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The deregulation of quarterly reporting and its effects on information asymmetry and firm value

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Abstract

In this article, we investigate accounting deregulation and analyze whether a reduction in the minimum content requirements for quarterly reporting negatively impacts information asymmetry and reduces firm value. Taking advantage of one of the rare deregulating measures, namely the transposition of the EU's Transparency Directive into German law, and using a novel dataset of firms listed on the Frankfurt Stock Exchange, we manually examine firms' quarterly reports for their content elements and construct a new quarterly reporting measure with an ordinal quality dimension. The results show that deregulation reverses beneficial regulatory effects and, on average, increases information asymmetry and decreases firm value. We find that this effect is stronger for first-tier stocks, highlighting the importance of quarterly reporting for these firms. The results are robust to potential selection effects regarding firms' choice of quarterly reporting content levels.

Keywords Quarterly reporting · Disclosure deregulation · Financial reporting · Interim management statement · Transparency directive

JEL classification G14 · G32

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1 Introduction

The consensus on mandating ever more disclosure is crumbling. While the academic literature has widely documented beneficial effects of increased disclosures (e.g., Leuz and Verrecchia 2000; Brown and Hillegeist 2007; Butler et al. 2007; Daske et al. 2008; Ernstberger et al. 2012; Fu et al. 2012), authorities have begun to retrench disclosure requirements amid criticisms of cost and complexity (Kraft et al. 2018; Kajüter et al. 2019). Most prominent are Singapore and the European Union (EU) in phasing out some quarterly reporting requirements.

Numerous empirical studies have shown that regulation that increases annual disclosures reduces information asymmetry and increases firm value (e.g., Botosan 1997; Leuz and Verrecchia 2000). The results have been similar for quarterly reporting, with some caveats. Studies show improved liquidity through higher reporting frequencies and content, although this involves additional preparation costs (e.g., Bushee and Leuz 2005; Iliev 2010; Brüggemann et al. 2017; Kajüter et al. 2019; Breuer 2021) or myopic management behavior (e.g., Kraft et al. 2018; Ernstberger et al. 2017; Fu et al. 2020). Overall, there seems to be a consensus that regulation in the form of expanded disclosures has had a positive impact on liquidity and firm value.

Nevertheless, it is by no means clear that deregulation—that is, a decreasing level of disclosure—will undermine the previously achieved benefits. The phenomenon of hysteresis (Christensen et al. 2016) even makes such a reversal unlikely or at least contestable. The empirical tax literature—to single out a phenomenon close to financial accounting—shows that the implementation and repeal of regulatory measures do not produce symmetrical effects (Heider and Ljungqvist 2015). In a similar vein, a reduction in the minimum content requirements for quarterly reporting could have zero or only a sluggish effect on information asymmetry and firm value. A firm's embrace of deregulation will not necessarily be seen as a market signal of reduced commitment to transparency or of low quality in a separating equilibrium. Investors may still feel sufficiently well informed or they may turn to additional informational channels that take over the function of mandatory reports.

Fu et al. (2012) examine voluntary retrenchments of quarterly reporting among firms in the US in the 1950s and 1960s and have found that a lower reporting frequency has no effect on information asymmetry. Lang and Stice-Lawrence (2015) have demonstrated that the mere existence of a disclosure instrument may not be sufficient for addressing how reduced quarterly reporting levels affect information asymmetries. Moreover, ample empirical studies have shown that capital market effects at a certain level of disclosure depend on firm characteristics such as firm size and analyst coverage (e.g., Bushee and Noe 2000; Lang and Lundholm 1996; Botosan 1997; Kajüter et al. 2019). Firm characteristics such as ownership concentration create firm-specific levels of agency costs, which imply different levels of informational demand (Jensen and Meckling 1976). Therefore, it is necessary to investigate whether capital market effects are stronger for firms with a high or low information demand.

In our empirical analysis, we consider effects of the 2015 transposition of the EU's Transparency Directive Amending Directive (2013/50/EU) into German law. The regulatory change resulted in the repeal of mandatory quarterly reporting, and the Frankfurt Stock Exchange (FSE) consequently mandated only what is called an interim management statement (IMS) for firms listed in the Prime Standard. While some firms preserved full quarterly financial reporting, others reduced the information provided for investors, constituting the quasi-natural experiment that we take advantage of in our empirical analysis.

Note that, statistically, firms' *ex-post* choice to adopt a certain level of disclosure is endogenous, but the *ex-ante* mandatory quarterly reporting constitutes an exogenous policy treatment, which is why we refer to the empirical setting as a quasi-natural experiment. Some firms that would otherwise have chosen a lower level of disclosure were exogenously forced to comply with higher levels of disclosure before the year 2016.

Most prior studies on quarterly reporting requirements assume a causal relationship between regulatory changes and capital market effects (Bushee and Leuz 2005; Iliev 2010; Fu et al. 2012; Ernstberger et al. 2017; Kajüter et al. 2019; Knappstein et al. 2020), whereas we follow the call of Leuz and Wysocki (2016) and first link the regulatory change to changes in firms' disclosure practices and then estimate capital market effects through the changes in disclosure. Because firms can circumvent the lifting of mandatory disclosure through voluntary disclosure, we also consider firms that voluntarily report the same level of information after the deregulation in 2015 as a control group. We follow previous research by manually constructing a disclosure measure (Botosan 1997; Francis et al. 2006). More precisely, we analyze the content elements of firms' quarterly reports from 2016 to 2019 and manually construct a new ordinal reporting measure that captures the quality of quarterly reports based on the previous requirements for mandatory quarterly reporting. We classify firms that continue to disclose a quarterly financial report according to the previous mandatory requirements into the highest quarterly reporting level. If quarterly information deviates from the previous mandatory requirements, firms publish an IMS. Because these types of reports can vary widely in content, we have further broken down the quarterly reporting level by examining the content of the IMS and assigned these reports to three quarterly reporting levels. This results in an ordinal measure of reporting content with four reporting levels.

Overall, our findings confirm that reduced quarterly disclosure on average increases information asymmetry and diminishes firm value. We thus show that the observed capital market effects do not result from deregulation itself but from firms' new disclosure practices. We evidence that mandatory quarterly reporting is overall beneficial for market participants. Our findings are also in line with the theoretical assumption that compliance costs, which are often argued to be burdensome especially for smaller firms (Leuz and Wysocki 2016), apparently do not exceed the benefits of steady information provision and enforcement.

