatory	107
Total			3,045

Panel B. Statistics of Key Variables

Variables	*N*	Mean	Std. Dev.	5%	25%	Median	75%	95%
SYNC	15,992	−1.893	2.736	−9.210	−2.390	−1.168	−0.297	0.860
POST	15,992	0.218	0.413	0.000	0.000	0.000	0.000	1.000
SIZE	15,992	6.303	1.961	3.122	4.937	6.287	7.598	9.627
MB	15,992	3.275	3.834	0.641	1.350	2.170	3.608	9.241
LEV	15,992	0.150	0.172	0.000	0.000	0.095	0.252	0.498
ROA	15,992	−0.014	0.216	−0.441	−0.018	0.041	0.083	0.170
N_IND	15,992	5.282	1.221	3.091	4.369	5.635	6.368	6.780
HERF_SALE	15,992	0.071	0.072	0.024	0.034	0.045	0.076	0.218
STD_ROA	15,992	0.115	0.451	0.010	0.024	0.053	0.120	0.340
ANA_COV	15,992	3.035	4.640	0.000	0.000	1.000	4.000	13.000

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We present the Pearson correlations of key variables in Table 2. Synchronicity (SYNC) is positively correlated with POST (0.06, $p < 0.01$). However, it should be noted that larger firms adopted XBRL early, and that the positive correlation could simply reflect the correlation between firm size and synchronicity, which is positive and significant (0.54, $p < 0.01$). In addition, this pattern points to the importance of controlling for firm size in our multivariate analyses. Synchronicity is also found to be positively correlated with financial leverage (LEV), firm profitability (ROA), industry level Herfindahl index (HERF_SALE), and analyst coverage (ANA_COV). It is negatively correlated with industry size (N_IND) and earnings volatility (STD_ROA).

TABLE 2

Pearson Correlations among Variables

Table 2 presents the Pearson correlations among variables used in the empirical analysis. The sample consists of mandatory adopters for the period 2005–2012. $SYNC_{i,t}$ is firm i's stock return synchronicity in year t measured as $\ln[R^2/(1-R^2)]$, where R^2 is estimated from a regression of weekly stock returns on market and industry returns. $POST_{i,t}$ equals 1 if a firm-year is after a firm's XBRL adoption, and 0 otherwise. $SIZE_{i,t-1}$ is the natural log of a firm's market capitalization at the end of the previous fiscal year. $MB_{i,t-1}$ is market capitalization scaled by the book value of equity. $LEV_{i,t-1}$ is total long-term debt scaled by total assets. $ROA_{i,t-1}$ is income before extraordinary items divided by total assets. $N_IND_{i,t-1}$ is the natural log of the number of firms in the industry to which firm i belongs. $HERF_SALE_{i,t-1}$ is the sum of the squared terms of the proportion of a firm's revenue to total revenue in the industry to which firm i belongs. $STD_ROA_{i,t-1}$ is the standard deviation of the ratio between income before extraordinary items and total assets in the previous 5 years. $ANA_COV_{i,t-1}$ is the number of analysts issuing annual forecasts for the last fiscal year. p-values are reported under the correlation coefficients.

Variables	SYNC	POST	SIZE	MB	LEV	ROA	N_IND	HERF_SALE	STD_ROA
POST	0.06								
	<0.01								
SIZE	0.54	0.20							
	<0.01	<0.01							
MB	0.00	−0.03	0.14						
	0.77	<0.01	<0.01						
LEV	0.16	0.04	0.19	0.07					
	<0.01	<0.01	<0.01	<0.01					
ROA	0.25	0.08	0.37	−0.17	0.05				
	<0.01	<0.01	<0.01	<0.01	<0.01				
N_IND	−0.15	−0.09	−0.11	0.10	−0.24	−0.18			
	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			
HERF_SALE	0.09	0.03	0.07	−0.05	0.13	0.11	−0.75		
	<0.01	0.00	<0.01	<0.01	<0.01	<0.01	<0.01		
STD_ROA	−0.07	−0.03	−0.13	0.11	−0.08	−0.19	0.08	−0.05	
	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
ANA_COV	0.30	0.20	0.55	0.02	0.13	0.16	−0.09	0.05	−0.06
	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01

B. Effect of XBRL Adoption on Stock Return Synchronicity

We report in Table 3 the main results of the effect of XBRL adoption on stock return synchronicity. We use two alternative models in the analyses. In column 1, we use a difference-in-differences approach for the staggered adoption program. We control for year and industry fixed effects and indicators for groups of firms that adopt XBRL filing in the same round. The coefficient on POST captures the effect of XBRL adoption on synchronicity for adopters compared with nonadopters. In column 2, we further restrict the empirical model by controlling for firm fixed effects that absorb both the adoption round indicators and the industry fixed effects (equation (2)).

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TABLE 3

The Effect of XBRL Adoption on Stock Return Synchronicity

Table 3 presents results of the effect of XBRL adoption on stock return synchronicity. The sample consists of mandatory adopters for the period 2005–2012. The dependent variable, $SYNC_{i,t}$, is firm i's stock return synchronicity in year t measured as $\ln[R^2/(1 - R^2)]$, where R^2 is estimated from a regression of weekly stock returns on market and industry returns. $POST_{i,t}$ equals 1 if a firm-year is after a firm's XBRL adoption, and 0 otherwise. $SIZE_{i,t-1}$ is the natural log of a firm's market capitalization at the end of the previous fiscal year. $MB_{i,t-1}$ is market capitalization scaled by the book value of equity. $LEV_{i,t-1}$ is total long-term debt scaled by total assets. $ROA_{i,t-1}$ is income before extraordinary items divided by total assets. $N_IND_{i,t-1}$ is the natural log of the number of firms in the industry to which firm i belongs. $HERF_SALE_{i,t-1}$ is the sum of the squared terms of the proportion of a firm's revenue to total revenue in the industry to which firm i belongs. $STD_ROA_{i,t-1}$ is the standard deviation of the ratio between income before extraordinary items and total assets in the previous 5 years. $ANA_COV_{i,t-1}$ is the number of analysts issuing annual forecasts for the last fiscal year. t-statistics (reported in parentheses) are computed based on standard errors clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using 2-tailed tests.