We also document substantial heterogeneity with regard to informational demand. First-tier stocks display stronger effects for liquidity and firm value. Thus, we also extend previous research on disclosure regulation (e.g., Bushee and Noe 2000; Lang and Lundholm 1996; Botosan 1997; Kajüter et al. 2019) by showing that information asymmetry increases and firm value decreases for first-tier stocks, but not for firms that are smaller and less visible in the public eye. We also add to the understanding of the heterogeneity of regulatory action—namely, that quarterly reporting is more relevant for some stocks but not for others: first-tier stocks benefit from mandatory regulation, whereas reducing quarterly reporting is irrelevant for smaller and less visible firms. While in some areas we are in agreement with related recent literature, in many areas our results are very different. For example, our results partially contradict those of Knappstein et al. (2020), who find an increase in information asymmetries especially for small firms immediately after deregulation. Instead, our results are consistent with those of Kajüter et al. (2019), showing information benefits of mandatory quarterly reporting for larger, index-listed firms rather than small, non-index firms. Evidence by Hitz and Moritz (2019) that quarterly reporting has a negative impact on long-term investments and firm value is also not supported by our analysis. Furthermore, we find no evidence that managerial short-termism, which is often associated with

quarterly reports, leads to negative effects on the firm's value (Ernstberger et al. 2017; Kraft et al. 2018; Fu et al. 2020).

The remainder of the paper is structured as follows. In the next section, we provide an overview of the regulation of quarterly financial reporting in Germany. Section 3 reviews the literature and develops our hypotheses. Section 4 describes our data and method. Section 5 reports results of our analysis and Sect. 6 presents our conclusions.

2 Institutional framework

Quarterly reporting has a short tradition in Germany. German firms began publishing quarterly reports voluntarily only in the 1990s.¹ In 1998, quarterly reports became a regulatory requirement at the FSE for firms listed in the market segment "Neuer Markt." At this time, however, quarterly reports were not mandated by law. The Transparency Directive (2004/109/EC) ultimately harmonized the disclosure requirements for firms listed in a regulated market throughout the European Economic Area (EEA). In 2007, the transposition of this directive into German law required firms in the regulated market to publish quarterly information. The FSE expanded the quarterly reporting requirements to the publication of a full quarterly financial report for firms listed in the market segment "Prime Standard." Besides an interim management report, a full quarterly financial report must include a condensed financial statement in accordance with IAS 34, consisting of a condensed statement of financial positions, which includes a comprehensive income statement, a cash flow statement, a change in equity statement, and explanatory notes. The interim management report has to be prepared in accordance with German commercial law and contains information on significant opportunities and risks and their effect on the firm's future development as well as information on significant transactions with related parties.

Following criticism by the industry that the quarterly reporting requirements based on the Transparency Directive were too high and constitute a burden for small and medium-sized firms (European Commission 2013), the revised Transparency Directive (2013/50/EU) and its transposition into national law in 2015 resulted in a significant change in regular financial reporting. Disclosure requirements were drastically reduced by eliminating the obligation to publish quarterly information. The FSE responded with a deregulation of quarterly reporting and reduced the requirements regarding quarterly reporting. Now only an IMS for firms listed in the Prime Standard is required.

However, deregulation does not force firms to immediately change their prior reporting practice. Therefore, since 2016, firms listed in the Prime Standard have had various options for quarterly reports. To fulfill the minimum requirements, a descriptive presentation of the current business situation is sufficient. Firms may also voluntarily exceed the minimum requirements by reporting certain interim financial statement elements such as a condensed statement of financial positions, a comprehensive income statement, a cash flow statement, a change in equity statement, and explanatory notes. If all interim financial statement elements are included, the quarterly report constitutes an interim financial statement in accordance with IAS 34. Firms can voluntarily publish a complete quarterly financial report by adding an interim management report to the interim financial statement. Thus, the deregulation has left firms with a wide range of reporting options, ranging from

¹ For example, Volkswagen AG already published quarterly reports voluntarily in the 1990s.

a descriptive quarterly report to a complete quarterly financial report. This deregulation has given rise to major differences in quarterly reports among firms listed in the Prime Standard, constituting the variation we use to empirically investigate the capital market effects of firms' disclosure decisions.

3 Literature and hypotheses

3.1 Directly related literature

In two working papers and one recently published article, Knappstein et al. (2020), Hitz and Moritz (2019), and Bornemann et al. (2023) all document that the EU's deregulation of quarterly disclosures has resulted in higher information asymmetries. Knappstein et al. (2020) find that reduced quarterly reporting increases information asymmetries, which they measure by bid-ask spreads and price impact, for firms listed on the FSE. Their results indicate that the increase in information asymmetry is particularly strong for small firms. Bornemann et al. (2023) investigate firms listed on the Vienna Stock Exchange and find that firms reducing the extent of quarterly reporting experience significant increases in bid-ask spreads. Based on interviews, they also emphasize that management primarily considers the needs of key stakeholders with regard to disclosure, while the costs associated with higher levels of disclosure play only a minor role in the decision of how much to disclose. Hitz and Moritz (2019) focus on listed firms headquartered in the EU-15 and examine the impact of disclosure on liquidity and long-term investments. Their results suggest an increase in information asymmetries following the abolition of mandatory quarterly reporting, which, according to their empirical analysis, also prevails in the longer term. Although all three articles examine the same general phenomenon, they all contribute to the literature through their various perspectives, methodological approaches, and specific findings. We contribute to this literature with our own methodological approach, a unique measurement of the variable of interest, and some new results.

From a methodological point of view, an improvement in our study is that we first link the regulatory change to changes in firms' disclosure practices and then estimate capital market effects through the changes in disclosure. Moreover, with the exception of Bornemann et al. (2023), previous studies have used dichotomous measures to capture disclosure rather than testing a fine-grained ordinary quality dimension. For example, Hitz and Moritz (2019) only examine firms that have generally stopped quarterly reporting. Our analysis uses a finer measure of disclosure by taking into account the different quality dimensions of quarterly reporting. Specifically, we use an ordinal scale of information disclosure instead of a coarse dichotomous measure.

Previous studies are also limited to investigating short-term market effects. For example, Knappstein et al. (2020) consider the period between the publication of the quarterly report and the publication of the subsequent half-year report. Hitz and Moritz (2019) only observe a two-year period and achieve their significant sample size by considering firms from 15 European countries. Nevertheless, the reduction of the minimum content requirements for quarterly reporting could have a sluggish impact on firms, which is why we consider a period of four years after Germany's implementation of the Transparency Directive. Indeed, we find that more than two years after deregulation, companies are still making changes to their quarterly reporting strategies. As a result, the empirical evidence may generally differ over longer sample periods and for certain conditional statistical effects.

Finally, similar to Bornemann et al. (2023), our empirical results might have somewhat more external validity due to the significantly extended sample period.

3.2 Hypotheses

The underlying problem making financial reporting necessary is that insider information leads to information asymmetries in capital markets, which result in market inefficiency and, in the worst case, market failure (Glosten and Milgrom 1985; Kyle 1985). When less-informed investors are expected to trade with better-informed investors, they are no longer able to make efficient investment decisions (Kim and Verrecchia 1994; Easley and O'Hara 2004). As a result, they either exit the market or demand a price discount to compensate for their exposure to risk. Thus, adverse selection results in reduced liquidity because it becomes more difficult to trade shares quickly at low costs and with little price impact (Kyle 1985; Glosten and Milgrom 1985; Leuz and Verrecchia 2000; Leuz and Wysocki 2016). When the information acquisition of investors is viewed as exogenous, the relevance of financial reporting increases because it can reduce information asymmetries and the resulting adverse selection through the disclosure of information (Diamond 1985; Bushman 1991; La Porta et al. 2000).

The theoretical link between financial reporting and liquidity can also be extended to firms' cost of capital and firm value (Amihud et al. 2005). High bid-ask spreads and low liquidity impose higher trading costs, for which investors demand a compensation in equilibrium, which in turn increases the required return and cost of capital (Amihud and Mendelson 1986; Gârleanu and Pedersen 2004). The adverse selection problem also transfers to primary markets, because investors are less willing to pay for a security at the time at which the firm issues shares, resulting in lower firm value (Baiman and Verrecchia 1996; Verrecchia 2001). In addition to the liquidity channel, there is a direct link between disclosure and both cost of capital and firm value. Because of incomplete information, some investors are not able to consider all firms in the economy, resulting in inefficient and incomplete risk sharing. However, increased financial reporting of lesser-known firms can enrich a firm's investor base and improve risk sharing in the market, leading to lower cost of capital and higher firm value (Leuz and Wysocki 2016). There is also a direct link between disclosure and cost of capital arising from the estimation of risk (Brown 1979; Barry and Brown 1984, 1985). As the quality and quantity of firm-specific disclosure increase, uncertainty of future cash flows decreases, thereby moving the cost of capital closer to the risk-free rate and lowering betas (Lambert et al. 2007).

In recent decades, debate about the need to regulate corporate disclosures and, in particular, corporate quarterly reporting has intensified. While many scholars believe in the efficiency of markets (Sharpe 1964; Jensen 1968; Fama 1970), evidence indicates that markets do not always operate in the public interest (Gaffikin 2005). Examples of the need for regulatory intervention are the call for a mandatory quarterly reporting regime in the EU in the early 2000s, which led to the Transparency Directive in 2004, and calls by market participants for regulation of non-financial reporting (e.g., Jackson et al. 2020). The primary goal of disclosure requirements is to provide minimum information, in a timely manner, to parties that do not have access to information to make efficient decisions in financial markets (Financial Accounting Standards Board 2010).

Theory predicts both advantages and disadvantages of a mandatory reporting regime. On the one hand, by bringing a variety of information into a uniform format, disclosure regulation increases comparability and thus enables investors to allocate their capital more

efficiently (Beaver 1998). Moreover, mandatory quarterly reporting implies a commitment to reveal information in good times and bad times, which increases information flow (Mahoney 1995; Rock 2002). The mandatory character of disclosure reflects a low-cost commitment tool, because in the case of voluntary commitment, investors anticipate the residual of withheld information (Leuz and Wysocki 2008). On the other hand, mandatory quarterly reporting comes at a compliance cost to firms, which can be very high especially for smaller firms (Beaver 1998). Without mandatory regulation, disclosure would be more flexible and compliance costs lower for some firms. Nevertheless, market participants would in some cases be confronted with disclosure levels below minimum standards and large differences between quarterly reports in terms of their quality. Under a voluntary reporting regime, only market participants themselves can reward or penalize erroneous disclosures, for example, through their buying and selling decisions. Although theoretical arguments suggest that quarterly reporting is related to management myopia, leading to short-termism and a decline in investments (Gigler et al. 2014), the mandatory character of disclosure regulation offers access to penalties and remedies, which are limited or do not exist in private contracts (Leuz and Wysocki 2016). Costs from fraud and agency conflicts can thus be mitigated through the enforcement systems of mandatory disclosure. When information production is left to firms, there is also a risk of information over- or under-production that is not socially desirable (Beaver 1998; Healy and Palepu 2001; Leuz and Wysocki 2008). Nevertheless, it is to be expected that in the event of deregulation, firms will stick to the previously mandatory reporting obligations, because market participants would interpret the lack of information negatively (Dye 1985; Jung and Kwon 1988; Beyer et al. 2010).

While regulators strive to balance the costs and benefits of disclosure regulation, mandatory disclosure is particularly beneficial if firms are uniformly interested in disclosing information because, under these circumstances, the costs of compliance are lower for all firms (Leuz and Wysocki 2008). Furthermore, mandatory disclosure requirements are more beneficial if investors differ in their level of sophistication. Regulators may be concerned about the social welfare of investors and therefore use minimum disclosure requirements to narrow the information gap between informed and uninformed investors (Beaver 1998; Healy and Palepu 2001). Mandatory disclosure through standardization also reduces the information processing costs for investors in a similar vein, as accounting standards provide a generally accepted language for the communication between management and investors (Healy and Palepu 2001). Mandatory disclosure regulation can therefore attract additional investors to the market and increase the capital available to the firm, which ultimately reduces the cost of equity and increases firm value.

Consistent with the theoretical assumption that more disclosure increases liquidity, a wealth of literature documents a positive association between disclosure and liquidity, in terms of both content and frequency of disclosure (e.g., Healy et al. 1999; Bushee and Leuz 2005; Brown and Hillegeist 2007; Fu et al. 2012; Lang and Stice-Lawrence 2015). However, in the case of quarterly reporting, most empirical studies have examined the capital market effects of increased disclosure requirements (Butler et al. 2007; Fu et al. 2012; Kajüter et al. 2019); relatively few articles have studied the capital market effects of reduced levels of financial disclosure (for noteworthy exceptions, see Fu et al. 2012; Hitz and Moritz 2019; Knapstein et al. 2020). While Fu et al. (2012) find that an increase in reporting frequency is associated with lower information asymmetries, they cannot identify a significant change in information asymmetries for firms that voluntarily decrease their reporting frequency.

While lower quarterly reporting can be expected to increase information asymmetries, the effects of disclosure on cost of equity and firm value are less clear. Several studies demonstrate improved liquidity as a result of quarterly reporting but often at an additional cost to firms, as the cost of information gathering and of preparing a report result in reduced profits and, consequently, lower firm value (e.g., Bushee and Leuz 2005; Iliev 2010; Brüggemann et al. 2017; Kajüter et al. 2019; Breuer 2021). With respect to quarterly reporting in particular, Hitz and Moritz (2019) find an increase in long-term investments for firms that choose to stop quarterly reporting in the EU. In a similar vein, Kraft et al. (2018), Ernstberger et al. (2017), and Fu et al. (2020) document a positive relation between quarterly reporting and myopic managerial behavior. While these studies find that higher disclosure requirements for quarterly reporting lead to managerial myopia and have a negative effect on firm value, Greenstone et al. (2006) and Downar et al. (2018) document improved firm performance and/or firm value as a result of additional disclosure requirements.