Variables	1	2
POST	−0.1950 (−2.25)**	−0.2771 (−2.98)***
SIZE	0.8600 (35.79)***	0.4969 (10.78)***
MB	−0.0279 (−4.86)***	0.0013 (0.14)
LEV	0.3646 (2.23)**	−0.3664 (−1.46)
ROA	0.4155 (3.28)***	0.5127 (2.69)***
N_IND	−1.1361 (−3.93)***	−0.7528 (−2.42)**
HERF_SALE	−1.1968 (−1.16)	−1.1442 (−1.02)
STD_ROA	0.0653 (2.29)**	0.1807 (2.84)***
ANA_COV	−0.0082 (−1.59)	−0.0057 (−1.22)
ROUND1	−1.0131 (−9.82)***	—
ROUND2	−0.0779 −1.28)	—
CONSTANT	−1.7349 (−1.16)	−1.4331 (−0.89)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	—
Firm fixed effects	—	Yes
No. of obs.	15,992	15,992
Adj. R^2	0.41	0.52

Results show that the coefficients on POST are reliably negative and significant in both specifications (−0.1950, $t = -2.25$ in column 1; −0.2771, $t = -2.98$ in column 2), supporting Hypothesis 1 that XBRL adoption significantly reduces stock return synchronicity. Based on the more restrictive specification in column 2, the coefficient on POST is economically significant because it represents 10.13% (0.2771/2.736) of the standard deviation of our synchronicity measure. Alternatively, the effect can also be translated in terms of R^2. A 0.2771 reduction in synchronicity means that the average R^2 decreases by 2.84% from 13.09% to 10.25%, given a mean value of synchronicity of −1.893.

As for control variables, our results are generally consistent with prior studies. Specifically, large firms tend to have a higher level of synchronicity because the coefficient on SIZE is positive and significant. A similar association is found for firm profitability (ROA). Industry size (N_IND) is negatively associated with synchronicity, suggesting that in more competitive industries, information is less

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likely to follow several leading firms. In line with Crawford et al. (2012), we find that the coefficient on earnings volatility (STD_ROA) is positive and significant. The insignificant coefficient on analyst coverage is not surprising because prior studies find mixed evidence on how analyst coverage affects stock return synchronicity (Piotroski and Roulstone (2004), Chan and Hameed (2006), Liu (2011), and Crawford et al. (2012)).[4]

C. Effect of XBRL Adoption over Time

In this section, we investigate the dynamic effect of XBRL adoption on stock return synchronicity. The development of XBRL is built on technological advancement and capital market participants' increased sophistication. However, such a reform requires both investors and firms to engage in a learning process because a new technology requires time for investors to understand. As such, we expect the impact of XBRL adoption on stock return synchronicity to enhance as time goes by. In other words, the effect should be more pronounced in subsequent years after adoption. We estimate the following regression:

$$\begin{aligned}(3)\quad \mathrm{SYNC}_{i,t} &= b_0 + b_1\mathrm{POST1}_{i,t} + b_2\mathrm{POST2}_{i,t} + b_3\mathrm{POST3}_{i,t} + b_4\mathrm{SIZE}_{i,t-1} \\ &\quad + b_5\mathrm{MB}_{i,t-1} + b_6\mathrm{LEV}_{i,t-1} + b_7\mathrm{ROA}_{i,t-1} + b_8\mathrm{N_IND}_{i,t-1} \\ &\quad + b_9\mathrm{HERF_SALE}_{i,t-1} + b_{10}\mathrm{STD_ROA}_{i,t-1} + b_{11}\mathrm{ANA_COV}_{i,t-1} \\ &\quad + \mathrm{FIRM_FIXED_EFFECTS} + \mathrm{YEAR_FIXED_EFFECTS} + \varepsilon_{i,t},\end{aligned}$$

where we replace the POST indicator with three event-year indicators, POST1, POST2, and POST3. POST1 (POST2 or POST3) equals 1 for observations that are 1 year (2 or 3 years) after a firm's XBRL adoption, and 0 otherwise. We have two expectations here. First, if XBRL adoption has a sustained impact on firms' informational efficiency, the coefficients on the three indicators should be consistently negative. Second, if there is a learning process for investors to understand XBRL, the impact of XBRL adoption should be more pronounced in later years than in earlier years. That is, the coefficients on POST3, POST2, and POST1 should decline in magnitude.

Results are presented in Table 4. The coefficients on the three postadoption event-year indicators are reliably negative and significant (-0.3148, $t=-3.22$ for POST1; -0.3674, $t=-2.67$ for POST2; -0.5237, $t=-2.88$ for POST3), demonstrating that the effect of XBRL adoption on stock return synchronicity is persistent in the postadoption period. In addition, a monotonically increasing pattern of the XBRL effect emerges. An F-test suggests that the difference between the coefficients on POST1 and POST3 is significant (POST3 – POST1 $= -0.2089$, f-value $= 2.75$). Collectively, results are consistent with the expectation that because both investors and firms face a learning curve in understanding XBRL, the effect of XBRL adoption on stock return synchronicity enhances over time.

[4]Our results are robust to the inclusion of a firm's fundamental synchronicity, that is, the comovement of a firm's ROA with the industry ROA and market ROA (the coefficient on POST is again negative and significant, -0.3222, $t = -3.35$). We choose not to include the variable in our main analysis for two reasons. First, variation for fundamental synchronicity estimated from a multiple-year window comes mostly from the cross section. Our inclusion of firm fixed effects largely absorbs this variation. Second, requiring multiple-year data significantly reduces sample size.

TABLE 4

The Effect of XBRL Adoption over Time

Table 4 presents the dynamic effects of XBRL adoption on stock return synchronicity. The sample consists of mandatory adopters for the period 2005–2012. The dependent variable, $SYNC_{i,t}$, is firm i's stock return synchronicity in year t measured as $\ln[R^2/(1 - R^2)]$, where R^2 is estimated from a regression of weekly stock returns on market and industry returns. POST1 (POST2 or POST3) equals 1 for observations that are 1 year (2 or 3 years) after a firm's XBRL adoption, and 0 otherwise. $SIZE_{i,t-1}$ is the natural log of a firm's market capitalization at the end of the previous fiscal year. $MB_{i,t-1}$ is market capitalization scaled by the book value of equity. $LEV_{i,t-1}$ is total long-term debt scaled by total assets. $ROA_{i,t-1}$ is income before extraordinary items divided by total assets. $N_IND_{i,t-1}$ is the natural log of the number of firms in the industry to which firm i belongs. $HERF_SALE_{i,t-1}$ is the sum of the squared terms of the proportion of a firm's revenue to total revenue in the industry to which firm i belongs. $STD_ROA_{i,t-1}$ is the standard deviation of the ratio between income before extraordinary items and total assets in the previous 5 years. $ANA_COV_{i,t-1}$ is the number of analysts issuing annual forecasts for the last fiscal year. t-statistics (reported in parentheses) are computed based on standard errors clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using 2-tailed tests.