The mixed results of empirical studies indicate that the theoretical debate over capital market effects of reduced mandatory disclosure is still unresolved and requires further empirical evidence. The current deregulation trend in quarterly reporting provides another piece of evidence that complements the many empirical studies investigating the capital market effects of tightening regulations. The majority of theoretical studies indicate that the accuracy and quantity of information provided to investors play a decisive role in reducing information asymmetries (Diamond and Verrecchia 1991; Kim and Verrecchia 1994; Easley and O'Hara 2004). Lang and Stice-Lawrence (2015) argue that a lower extent of information in annual reports and a reduced comparability leads to negative economic outcomes. As a result of the deregulation of quarterly reporting in 2015, firms can respectively reduce both the accuracy and quantity of information in quarterly reports. We expect that, on average, firms' quarterly reports are less accurate, provide less information to investors, and can no longer be easily compared with one another, requiring the provision of more private information to the market. Therefore, we hypothesize:

H1a Lower quarterly disclosure levels increase information asymmetry.

H1b Lower quarterly disclosure levels reduce firm value.

In addition to the general effects of lower quarterly disclosure on information asymmetries and firm value, it is unclear whether capital market effects of a lower disclosure level depend on specific firm characteristics. As previous research has shown, other factors such as firm size and analyst coverage can influence the relationship between lower quarterly reporting levels and information asymmetries and firm value, respectively (e.g., Lang and Lundholm 1996; Botosan 1997; Kajüter et al. 2019; Knapstein et al. 2020).

In theory, the capital market effects resulting from a mandatory quarterly reporting regime may be firm-specific. On the one hand, with mandatory quarterly reporting, lesser-known firms can credibly commit to a certain transparency level, making it easier for them to raise capital (Ferrell 2004; Leuz and Wysocki 2008). Because smaller firms are covered by fewer analysts (Bhushan 1989), they suffer from a weaker information environment, and therefore more quarterly reporting can increase their visibility in the capital market. On the other hand, a one-size-fits-all regulation of quarterly reporting may cause problems if the differences between firms are too great. For smaller firms, mandatory quarterly reporting can be overly burdensome due to high compliance costs such as preparation costs (Leuz and Wysocki 2016). Moreover, the shortage of financial analysts implies that information reaches investors in an unfiltered manner, which increases the ability and incentives among investors to acquire private information, resulting in higher information asymmetries (Lang and Lundholm 1996). Because of the concentrated ownership structure of small firms

(Demsetz and Lehn 1985), the content of quarterly reports only provides new information for a few investors, because large block holders typically have more timely access to superior information (Kajüter et al. 2019).

Larger firms with more public exposure can in theory show opposing capital market effects as a result of mandatory quarterly reporting. The impact of a lower quarterly reporting level on information asymmetries and firm value may be smaller due to their generally better information environment through greater analyst and media coverage (Collins et al. 1987; Bhushan 1989). Alternative information channels could reduce the relevance of quarterly reports in providing novel information (Brown and Hillegeist 2007). However, it may be precisely the large investor base and the high analyst and media coverage that create demand for more information (Firth 1979). According to agency theory, large firms have higher agency costs because they have more contracts that are also more complex and exhibit a more heterogeneous ownership structure than smaller firms (Jensen and Meckling 1976). Higher agency costs imply a higher demand for disclosure by larger firms because financial disclosure is a means by which managers' activity can be monitored and agency costs can be reduced (Jensen and Meckling 1976; Depoers 2000). Under the premise that larger firms use voluntary disclosure and continue to publish at the quarterly reporting level the same as under a mandatory quarterly reporting system, negative capital market effects due to withheld information could be avoided (Bertomeu and Cheynel 2013). By contrast, if these firms do not voluntarily disclose information and opt for a lower quarterly reporting level, the information supply to the capital market decreases, which would lead to negative capital market effects.

Empirical research suggests that firm size affects the impact of disclosure on capital market effects (Botosan 1997; Kajüter et al. 2019; Knappstein et al. 2020). Using a self-constructed disclosure index, Botosan (1997) finds a negative effect of disclosure on cost of equity for firms that are covered by fewer analysts, which highlights the importance of quarterly reporting for small firms. Brown and Hillegeist (2007) find that investor relations activities reduce information asymmetries as measured by the number of informed trades, which evidences the relevance of alternative disclosure activities. However, the transferability of the results to today's media environment is in doubt given the sample period from 1986 to 1996, because the higher frequency of information through media channels such as X (formerly known as Twitter) leads to more information supply and potentially also information overload among investors (Blankespoor et al. 2014; Rakowski et al. 2021). Knappstein et al. (2020) find that quarterly reporting is more important for small firms in Germany, which are prone to higher information asymmetries in the short run. Iliev (2010) and Kajüter et al. (2019) evidence that small firms incur relatively higher compliance costs as a result of increased reporting requirements, which in turn reduces their firm value. Regarding the capital market effects of disclosure requirements for large firms, Kajüter et al. (2019) find that large firms in Singapore with greater analyst coverage and more dispersed ownership experience informational benefits of mandatory quarterly reporting.

Because both the theoretical and empirical literature show differential effects for the relationship between firm characteristics and disclosure, further empirical evidence is needed. As mentioned above, firms only benefit from mandatory quarterly reporting if they have a rather similar interest in the disclosure of information (Leuz and Wysocki 2008). In 2019, 316 firms were part of the FSE's Prime Standard.² Some of these firms have

² Historical listings of the FSE's Prime Standard firms were collected from www.dax-indices.com.

additional listings, such as in the benchmark index DAX, as a result of their market capitalization, which indicates that firms that are part of a benchmark index are more homogeneous than the entire universe of Prime Standard firms. Because agency costs differ as a result of stronger differences in firm characteristics, we assume a more diverse demand for information from Prime Standard firms than from firms that are part of a benchmark index. Consequently, the firms of a benchmark index should benefit more from higher quarterly reporting because they have a more heterogeneous investor base and suffer on average from higher agency costs. The theoretical argument that the demand for information increases with increasing agency costs is also supported by Kajüter et al.'s (2019) empirical study, which suggests a greater relevance of quarterly reporting in terms of information benefits for larger firms. Consequently, we assume stronger capital market effects of reduced quarterly reporting levels for firms with a higher demand for information and higher agency costs. We therefore hypothesize:

H2 The increase in information asymmetry and the reduction in firm value are stronger for firms with a high demand for information.

4 Data and method

4.1 Data

We identified all firms that have been listed in the Prime Standard of the FSE from 2012 to 2019 and consider them in our empirical analysis. For price and accounting information, we use data from Thomson Reuters Datastream.³ To investigate firms' quarterly reporting level, we manually examined quarterly reports from firm websites. We collected patent data from lens.org to measure firms' innovation capacity. For our analysis of firms' information environment, we collected yearly information of index listings. Our final sample consists of 361 firms over the period 2012–2019, resulting in 2,005 firm-year observations. In addition to index listings, we collected the number of press releases and newswires for each firm from Lexis Nexis to investigate firms' media coverage.

4.2 Variables

4.2.1 Dependent variables

We test H1 by analyzing the effect of lower quarterly disclosure levels on information asymmetry (H1a) and firm value (H1b). H1a is specified by two common liquidity measures: the bid–ask spread and price impact. In line with Daske et al. (2008) and Ernstberger et al. (2012), we calculate daily relative bid–ask spreads as the mean of daily differences between bid and ask prices divided by their average $((ask - bid)/(ask + bid)/2)$. We use the relative spread because total spreads possibly increase as the price of the securities increases (Gros and Wallek 2015). Our second variable is price impact, which measures illiquidity by the capacity to trade stocks without affecting the price. We follow Daske

³ We use XETRA as a basis for price information.

et al. (2008) and Fu et al. (2012) in calculating price impact as the yearly median of the Amihud (2002) illiquidity measure.

We test H1b using two common measures of firm value. Our first measure is the market-to-book ratio (MTB), which is the ratio between the market value of a firm's equity to the book value of its equity. Assuming that lower information risk leads to lower cost of equity and/or higher expectations of future cash inflows, a higher ratio suggests a higher valuation. The second measure is Tobin's Q, which captures the ratio between the market value of a firm and the replacement costs of all assets. A higher ratio captures a greater willingness of investors to provide funds for shares, thereby suggesting a higher firm value.

We test H2 using our liquidity and firm valuation measures as dependent variables to identify possible differences in quarterly reporting levels for different information environments. All our dependent variables are winsorized at the top and bottom 1% to account for outliers.

4.2.2 Explanatory variables

To test H1a and H1b, we need an adequate measure for the quality and extent of firms' quarterly reporting. In early studies, disclosure scores were often subject to measurement error (Leuz and Wysocki 2016). To mitigate this problem, the capital market effect of regulatory changes was estimated directly and roughly with the regulatory change as such. However, this approach led to further statistical concerns, because capital market effects are possibly linked to unrelated shocks. We do not rely on these reduced-form approaches. Rather, we first link the regulatory change of the transposition of the EU's Transparency Directive into German law to changes in reporting. In a second step, we estimate the capital market effects, which enables us to explore the mechanisms through which these effects occur. We thus respond to the call by Leuz and Wysocki (2016) to provide further evidence that a regulatory change indeed operates through disclosure changes and not through an unobserved event at the time of the regulatory change.

Because no established measure for quarterly reporting quality exists in the literature, we follow earlier literature and establish a self-constructed disclosure measure (Botosan 1997; Francis et al. 2006). By focusing on quarterly reporting, which constitutes a specific type of disclosure, we construct a measure that has an ordinal quality dimension. Before deregulation, all firms listed in the FSE Prime Standard were required to publish a quarterly financial report, and a consistent quarterly reporting level was in place until 2015. Since the abolishment of mandatory quarterly financial reports, their content has been regulated in a more basic form. From 2016 onwards, only an IMS with a descriptive presentation of financial position and performance and an explanation of material events and transactions and their effect on the financial position of the business have been required. As a result, firms have greater freedom with regard to the content elements in quarterly reports, and they could in principle also stick with the previously mandatory highest quarterly reporting level. This is the variation we use in our empirical analysis and which we contrast with the earlier mandatory disclosure regime. We manually examined the quarterly reports of FSE Prime Standard firms for their content elements and coded the elements published in quarterly reports by firms from 2016 to 2019. To classify the content elements, we follow the former regulatory requirements for quarterly financial reports. In particular, we analyze whether quarterly reports contain the following elements: interim financial statement in accordance with IAS 34, balance sheet, income statement, statement of cash flows, statement of changes in equity, notes, and interim management report.

Definition of Quarterly Report	Content Level	Content Elements
Quarterly Financial Report	QLevel 4	Interim Financial Statement in accordance with IAS 34 and Interim Management Report
Quarterly Report	QLevel 3	Interim Financial Statement in accordance with IAS 34
Quantitative Interim Management Statement	QLevel 2	At least a condensed statement of financial positions, of income and of cash flows
Descriptive Interim Management Statement	QLevel 1	Less than a condensed statement of financial positions, of income and of cash flows

Fig. 1 Classification of quarterly reports. Classifications of Quarterly Reports were assigned by analyzing firms' quarterly reports from 2016 to 2019. Quarterly reports were obtained from firm websites. Prior to 2016, the disclosure of quarterly financial reports (QLevel 4) was mandatory for our sample firms

Consequently, we generate the variable *QLevel*, which takes values from 1 (low quarterly reporting level) to 4 (high quarterly reporting level). Firms' quarterly reports are classified at *QLevel 4* (Quarterly Financial Report) if an interim financial statement and an interim management report are included, which corresponds to the previous mandatory requirements. Where the previous mandatory elements are not included, the quarterly report is an IMS, which can differ considerably in terms of content. Therefore, reports that follow IAS 34 still include an interim financial statement and are classified at *QLevel 3* (Quarterly Report). Compliance with IAS 34 contributes to disclosure quality because it is an internationally recognized standard for interim financial reporting. If at least a balance sheet, an income statement, and a cash flow statement are included, the reports are classified at *QLevel 2* (Quantitative Quarterly Report). Reports with only two of the three elements are classified at *QLevel 1* (Descriptive Quarterly Report). Figure 1 gives an overview of the precise classification of *QLevel*.

To demonstrate the internal validity of *QLevel* as a measure of financial disclosure, we replicate other disclosure measures previously used in the literature and regress them on *QLevel*. First, we follow Knapstein et al. (2020) and construct a dummy variable that is equal to 1 if a firm published an Interim Financial Statement in accordance with IAS 34 as well as an interim management report, and 0 otherwise. In order to demonstrate the internal validity of *QLevel* in comparison to a cardinal scale, we used the overall number of pages in a firm's quarterly reports (see e.g., Hackston and Milne 1996; Hooks and van Staden 2011). In Table 9 of the Appendix we regress the alternative binary and cardinal measures of financial disclosure on *QLevel*. The R^2 value of 0.862 indicates that *QLevel* is highly correlated with established measures of financial disclosure, indicating that *QLevel* is a valid measure of financial disclosure.

To test H2, we need a measure that captures firms' demand for information. A large number of firm characteristics such as firm size, financial needs, and ownership structure determine the extent of agency costs and thus also the demand for information (Jensen and Meckling 1976). To examine whether capital market effects of quarterly reporting are

stronger for firms with high information demand, we consider a measure in which as many firm characteristics as possible are homogeneous for a subsample of firms, which indicates a higher demand for information provision. We regard one's listing in a benchmark index as such a measure. Based on market capitalization and stock exchange turnover, Prime Standard firms are entitled to be additionally listed in a benchmark index, such as DAX, MDAX, SDAX, or TecDAX, and thus receive greater visibility and public interest without having additional disclosure requirements. According to Botosan (1997), the listing in a benchmark index constitutes a valid proxy for the quality of the information demand because of the corresponding greater analyst coverage. Furthermore, we assume a more uniform firm size for index firms because the market capitalization is higher, and therefore the financial needs and ownership structure are also more similar for index firms. We therefore create the dummy variable *Index*, which is coded as 1 for firms that are part of an index and 0 otherwise. To test H2, we consider an interaction term of our variable of interest *QLevel* with the dummy variable *Index*.