Variables	1
POST1	−0.3148 (−3.22)***
POST2	−0.3674 (−2.67)***
POST3	−0.5237 (−2.88)***
SIZE	0.5001 (10.86)***
MB	0.0009 (0.10)
LEV	−0.3497 (−1.39)
ROA	0.5068 (2.65)***
N_IND	−0.7421 (−2.40)**
HERF_SALE	−1.1300 (−1.01)
STD_ROA	0.1824 (2.87)***
ANA_COV	−0.0044 (−0.94)
CONSTANT	−1.4390 (−0.90)
Year fixed effects	Yes
Firm fixed effects	Yes
No. of obs.	15,992
Adj. R^2	0.52

D. Information Quality of XBRL Filings

To ensure that the observed reduction in stock return synchronicity is due to a reduction in information-processing cost after XBRL adoption, we conduct corroborative tests. We start by exploring the impact of XBRL filings under the voluntary adoption program. XBRL adoption started as a voluntary program in 2005 and became mandatory in 2009. In contrast with the mandatory program, the voluntary program has less stringent requirements on the timeliness and reliability of the filings and thus adds little value to investors in terms of information processing (SEC (2005)). As a result, we expect a weaker effect of XBRL adoption on stock return synchronicity under the voluntary program.

We identify a sample of voluntary adopters (those adopting XBRL before June 15, 2009) and estimate the effect of voluntary XBRL adoption on stock return synchronicity. In column 1 of Table 5, we choose 2005–2009 as our sample

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period. We find that the effect of voluntary XBRL adoption on stock return synchronicity is not significant (0.0018, $t = 0.00$). Such a result is consistent with the argument that because the voluntary program is just a trial, XBRL filings under this program lack the timeliness and reliability for investors to rely on and hence are less likely to enhance the informational efficiency of stock prices. This result supports Hypothesis 2.

TABLE 5

The Effect of Voluntary Adoption of XBRL

Table 5 presents results of the effect of voluntary XBRL adoption on stock return synchronicity. The sample in column 1 consists of voluntary adopters for the period 2005–2009. The sample in column 2 consists of voluntary adopters for the period 2005–2012. In both columns, the dependent variable, $SYNC_{i,t}$, is firm *i*'s stock return synchronicity in year *t* measured as $\ln[R^2/(1 - R^2)]$, where R^2 is estimated from a regression of weekly stock returns on market and industry returns. $POST_{i,t}$ equals 1 if a firm-year is after a firm's XBRL adoption, and 0 otherwise. $SIZE_{i,t-1}$ is the natural log of a firm's market capitalization at the end of the previous fiscal year. $MB_{i,t-1}$ is market capitalization scaled by the book value of equity. $LEV_{i,t-1}$ is total long-term debt scaled by total assets. $ROA_{i,t-1}$ is income before extraordinary items divided by total assets. $N_IND_{i,t-1}$ is the natural log of the number of firms in the industry to which firm *i* belongs. $HERF_SALE_{i,t-1}$ is the sum of the squared terms of the proportion of a firm's revenue to total revenue in the industry to which firm *i* belongs. $STD_ROA_{i,t-1}$ is the standard deviation of the ratio between income before extraordinary items and total assets in the previous 5 years. $ANA_COV_{i,t-1}$ is the number of analysts issuing annual forecasts for the last fiscal year. MAND_PER equals 1 for years after 2009, and 0 otherwise. *t*-statistics (reported in parentheses) are computed based on standard errors clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using 2-tailed tests.

	2005–2009	2005–2012
Variables	1	2
POST	0.0018 (0.00)	0.1830 (0.52)
POST × MAND_PER	—	−1.2677 (−3.44)***
SIZE	−0.0610 (−0.16)	0.2554 (1.08)
MB	0.0354 (1.09)	0.0339 (1.43)
LEV	−1.3545 (−0.62)	1.2826 (0.79)
ROA	−2.4925 (−0.54)	0.5394 (0.45)
N_IND	0.1278 (0.05)	−1.2184 (−1.18)
HERF_SALE	13.8158 (1.74)*	4.5188 (0.59)
STD_ROA	0.1002 (0.14)	0.6500 (1.22)
ANA_COV	0.0134 (0.61)	−0.0058 (−0.44)
CONSTANT	−0.7980 (−0.06)	3.3433 (0.53)
Year fixed effects	Yes	Yes
Firm fixed effects	Yes	Yes
No. of obs.	304	527
Adj. R^2	0.54	0.51

We move one step further and investigate whether the insignificant impact of voluntary adoption changes at the onset of the XBRL mandate. As the mandatory program specifies, requirements of the mandatory program also apply to the former voluntary adopters. That is, XBRL filings of voluntary adopters also need to adhere to rules under the mandatory program regarding the timeliness and reliability of filings. Therefore, we expect to observe a reduction in stock return synchronicity for voluntary adopters under the mandatory program. To test

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this, we modify the regression model in column 1 of Table 5 by adding the term POST × MAND_PER, where MAND_PER equals 1 for years after 2009, and 0 otherwise. The sample period is enlarged to 2005–2012 to include the mandatory period. We report results in column 2 of Table 5. The coefficient on POST × MAND_PER is negative and significant (−1.2677, $t = -3.44$), suggesting that the effect of XBRL adoption plays a role in reducing stock return synchronicity under the mandatory program for former voluntary adopters. A test of a linear combination of the coefficients on POST and POST × MAND_PER suggests that the net effect is negative and significant during the mandatory period (−1.0847, $t = -1.79$). This result again supports Hypothesis 2.

One caveat here is that firms can self-select into the voluntary adoption program. If more transparent firms have a stronger incentive to participate in the program, the insignificant effect of voluntary adoption can be driven by a selection bias. We mitigate this concern in the following ways. First, we employ a Heckman selection procedure and control for the inverse Mills ratio. Untabulated results suggest that the effect of XBRL adoption under the voluntary program remains insignificant. Second, we find that voluntary adopters also experience a reduction in stock return synchronicity under the mandatory program. Such a result is inconsistent with a selection bias argument, which would predict an insignificant effect throughout the two programs. We thus conclude that the insignificant effect of voluntary XBRL adoption is best explained by the information quality of XBRL filings.

E. High versus Low Information-Processing Cost

1. Effect of XBRL Adoption Conditional on Financial Reporting Opacity

Because XBRL adoption reduces the cost of processing supplemental information such as quantitative notes and firms are likely to provide more information in their financial statements after XBRL adoption (Blankespoor (2012)), investors of opaque firms will benefit more from a reduction in information-processing cost. Such an assertion is also consistent with the argument that financial opacity is associated with a high level of stock return synchronicity because a lack of transparency in financial statements results in less revelation of firm-specific information (Hutton et al. (2009)).