In addition to the index listing, we use a second measure to test the information demand of firms as outlined in H2. Namely, we measure firms' media coverage using the information flow through press releases and newswires, which is a measure of the public's demand for information that goes beyond professional investors' information demand. If public interest is greater and media covers the firm to a greater extent, we can assume that firms are more similar in that regard. Moreover, public information demand potentially goes beyond the demand for information that is justified by agency costs resulting from contractual relations. We manually count the sum of press releases and newswires for each firm *i* in year *t* and generate the variable *High_MC*, which equals 1 if the respective firm operates in a news environment with above-median media coverage and 0 otherwise.⁴ Subsequently, we examine the interaction term of *QLevel* and *High_MC*.

Our third measure for the information environment of a firm is the number of analysts providing an estimate for the earnings per share. The variable *AnalystCoverage* captures the number of analysts following a firm. Furthermore, we generate the dummy variable *HighAnalystCoverage*, which equals 1 if the respective firm operates in an analyst's environment with above-median analyst coverage and 0 otherwise. In line with our procedure for *Index* and *High_MC*, we then test H2 through an interaction term with our variable of interest *QLevel*.

4.2.3 Control variables

In line with prior research (Leuz and Verrecchia 2000; Daske et al. 2008; Fu et al. 2012), we use firm size, share turnover, and return volatility as control variables when testing H1a. *Size* is the natural logarithm of the average market value of firms' equity for the prior calendar year. *Share turnover* is calculated as the natural logarithm of the yearly median value of daily share trading volume divided by the market capitalization on that day. *Return volatility* is the natural logarithm of the standard deviation of daily returns during the year.

We follow Daske et al. (2008) and Meser et al. (2015) in using firm size, firm growth, leverage, and return on equity (*ROE*) as a measure of profitability, as control variables when testing H1b. In line with Fu et al. (2012), we calculate leverage as the total liabilities

⁴ We use the median to compute this variable to account for potential outliers with a high number of press releases and newswires.

divided by the sum of total liabilities and beginning-of-year market value of equity.⁵ *ROE* is defined as a firm's net income divided by its total equity. We measure *firm growth* as the natural logarithm of 1 plus the percentage change in book value of equity.⁶ Furthermore, we use the share of institutional investors invested in the firm as a proxy for corporate governance, as management literature stipulates that institutional investors have a positive influence on corporate governance (e.g., Doidge et al. 2015; OECD 2011). We also consider a firm's innovation capacity, which could be hindered by frequent and comprehensive disclosure. Following Fu et al. (2020), we use the number of patent applications per year as a proxy for a firm's innovative capacity. All of our control variables are winsorized at the top and bottom 1% to account for outliers.⁷

4.3 Method

4.3.1 Baseline model

As a starting point, we estimate a pooled OLS regression explaining information asymmetry and firm value with quarterly reporting levels. Because the relation between our dependent and explanatory variables might depend on the particular information environment of a firm, we include index fixed effects. Our basic regression model is as follows:

$$DV_{Information\ Asymmetry_{it}/Firm\ Value_{it}} = \alpha + \beta_1 QLevel_{it} + \beta_2 Controls_{it} + \varepsilon_{it}, \quad (1)$$

where *DV* is the dependent variable measuring information asymmetry or firm value; *QLevel* is our variable of interest measuring the level of quarterly reporting; and **Controls** is a vector of control variables.

In the next step, we follow Fu et al. (2012) and control for time-invariant unobserved variation. A Hausman test (1978) indicates that random effects would be inconsistent, which is why we estimate a firm fixed effects regression.

4.3.2 Causal inference

Quarterly financial reporting in the Prime Standard is no longer mandatory after the year 2015; hence the observed level of quarterly reporting reflects firms' deliberate choices. Because only those firms that benefit the most from it might decide to reduce the content level of quarterly financial reporting, the pooled and panel regression estimates of *QLevel* potentially suffer from endogeneity in the form of selection bias. We address this concern in two ways: (1) we implement an instrumental variable (IV) approach, and (2) we generate an artificial control group of firms.

For the instrumental variable approach to be successful, we need to find a valid instrument. A valid instrument is strongly correlated with the endogenous variable (*relevance*), but uncorrelated with the error term (*exogeneity*). We follow Fu et al. (2012) and use Year Index as the instrumental variable, which is calculated as the absolute value of the calendar year of the respective quarterly report minus 2019, the year when

⁵ Results remain unchanged if we calculate leverage following Daske et al. (2008) as the ratio of total liabilities to total assets.

⁶ Results remain unchanged if we use asset growth as an alternative.

⁷ Results remain unchanged if we use unwinsorized values.

Panel A: Information Asymmetry Measures



Panel B: Valuation Measures

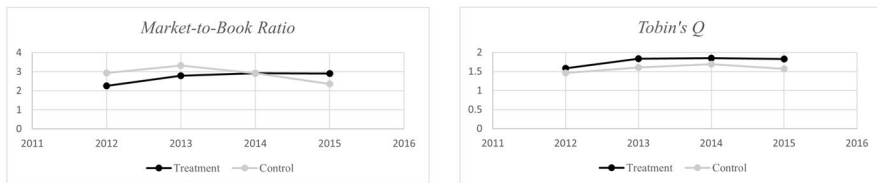


Fig. 2 Common trend assumption pre-period

our sample period ends. Thus, the Year Index is 0 for observations from the year 2019 and 7 for the year 2012. We assume that the FSE's action to abolish mandatory quarterly financial reporting starting in 2016 was to some degree unexpected and therefore led to decreasing quarterly reporting levels over time. This implies a positive relation between the quarterly reporting level $QLevel$ and the Year Index (*relevance*). At the same time, the year index should not systematically affect liquidity and firm value (*exogeneity*).

While the exogeneity assumption of the instrument cannot be statistically tested, we investigate the first-stage regression to test for the relevance of our instrument. We follow Stock and Yogo (2005) and test for the relevance of our instrumental variable by performing a Wald test. Our results lead us to reject the null hypothesis of weak instruments for both our information asymmetry and firm value models. In all cases, the resulting F-statistics are greater than 10, which indicates that the instruments have an influence on the endogenous variable that can be distinguished from 0. Thus, both tests suggest that we do not have a weak instrument problem. We therefore estimate two-stage least squares (2SLS) with standard errors clustered at the firm level.

Given that we cannot test whether the year index correlates with missing variables, we consider another way to establish causality. In line with Daske et al. (2008), we use a difference-in-differences approach to examine the change in information asymmetry and firm value. In a first step, we test the parallel trend assumption and compare differences between treatment and control firms that have not changed their quarterly reporting level for the period before and after the change in mandatory quarterly reporting, respectively. Treatment and control firms should share parallel trends in information asymmetry and firm value in the absence of treatment (Angrist and Pischke 2009). To analyze this assumption, we compute the mean values of our dependent variables for information asymmetry and firm value for each year of the pre-treatment period. Panel A of Fig. 2 shows the trend for bid-ask spread and price impact and panel B for MTB and Tobin's Q. The panels show parallel trends for all variables except MTB. The mean values of MTB show a somewhat larger decrease from 2014 to 2015 for the control group than for the treatment group. We test the difference in the decrease for MTB from

2014 to 2015 between the control and treatment groups and find no statistically significant differences ($p=0.861$).

While the parallel trends give us confidence that the difference-in-differences regression produces valid results, we use a matched control sample approach to provide further robustness for our identification strategy. Following Fu et al. (2012) and Knappstein et al. (2020), we generate an artificial control group using propensity score matching. The matched control sample compares changes in information asymmetry and firm value for firms that reduced their quarterly reporting level with otherwise similar firms that did not. Put differently, firms that have not changed their quarterly reporting level serve as a control group. We require the matched observations to have the same year–industry combination as the treatment observation, which allows us to capture intertemporal changes in industry- and market-wide factors. Furthermore, we match firms that are closest to the treatment observation in terms of firm size and use a one-to-many matching procedure to increase precision regarding the similarity in firm size.⁸ We also control for other possible time-variant drivers of information asymmetry and firm value by adding additional control variables such as size, share turnover, return volatility, the share of institutional investors, the number of analysts following, patent applications, leverage, *ROE*, and firm growth.

We estimate the following difference-in-differences regression:

$$DV = \alpha + \beta_1 Post_{it} + \beta_2 Treat_{it} + \beta_3 Post_{it} \times Treat_{it} + \beta_4 \mathbf{Controls}_{it} + \varepsilon_{it}, \quad (2)$$

where *DV* is our dependent variable measuring information asymmetry or firm value. *Post* equals 1 for the periods after the change in quarterly reporting level starting in 2016 and 0 otherwise. *Treat* equals 1 if the firm changed its quarterly reporting level and 0 otherwise. The interaction term produces our coefficient of interest, which represents the incremental effect of quarterly reporting on bid–ask spread, price impact, *MTB*, and *Tobin's Q* not resulting from time trends, firm size, and industry factors. **Controls** is a vector of control variables. We use robust standard errors to account for heteroscedasticity.

4.3.3 Interaction effects

To investigate H2, we interact our variable of interest *QLevel* with three dummy variables, which are proxy variables for the information environment. First, we use the dummy variable *Index*. The interaction between *QLevel* and the dummy variable *Index* captures the impact of the overall information environment on the effect of information disclosure. We further test H2 with the interaction of *QLevel* and *High_MC*, which captures the impact of quarterly reporting level conditional on the extent of media coverage and press releases. Lastly, we interact *QLevel* with the dummy variable *HighAnalystCoverage*, which indicates whether a firm receives above-median analyst coverage. We estimate the following regression:

$$DV_{IA/FV_{it}} = \alpha + \beta_1 QLevel_{it} + \beta_2 InteractionVariable_{it} + \beta_3 QLevel_{it} \times InteractionVariable_{it} + \beta_4 \mathbf{Controls}_{it} + \varepsilon_{it}, \quad (3)$$

where *DV* is our dependent variable measuring information asymmetry or firm value. *QLevel* and *InteractionVariable* in the form of *Index*, *High_MC*, and *HighAnalystCoverage*

⁸ Because control firms are a smaller group than the treatment firms, one-to-one matching would result in a stark loss of observations.

Table 1 Content elements of quarterly reports

Year	N	IAS 34 (%)	Balance sheet (%)	Income statement (%)	Cash flow statement (%)	Statement of changes in equity (%)	Notes (%)	Interim management report (%)
2012–2015	1005	100	100	100	100	100	100	100
2016	238	50	94	94	91	68	54	51
2017	239	40	92	91	86	58	42	41
2018	257	32	92	92	85	51	35	34
2019	265	27	90	90	82	46	30	31

The sample includes 2,005 firm-year observations for the period 2012–2019. Before deregulation, all firms were required to publish a quarterly financial report. From 2016 onward, quarterly reports were hand-collected from firm websites and manually examined for the following elements: interim financial statement in accordance with IAS 34, balance sheet, income statement, cash flow statement, statement of changes in equity, notes, and interim management report. The content elements included in quarterly reports for firm i in year t provide the database for the self-constructed explanatory variable *QLevel*

are the variables of interest and respectively capture the quarterly reporting level and whether firms are listed in a benchmark index or receive increased media or analyst coverage. Following Botosan (1997) and Burks et al. (2019), we include the two constitutive terms *QLevel* and, respectively, *Index*, *High_MC* and *HighAnalystCoverage* as explanatory variables in our model, because omitting the constitutive term will result in biased and inconsistent estimates (Greene 2003). **Controls** is a vector of control variables. All regressions include firm fixed effects, and standard errors are clustered at the firm level.

5 Results

5.1 Descriptive statistics

Table 1 presents the composition of the variable *QLevel*, which measures the content elements of quarterly reports for the sample firms. Because quarterly financial reporting was mandatory until 2015, all firms' quarterly reports from 2012 to 2015 contain all relevant content elements. Immediately after deregulation, we find that many firms chose to stop preparing interim financial statements in accordance with IAS 34. Nevertheless, most firms still prepared a balance sheet, income statement, and cash flow statement. In addition, half the firms immediately took advantage of the deregulation to dispense with condensed notes and an interim management report.

The change in disclosure practice was more or less persistent. As Fig. 3 shows, only about one fourth of all firms that decreased their level of disclosure in 2016 changed their level of disclosure again in the following years. However, this number includes firms that further decreased their level of disclosure. We only find three firms that increased their disclosure after decreasing it in 2016. Two out of these three firms go back to a disclosure of *QLevel* 4. One firm decreased its level of disclosure in 2016, increased it in 2017 and decreased it back to its 2016 level in 2018. Thus, firms that change their disclosure level multiple times represent exceptions in our sample, as only 4.71% of all firms change their disclosure level more than once.