To test this prediction, we split the full sample into two subsamples based on the extent of firms' financial opacity. The value of the opacity measure is restricted to fiscal years ending before June 15, 2009. Therefore, the split is based on information before XBRL adoption. We measure financial reporting opacity following Dechow and Dichev (2002):

$$\text{TCA}_{i,t} = a_0 + a_1\text{CFO}_{i,t-1} + a_2\text{CFO}_{i,t} + a_3\text{CFO}_{i,t+1} + \mu_{i,t}, \tag{4}$$

where TCA is the total current accruals, calculated as ΔCA − ΔCL − ΔCASH + ΔST_DEBT; ΔCA is the change in current assets; ΔCL is the change in current liabilities; ΔCASH is the change in cash; and ΔST_DEBT is the change in debt in current liabilities. CFO is the cash flow from operations, constructed as net income before extraordinary items minus total current accruals, measured as previously noted, plus depreciation and amortization expenses. All variables are deflated by total assets. Subscripts i and t represent firm and year, respectively.

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The economic meaning of equation (4) comes from the assumption that accruals should be mapped into previous, current, and future cash flows. As a consequence, variance of the error term can be viewed as an inverse measure of accounting quality. Our main measure of accounting quality for firm i in year t is the standard deviation of the error term for firm i during the period from years $t-4$ to t, STD($\mu_{i,k}$), where k ranges from $t-4$ to t. We then split the full sample into two subsamples based on firms' accounting quality. Firms with STD($\mu_{i,k}$) lower than its median are categorized into the low-opacity subsample, and firms with STD($\mu_{i,k}$) higher than or equal to its median are categorized into the high-opacity subsample.

Results are shown in Table 6. In column 1, the coefficient on POST is negative but insignificant (-0.1457, $t = -1.11$), suggesting that the effect of XBRL

TABLE 6

The Effect of XBRL Adoption Conditional on Information Opacity

Table 6 presents results of the effect of XBRL adoption on stock return synchronicity conditional on financial reporting opacity. The sample consists of mandatory adopters for the period 2005–2012. Two alternative measures of financial reporting opacity are estimated from the Dechow and Dichev (2002) model or the modified Jones (1991) model, respectively. We split the sample into one subsample with lower opacity and another subsample with higher opacity based on each measure's median value. In all columns, the dependent variable, $SYNC_{i,t}$, is firm i's stock return synchronicity in year t measured as $\ln[R^2/(1-R^2)]$, where R^2 is estimated from a regression of weekly stock returns on market and industry returns. $POST_{i,t}$ equals 1 if a firm-year is after a firm's XBRL adoption, and 0 otherwise. $SIZE_{i,t-1}$ is the natural log of a firm's market capitalization at the end of the previous fiscal year. $MB_{i,t-1}$ is market capitalization scaled by the book value of equity. $LEV_{i,t-1}$ is total long-term debt scaled by total assets. $ROA_{i,t-1}$ is income before extraordinary items divided by total assets. $N_IND_{i,t-1}$ is the natural log of the number of firms in the industry to which firm i belongs. $HERF_SALE_{i,t-1}$ is the sum of the squared terms of the proportion of a firm's revenue to total revenue in the industry to which firm i belongs. $STD_ROA_{i,t-1}$ is the standard deviation of the ratio between income before extraordinary items and total assets in the previous 5 years. $ANA_COV_{i,t-1}$ is the number of analysts issuing annual forecasts for the last fiscal year. t-statistics (reported in parentheses) are computed based on standard errors clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using 2-tailed tests.

	Financial Opacity			
	Dechow and Dichev		Modified Jones	
Variables	Low	High	Low	High
POST	−0.1457 (−1.11)	−0.3933 (−2.09)**	−0.1881 (−1.52)	−0.2976 (−1.75)*
SIZE	0.4038 (5.35)***	0.5240 (7.78)***	0.4864 (6.36)***	0.5075 (7.87)***
MB	0.0191 (1.34)	0.0055 (0.45)	0.0103 (0.82)	0.0027 (0.21)
LEV	−0.5136 (−1.58)	−0.2350 (−0.59)	−0.6358 (−1.70)*	0.0264 (0.07)
ROA	0.3675 (0.86)	0.4827 (2.06)**	0.2968 (0.87)	0.7056 (2.92)***
N_IND	−1.1551 (−2.78)***	−0.4589 (−0.87)	−0.7324 (−1.20)	−0.9413 (−2.55)**
HERF_SALE	−0.6041 (−0.43)	−0.6770 (−0.28)	−1.5106 (−0.60)	−0.4619 (−0.36)
STD_ROA	−0.2807 (−0.49)	0.2229 (2.37)**	−0.0091 (−0.05)	0.1164 (0.92)
ANA_COV	−0.0047 (−0.76)	−0.0053 (−0.58)	0.0067 (1.05)	−0.0209 (−2.66)***
CONSTANT	1.1489 (0.55)	−3.1396 (−1.10)	−1.4934 (−0.47)	−0.5615 (−0.29)
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
No. of obs.	6,314	6,989	6,839	7,297
Adj. R^2	0.51	0.47	0.51	0.49

adoption in reducing synchronicity is insignificant for firms with low opacity before the XBRL adoption. In contrast, the coefficient on POST is negative and significant in column 2 (-0.3933, $t = -2.09$) in the subsample of firms with high opacity. Alternatively, we use the absolute value of discretionary accrual estimated from the modified Jones (1991) model to measure firms' accounting quality. A higher value of absolute discretionary accrual indicates high opacity. We again find that the effect of XBRL adoption on stock return synchronicity is significant only in the group of firms with high opacity (-0.1881, $t = -1.52$ in column 3; -0.2976, $t = -1.75$ in column 4). Evidence here supports Hypothesis 3 that the effect of XBRL adoption on stock return synchronicity is more pronounced in financially opaque firms.

2. Effect of XBRL Adoption Conditional on Firm Complexity

In addition to firms' financial opacity, we also investigate whether the effect of XBRL adoption varies due to firm complexity. Complex firms have financial information that is inherently more difficult to process and understand. Cohen and Lou (2011) show that, compared with a pseudo firm comprising the same set of business segments, complex firms have a significant stock price delay and hence higher return predictability. They further argue that firm complexity represents a significant market friction that deters information from being incorporated into stock prices.

To measure complexity, we rely on the number of a firm's business segments (Cohen and Lou (2011)). We retrieve business segment data from the Compustat segment database. Statement of Financial Accounting Standards (SFAS) No. 131 (Reporting Desegregated Information about a Business Enterprise) requires firms to report business segments that generate more than 10% of their total consolidated sales. The reported information includes each segment's total assets, sales, earnings, and cash flow from operation, among others. To ascertain the validity of the segment information, we keep observations only where the ratio of all segments' total sales divided by the firm's total reported sales ranges from 0.8 to 1.2. We then split the full sample into two subsamples. The first subsample contains firms that have only one business segment (less complexity), and the second subsample contains firms that have more than one business segments (more complexity). Segment information is restricted to fiscal years ending before June 15, 2009, so that the split is based on information before the XBRL mandate. Regressions are then estimated separately for the two subsamples.

We present results in Table 7. We find that the effect of XBRL adoption on stock return synchronicity is significant only in the subsample of firms with high operational complexity. Specifically, in the results reported in column 1 for single-segment firms, the coefficient on POST is negative and insignificant (-0.2521, $t = -1.54$), suggesting that XBRL adoption does not affect stock return synchronicity in firms with low operational complexity. In the results reported in column 2 for multiple-segment firms, the coefficient on POST is negative and significant (-0.3024, $t = -2.42$), suggesting that XBRL adoption reduces stock return synchronicity in firms with high operational complexity. Overall, the results discussed in this section support Hypothesis 4 that the effect of XBRL adoption on stock return synchronicity is more pronounced in complex firms.

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TABLE 7

The Effect of XBRL Adoption Conditional on Firm Complexity

Table 7 presents results of the effect of XBRL adoption on stock return synchronicity conditional on firm complexity. The sample consists of mandatory adopters for the period 2005–2012. The sample is split into two subsamples based on whether the firm has one or multiple business segments. In both columns, the dependent variable, $SYNC_{i,t}$, is firm i's stock return synchronicity in year t measured as $\ln[R^2/(1-R^2)]$, where R^2 is estimated from a regression of weekly stock returns on market and industry returns. $POST_{i,t}$ equals 1 if a firm-year is after a firm's XBRL adoption, and 0 otherwise. $SIZE_{i,t-1}$ is the natural log of a firm's market capitalization at the end of the previous fiscal year. $MB_{i,t-1}$ is market capitalization scaled by the book value of equity. $LEV_{i,t-1}$ is total long-term debt scaled by total assets. $ROA_{i,t-1}$ is income before extraordinary items divided by total assets. $N_IND_{i,t-1}$ is the natural log of the number of firms in the industry to which firm i belongs. $HERF_SALE_{i,t-1}$ is the sum of the squared terms of the proportion of a firm's revenue to total revenue in the industry to which firm i belongs. $STD_ROA_{i,t-1}$ is the standard deviation of the ratio between income before extraordinary items and total assets in the previous 5 years. $ANA_COV_{i,t-1}$ is the number of analysts issuing annual forecasts for the last fiscal year. t-statistics (reported in parentheses) are computed based on standard errors clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using 2-tailed tests.

	1 Segment	>1 Segment
Variables	1	2
POST	−0.2521	−0.3024
	(−1.54)	(−2.42)**
SIZE	0.5434	0.4772
	(7.43)***	(6.35)***
MB	0.0015	−0.0123
	(0.12)	(−0.71)
LEV	−0.2009	−0.6084
	(−0.51)	(−1.48)
ROA	0.5364	0.2413
	(2.15)**	(0.67)
N_IND	−0.3989	−0.8363
	(−0.68)	(−1.92)*
HERF_SALE	−0.6530	−0.5399
	(−0.22)	(−0.44)
STD_ROA	0.2431	0.1528
	(3.26)***	(1.02)
ANA_COV	−0.0148	0.0043
	(−1.84)*	(0.63)
CONSTANT	−3.7546	−0.7275
	(−1.18)	(−0.33)
Year fixed effects	Yes	Yes
Firm fixed effects	Yes	Yes
No. of obs.	6,700	5,979
Adj. R^2	0.48	0.51

F. Quasi-Regression–Discontinuity Design

So far, we have employed a difference-in-differences identification strategy (equation (2)) to test how XBRL adoption affects stock return synchronicity. Such a model has also been used in prior studies to identify the causal impact of regulations with a staggered adoption scheme, for example, the adoption of antitakeover provisions in different states in the 1980s (Bertrand and Mullainathan (2003)). However, there exists a concern for the difference-in-differences approach in that our treatment sample is not randomly selected. Instead, the selection is based on a certain firm attribute, public float, in XBRL adoption. Although firm size is observable and controlled, a concern remains because treatment and control firms are not perfectly comparable.

To resolve this issue, we adopt a quasi-regression–discontinuity design approach as used by Thistlethwaite and Campbell (1960). The underlying rationale

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of this design is that assignments near a cutoff can be viewed as random. Thus, a difference-in-differences approach using a subsample around a cutoff point can generate consistent estimates. We choose treatment firms and control firms with similar firm size.

We first identify firms that submit XBRL 10-K filings in year 2010, but not in year 2009.[5] These firms form our treatment group. For each treatment firm, we match with it a firm in the same industry (based on 2-digit SIC codes) with the closest market capitalization as of June 2009 and that did not submit XBRL 10-K filings in both 2009 and 2010. This firm serves as the control firm. To ensure similarity in firm size between the treatment and the control firms, we require the ratio of a control firm's market capitalization to its treatment firm's market capitalization to be within $[0.6 \sim 1.4]$.[6] We then construct the synchronicity measure within 3 months after the 10-K filing date. Following Crawford et al. (2012), we use daily return to construct the synchronicity measure due to insufficient number of weeks to estimate the regression. We then estimate the following difference-in-difference specification:

$$\begin{aligned}(5)\quad \text{SYNC_10K}_{i,t} &= b_0 + b_1\text{YR10}_t + b_2\text{TREAT}_i + b_3\text{YR10}_t \times \text{TREAT}_i \\ &\quad + \text{INDUSTRY_FIXED_EFFECTS} + \varepsilon_{i,t},\end{aligned}$$

where $\text{SYNC_10K}_{i,t}$ is a firm's stock return synchronicity during the 3 months after its 10-K filing date. YR10_t is an indicator that equals 1 for year 2010, and 0 for year 2009. TREAT_i is an indicator that equals 1 for a treatment firm, and 0 for its control firm.

To further address the possibility that firm size can have a nonlinear impact on the outcome, we apply a flexible functional form of firm size in the specification by including its higher-order terms (up to 4), following Iliev (2010). We also include control variables used in the baseline model (equation (2)):

$$\begin{aligned}(6)\quad \text{SYNC_10K}_{i,t} &= b_0 + b_1\text{YR10}_t + b_2\text{TREAT}_i + b_3\text{YR10}_t \times \text{TREAT}_i \\ &\quad + b_4\text{SIZE}_{i,t-1} + b_5\text{SIZE}^2_{i,t-1} + b_6\text{SIZE}^3_{i,t-1} + b_7\text{SIZE}^4_{i,t-1} \\ &\quad + b_8\text{MB}_{i,t-1} + b_9\text{LEV}_{i,t-1} + b_{10}\text{ROA}_{i,t-1} + b_{11}\text{N_IND}_{i,t-1} \\ &\quad + b_{12}\text{HERF_SALE}_{i,t-1} + b_{13}\text{STD_ROA}_{i,t-1} \\ &\quad + b_{14}\text{ANA_COV}_{i,t-1} + \text{INDUSTRY_FIXED_EFFECTS} + \varepsilon_{i,t}.\end{aligned}$$

Results in Table 8 show a consistent pattern. In column 1, we present results of the baseline estimation without control variables (equation (5)). The coefficient on YR10 × TREAT is negative and significant (-0.3999, $t = -2.80$). In column 2, we incorporate higher-order terms of firm size as control variables

[5]One challenge we face is the inappropriateness in using the yearly synchronicity measure (SYNC) for a difference-in-differences estimation within a 2-year period. For a firm adopting XBRL in 2009, its postadoption period is year 2010. However, a control firm with similar size is most likely adopting XBRL in year 2010, which would be excluded from the analysis because it contains both preadoption and postadoption periods. Acknowledging this difficulty, we follow Crawford et al. (2012) by using a 3-month period after a firm's 10-K filing as our synchronicity measurement period.

[6]Using an alternative range (e.g., $[0.7 \sim 1.3]$, $[0.5 \sim 1.5]$) provides qualitatively similar results.

TABLE 8

Quasi-Regression–Discontinuity Design

Table 8 presents results of the effect of XBRL adoption on stock return synchronicity using a quasi-regression–discontinuity design. We identify treatment firms as those that submit XBRL 10-K filings in year 2010, but not in year 2009. For each treatment firm, we match with it a control firm in the same industry with the most similar market capitalization as of June 2009 and that submits non-XBRL 10-K filings in both 2009 and 2010. To assure the comparability of firm size of the treatment and the control firm, we require the ratio of control firms' market capitalization to treatment firm's market capitalization to be within [0.6 ∼ 1.4]. We then construct synchronicity using daily stock returns within 3 months after the 10-K filing date. In all columns, the dependent variable, $SYNC_{i,t}$, is firm i's stock return synchronicity within 3 months after the 10-K filing date measured as $\ln[R^2/(1-R^2)]$, where R^2 is estimated from a regression of daily stock returns on market and industry returns. $YR10_t$ is an indicator that equals 1 for year 2010 and 0 for year 2009. $TREAT_i$ is an indicator that equals 1 for a treatment firm and 0 for its control firm. $SIZE_{i,t-1}$ is the natural log of a firm's market capitalization at the end of the previous fiscal year. $SIZE^2$, $SIZE^3$, and $SIZE^4$ are higher-order terms of SIZE. $MB_{i,t-1}$ is market capitalization scaled by the book value of equity. $LEV_{i,t-1}$ is total long-term debt scaled by total assets. $ROA_{i,t-1}$ is income before extraordinary items divided by total assets. $N_IND_{i,t-1}$ is the natural log of the number of firms in the industry to which firm i belongs. $HERF_SALE_{i,t-1}$ is the sum of the squared terms of the proportion of a firm's revenue to total revenue in the industry to which firm i belongs. $STD_ROA_{i,t-1}$ is the standard deviation of the ratio between income before extraordinary items and total assets in the previous 5 years. $ANA_COV_{i,t-1}$ is the number of analysts issuing annual forecasts for the last fiscal year. t-statistics (reported in parentheses) are computed based on standard errors clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using 2-tailed tests.

Variables	1	2	3
YR10	0.2457 (2.48)**	0.2364 (2.17)**	0.2402 (1.70)*
TREAT	0.4722 (4.16)***	0.4741 (3.95)***	0.4261 (3.36)***
YR10 × TREAT	−0.3999 (−2.80)***	−0.3979 (−2.70)***	−0.3752 (−2.52)**
SIZE	—	−8.0361 (−0.87)	−6.1256 (−0.66)
$SIZE^2$	—	1.6751 (1.02)	1.2891 (0.79)
$SIZE^3$	—	−0.1467 (−1.15)	−0.1136 (−0.90)
$SIZE^4$	—	0.0046 (1.28)	0.0036 (1.01)
MB	—	—	−0.0066 (−0.75)
LEV	—	—	0.9940 (2.35)**
ROA	—	—	0.4131 (1.02)
N_IND	—	—	−0.0351 (−0.02)
HERF_SALE	—	—	−4.6836 (−0.64)
STD_ROA	—	—	−1.0393 (−0.70)
ANA_COV	—	—	0.0128 (1.46)
CONSTANT	−0.1066 (−1.03)	13.1740 (0.70)	10.0766 (0.44)
Industry fixed effects	Yes	Yes	Yes
No. of obs.	576	576	576
Adj. R^2	0.33	0.33	0.35

and find consistent results on YR10 × TREAT (−0.3979, $t = -2.70$). Finally, in column 3, we add in all other control variables as in equation (6) and again find the coefficient on YR10 × TREAT to be negative and significant (−0.3752, $t = -2.52$). Taken together, evidence here establishes the robustness of our results and minimizes the concern over the possibility that such a regulation is not a purely exogenous event.

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G. Effect of XBRL Adoption on Stock Price Delay

Stock return synchronicity has been extensively used to proxy for informational efficiency in prior studies (Piotroski and Roulstone (2004), Hutton et al. (2009), Kim and Shi (2012), and Crawford et al. (2012)). Its ability to measure informational efficiency has received support in the literature (Durnev, Morck, Yeung, and Zarowin (2003), Durnev, Morck, and Yeung (2004)). However, such a measure is not without criticism (Li, Rajgopal, and Venkatachalam (2014)). Here, we look into an alternative dimension of informational efficiency.

Hou and Moskowitz (2005) suggest that the delay in stock prices' incorporation of information represents a significant friction in the capital market. Such a friction leads to anomalous behaviors such as the drift following an earnings announcement. Their measure of price delay relies on the relative R^2 from estimating two market models. The first model is a regression of stock returns on only current market returns, generating a restricted R^2. The second model is a regression of stock returns on current and historical market returns, generating an unrestricted R^2. If there is a significant price delay, the unrestricted R^2 will be significantly larger than the restricted R^2. PRICE_DELAY is measured as [1 − (RESTRICTED_R^2/UNRESTRICTED_R^2)]. For the purpose of our analysis, we also incorporate industry returns to be consistent with our measure of stock return synchronicity. First, we estimate equation (1) and define the estimated R^2 as RESTRICTED_R^2. In the second step, we estimate the following enhanced specification incorporating historical market and industry returns:

$$\text{RET}_{i,t} = \alpha_0 + \alpha_1 \text{RET_MKT}_t + \alpha_2 \text{RET_IND}_{i,t} + \alpha_3 \text{RET_MKT}_{t-1} + \alpha_4 \text{RET_IND}_{i,t-1} + \varepsilon_{i,t}. \tag{7}$$

We define the R^2 estimated from equation (7) as UNRESTRICTED_R^2. PRICE_DELAY is then measured as follows, where a higher value indicates more delay in stock prices:

$$\text{PRICE_DELAY} = 1 - \left[\frac{\text{RESTRICTED_}R^2}{\text{UNRESTRICTED_}R^2} \right]. \tag{8}$$

We replace SYNC with the price delay measure to determine whether XBRL adoption results in less price delay. Results in Panel A of Table 9 suggest that XBRL adoption significantly reduces firms' price delay because the coefficient on POST is negative and significant in column 1 (-1.7495, $t = -1.83$). We further control for the extent of a firm's exposure to market and industry information, measured as the absolute value of its market and industry betas. The coefficient on POST remains negative and significant (-1.8167, $t = -1.91$).

Next, we investigate whether such an effect is more pronounced in firms that are more likely to be affected by market and industry information. We split the sample into two subsamples based on the absolute value of each firm's market beta (ABS_BETA_MKT) and industry beta (ABS_BETA_IND). We use the absolute value of a firm's market and industry beta to capture its correlation with the market and industry. For firms with absolute market and industry betas that are lower than the sample median, we group them into the LOW subsample (low correlation with market- and industry-level information). For firms with absolute market and industry betas that are higher than or equal to the sample median, we

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group them into the HIGH subsample (high correlation with market- and industry-level information). We expect a more pronounced association between price delay and XBRL adoption in the HIGH subsample.

Results shown in Panel B of Table 9 are consistent with our expectations. Specifically, based on the market beta, the coefficient on POST is negative but insignificant in the LOW subsample (-0.8081, $t = -0.44$), whereas it is negative and significant in the HIGH subsample (-2.1105, $t = -2.04$). Based on the industry beta, the coefficient on POST is negative but insignificant in the LOW subsample (-1.3236, $t = -0.57$), whereas it is negative and significant in the HIGH subsample (-2.0053, $t = -2.26$). Collectively, results here suggest

TABLE 9

The Effect of XBRL Adoption on Stock Price Delay

Table 9 presents results of the effect of XBRL adoption on price delay. The sample consists of mandatory adopters for the period 2005–2012. In Panel A, we examine the unconditional XBRL effect for the pooled sample. In Panel B, we examine the XBRL effect conditional on stock comovement with market and industry returns. From a firm-year regression of weekly stock return on weekly market and industry return, we defined the absolute value of the coefficient on market (industry) return as ABS_BETA_MKT (ABS_BETA_IND). We split the sample into two subsamples based on the two variables' median value. In both Panel A and Panel B, the dependent variable, PRICE_DELAY, is computed as [1 − (RESTRICTED_R^2/UNRESTRICTED_R^2)], where RESTRICTED_R^2 is the R^2 of a regression of stock returns on current market and industry returns and UNRESTRICTED_R^2 is the R^2 of a regression of stock returns on current and past market and industry returns. $\text{POST}_{i,t}$ equals 1 if a firm-year is after a firm's XBRL adoption, and 0 otherwise. $\text{SIZE}_{i,t-1}$ is the natural log of a firm's market capitalization at the end of the previous fiscal year. $\text{MB}_{i,t-1}$ is market capitalization scaled by the book value of equity. $\text{LEV}_{i,t-1}$ is total long-term debt scaled by total assets. $\text{ROA}_{i,t-1}$ is income before extraordinary items divided by total assets. $\text{N_IND}_{i,t-1}$ is the natural log of the number of firms in the industry to which firm *i* belongs. $\text{HERF_SALE}_{i,t-1}$ is the sum of the squared terms of the proportion of a firm's revenue to total revenue in the industry to which firm *i* belongs. $\text{STD_ROA}_{i,t-1}$ is the standard deviation of the ratio between income before extraordinary items and total assets in the previous 5 years. $\text{ANA_COV}_{i,t-1}$ is the number of analysts issuing annual forecasts for the last fiscal year. *t*-statistics (reported in parentheses) are computed based on standard errors clustered at the firm level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, using 2-tailed tests.

Panel A. The Effect of XBRL Adoption on Stock Price Delay: Unconditional Effect

Variables	1	2
POST	−1.7495 (−1.83)*	−1.8167 (−1.91)*
ABS_BETA_MKT	—	0.5664 (2.29)**
ABS_BETA_IND	—	0.1696 (0.63)
SIZE	0.1924 (0.41)	0.2735 (0.58)
MB	0.1262 (1.58)	0.1193 (1.48)
LEV	1.8835 (0.81)	1.7692 (0.77)
ROA	4.4887 (2.12)**	4.7893 (2.25)**
N_IND	−2.6932 (−1.25)	−2.7921 (−1.29)
HERF_SALE	−9.5405 (−0.95)	−9.7203 (−0.96)
STD_ROA	0.1420 (0.37)	0.1522 (0.39)
ANA_COV	−0.0004 (−0.01)	−0.0042 (−0.12)
CONSTANT	10.0224 (0.89)	9.4274 (0.84)
Year fixed effects	Yes	Yes
Firm fixed effects	Yes	Yes
No. of obs.	15,992	15,992
Adj. R^2	0.05	0.05

(continued on next page)

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TABLE 9 (continued)

The Effect of XBRL Adoption on Stock Price Delay

Panel B. The Effect of XBRL Adoption on Stock Price Delay: Conditional on the Comovement with the Market and Industry

	ABS_BETA_MKT		ABS_BETA_IND	
Variables	LOW	HIGH	LOW	HIGH
POST	−0.8081 (−0.44)	−2.1105 (−2.04)**	−1.3236 (−0.57)	−2.0053 (−2.26)**
SIZE	−0.0080 (−0.01)	0.7183 (0.98)	−0.4510 (−0.50)	0.8369 (1.29)
MB	0.1147 (0.68)	0.1287 (1.05)	0.1344 (0.78)	0.0825 (0.70)
LEV	2.5699 (0.62)	1.3962 (0.38)	3.9485 (1.03)	−0.8219 (−0.22)
ROA	6.1039 (1.52)	3.7114 (1.18)	10.1805 (1.80)*	1.1056 (0.41)
N_IND	−1.2497 (−0.40)	−3.2824 (−0.88)	−2.8800 (−0.93)	−3.0633 (−0.72)
HERF_SALE	9.7659 (0.67)	−23.0755 (−1.02)	−6.2522 (−0.60)	−26.4805 (−1.23)
STD_ROA	1.0570 (0.61)	0.0786 (0.17)	1.1962 (0.71)	0.2482 (0.32)
ANA_COV	−0.0318 (−0.73)	−0.0321 (−0.43)	−0.0114 (−0.12)	−0.0288 (−0.67)
CONSTANT	1.6697 (0.11)	11.5407 (0.58)	14.0656 (0.88)	9.7849 (0.44)
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
No. of obs.	7,440	8,552	7,852	8,140
Adj. R^2	0.09	0.03	0.05	0.15

that XBRL adoption improves stock prices' informational efficiency as investors incorporate market and industry information at a higher speed after adoption. Such an effect is more pronounced in firms that are previously affected more by market- and industry-level information.

V. Conclusion

Information-processing cost leads to underinvestment in information production, and therefore deters market participants in their attempt to translate firm-specific information into security prices. We investigate this issue by analyzing how a reduction in information-processing cost affects stock return synchronicity, that is, the extent to which a firm's stock price comoves with the market and the industry. The higher is the level of stock return synchronicity, the less firm-specific information exists in firms' stock prices.

We make use of a natural experiment resulting from a recent mandate that U.S. firms be required to adopt XBRL when submitting filings (10K/Q, 8K filings, among others) to the SEC. XBRL filings make financial data standardized, tagged, and machine readable. The SEC expects such an adoption to significantly reduce market participants' information-processing cost and increase market efficiency.

We find that XBRL adoption significantly reduces adopters' stock return synchronicity. In addition, the effect of XBRL adoption largely applies to mandatory-adopting firms as compared with voluntary-adopting firms. We

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attribute this difference to a lax in the requirements of the voluntary program regarding the timeliness and reliability of the filings. The impact of XBRL adoption enhances over time because XBRL is a new technology in financial reporting and investors face a learning curve when using it. Conditional analyses further support the argument that information-processing cost is a major driving factor for the reduction in stock return synchronicity. The impact of XBRL adoption is more pronounced in financially opaque firms or complex firms, both of which are expected to benefit more from a reduction in information-processing cost. Our results are robust when we use an alternative measure of share prices' informational efficiency and when we require continuity in the size of adopters and nonadopters.

Our study provides empirical support for theoretical work of Grossman and Stiglitz (1980) and Sims (2003), (2006), who suggest that information-processing cost brings frictions to the information capitalization process, leading to a higher level of informational inefficiency. We make use of a setting that is relatively free of endogeneity and provide consistent results. In addition, our study is a timely feedback to the SEC that XBRL adoption affects the capital markets because market participants translate more firm-specific information into stock prices when information-processing cost is reduced.

Appendix. XBRL and Information-Processing Cost

This Appendix provides an example illustrating why eXtensible Business Reporting Language (XBRL) filings are machine readable and how they reduce information-processing costs. The first two figures present information extracted from the 2012 quarterly reports of Microsoft (Figure A1) and Apple (Figure A2). The figures show that accounting information on sales (revenue) is reported under different item names by the two firms. It is labeled "Revenue" by Microsoft but called "Net Sales" by Apple. Such a lack of conformity makes it difficult for computers to read these filings and generate decision-useful information.

FIGURE A1

Information Extracted from Microsoft's 2012 Quarterly Report

Figure A1 presents a snapshot of the part of Microsoft's quarterly report of Mar. 2012 that relates to information regarding the firm's quarterly revenue.

(In millions, except per share amounts) (unaudited)	Three Months Ended March 31	
	2012	2011
Revenue	$17,407	$16,428
Operating expenses:		
Cost of revenue	3,952	3,897
Research and development	2,517	2,269
Sales and marketing	3,414	3,393
General and administrative	1,150	1,160
Total Operating expenses	11,033	10,719
Operating income	6,374	5,709

Financial reporting using XBRL standardizes information in that items with the same economic meaning are labeled by a unique name for all firms. For example, the sales items in Figures A1 and A2 are labeled "SalesRevenueNet" in XBRL (see Figure A3 for a list of example taxonomies for financial statement items). Such standardization makes XBRL filings readable to computers.

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FIGURE A2

Information Extracted from Apple's 2012 Quarterly Report

Figure A2 presents a snapshot of Apple's quarterly report of June 2012 that relates to information regarding the firm's quarterly revenue.

	Three Months Ended	
	June 30, 2012	June 25, 2011
Net sales	$ 35,023	$ 28,571
Cost of sales	20,029	16,649
Gross margin	14,994	11,922
Operating expenses:		
Research and development	876	628
Selling, general and administrative	2,545	1,915
Total operating expenses	3,421	2,543
Operating income	11,573	9,379

FIGURE A3

A List of Example Taxonomies for Financial Statement Items

Figure A3 presents a list of example taxonomies for financial statement items under XBRL.

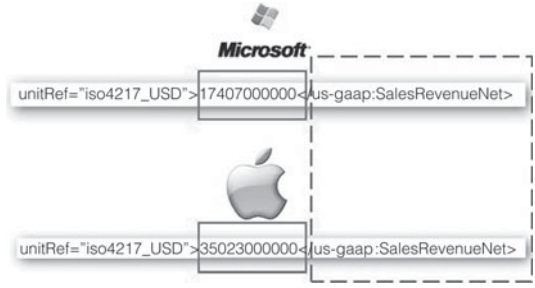
XBRL Element Name
usfr–pte:SalesRevenueNetGoods
usfr–pte:SalesRevenueNetServices
usfr–pte:SalesRevenueNet
usfr–pte:OperatingRevenue
usfr–pte:CostGoodsSold
usfr–pte:CostServices
usfr–pte:CostGoodsServicesSold
usfr–pte:GrossProfit
usfr–pte:SellingGeneralAdministrativeExpenses
usfr–pte:DepreciationAmortization
usfr–pte:RestructuringCharges

Finally, getting back to the example relating to Microsoft and Apple, the corresponding information on sales (revenue) in XBRL format is presented in Figure A4. In XBRL

FIGURE A4

Sales (Revenue) Information in XBRL Filings

Figure A4 presents information on the quarterly sales of Microsoft and Apple under XBRL. The top line was extracted from Microsoft's XBRL filing corresponding to the quarterly report of Mar. 2012. The bottom line was extracted from Apple's XBRL filing corresponding to the quarterly report of June 2012. The XBRL taxonomy corresponding to the financial statement item of sales (revenue) is "us-gaap:SalesRevenueNet."



filings, the information on sales (revenue) is now reported under the same item name (us-gaap:SalesRevenueNet).

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