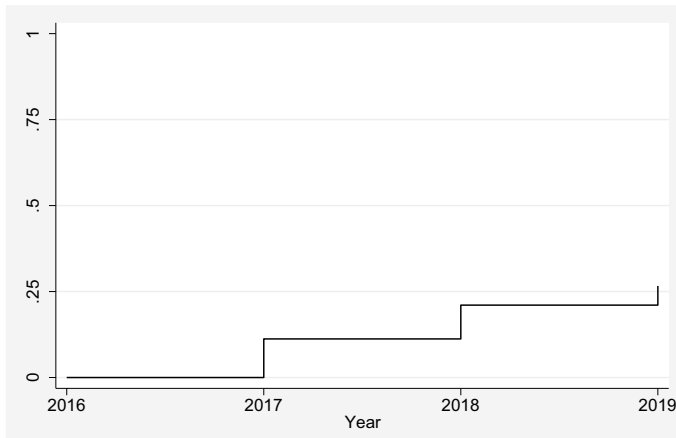


Fig. 3 Cumulative share of firms that again changed their level of disclosure after a decrease in 2016. Graph displays a Kaplan–Meier survivor cumulative hazard function. “Failure” is defined as an additional change in the level of disclosure after a decrease in 2016

Table 2 Quarterly reporting of prime standard firms

Year	N	<i>QLevel 1 (%)</i>	<i>QLevel 2 (%)</i>	<i>QLevel 3 (%)</i>	<i>QLevel 4 (%)</i>	<i>Mean QLevel</i>
2012–2015	1005	0.00	0.00	0.00	100.00	4.00
2016	238	10.08	40.76	4.62	44.54	2.84
2017	239	15.06	46.44	4.18	34.31	2.58
2018	257	15.18	52.14	3.50	29.18	2.47
2019	265	19.17	53.38	3.38	24.06	2.32

The sample includes 2,005 firm-year observations for the period 2012–2019. Quarterly reporting level data were hand-collected from firm websites and manually examined. *QLevel*=1 (%) indicates the percentage of firms with a descriptive quarterly report. *QLevel*=2 (%) indicates the percentage of firms publishing a quarterly report with at least a condensed statement of financial positions, of comprehensive income and of cash flows. *QLevel*=3 (%) indicates the percentage of firms publishing a quarterly report according to IAS 34. *QLevel*=4 (%) indicates the percentage of firms publishing a quarterly report according to IAS 34 and a management report according to German Commercial Law

Table 2 shows the distribution of firms in our sample by the content level of quarterly reports. In the period from 2012 to 2015, when quarterly financial reporting was mandatory for Prime Standard firms, all sample firms reported at the highest disclosure level. After the regulatory change in 2016, we observe a steady decline in reporting, with the exception of the condensed balance sheet and income statement. In 2019, only about one third of the firms listed in the FSE’s Prime Standard still prepared interim financial statements in accordance with IAS 34 and an interim management report. The mean value of *QLevel* after the year 2015 is 2.55 with a standard deviation of 1.09, which indicates that we have an adequate sample period and reasonable variation in firms’ quarterly reporting levels to capture potential inertia in disclosure changes.

Table 3 presents descriptive statistics. The mean values of our information asymmetry measures (bid–ask spread and price impact) are 0.971 and 9.213. The values are in line with other studies (Knappstein et al. 2020) and appear reasonable for firms listed in

Table 3 Descriptive statistics

	N	Mean	SD	p25	Median	p75
QLevel	1000	2.550	1.090	2	2	4
IA _{Spread}	2005	0.971	1.091	0.191	0.524	1.402
IA _{Price Impact}	2005	9.213	28.156	0.018	0.277	4.154
MTB	2005	2.902	4.714	1.119	1.793	3.028
TobinsQ	2005	1.767	1.788	1.035	1.283	1.816
Size	2005	5,033,659	13,448,520	122,744	457,292	2,391,526
LnTurnover	2005	-6.983	1.362	-7.806	-6.786	-5.975
LnVolatility	2005	-4.113	0.303	-4.311	-4.09	-3.891
LnLeverage	2005	-1.017	0.759	-1.374	-0.826	-0.458
ROE	1913	6.931	22.596	3.250	10.770	16.420
LnGrowth	2005	0.044	0.267	-0.017	0.054	0.124
InstitutionalInvestors	1899	0.029	0.051	0.000	0.000	0.050
AnalystsFollowing	1837	11.052	9.918	3.000	7.000	18.000
PatentApplications	1901	0.182	0.480	0.000	0.000	0.060

The sample includes 2,005 firm-year observations for the period 2012–2019. All variables are based on a calendar year. *QLevel* is the quarterly reporting level calculated by included content elements in quarterly reports as shown in Table 1 for the period 2016–2019. *IA_{Spread}* is the daily bid–ask spread calculated as the mean of daily differences between bid and ask prices divided by the mean of daily bid–ask spreads. *IA_{Price Impact}* is the price impact calculated as the yearly median of the Amihud (2002) illiquidity measure. *MTB* is the market-to-book ratio, calculated as the ratio between the market value of a firm's equity and the book value of its equity. *TobinsQ* is calculated as the ratio between the market value of a firm and the replacement costs of all assets. *Size* is the average market value of equity at the beginning and end of the prior calendar year. *LnTurnover* is computed as the log of the median of the euro value of all shares traded during the day divided by the market capitalization on that day. *LnVolatility* is the log of the standard deviation of daily returns during the year. *LnLeverage* is total liabilities divided by the sum of total liabilities and beginning-of-year market value of equity. *ROE* is return on equity. *LnGrowth* is the log of 1 plus the percentage change in book value of equity. *PatentApplications* is the number of patent applications. *InstitutionalInvestors* is the percentage share of institutional investors out of the total number of investors in the firm. *AnalystsFollowing* is the number of analysts giving an estimate on the earnings per share. The values of *IA_{Spread}* and *IA_{Price Impact}* are multiplied by 100 for expositional purposes. The values for *InstitutionalInvestors* and *AnalystsFollowing* are divided by 100 for expositional purposes.

the Prime Standard. Price impact, however, is high in comparison with older samples and international standards (Daske et al. 2008; Fu et al. 2012). Our measures for firm value, *Tobin's Q* and *MTB*, have mean values of 1.767 and 2.902. The mean balance sheet size (*Size*) is 5,033,659 EUR.⁹ Our control variables *LnVolatility* and *LnTurnover* have mean values of -4.113 and -6.983, which are comparable to the sample used by Fu et al. (2012). *ROE* has a mean value of 6.93%. The average share of a firm's total shares held by institutional investors was 2.9%. About eleven analysts provided estimates of a firm's earnings per share, and on average a firm filed 18 patents each year.

Table 4 reports Spearman and Pearson correlation coefficients for our dependent and explanatory variables. The correlation between the level of quarterly reporting and the variables measuring information asymmetry and firm value implies that information asymmetry is higher and firm value is lower for firms with a high quarterly reporting level. Our

⁹ To give an intuitive interpretation, we present unlogarithmised values of *Size* for the descriptive statistics.

Table 4 Spearman (lower diagonal) and Pearson (upper diagonal) correlation coefficients

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]
<i>QLevel</i> [1]	1.000	0.069	0.087	-0.059	-0.073	-0.002	0.021	0.078	0.082	0.009	0.001	-0.071	-0.041	0.051
<i>IA_{Spread}</i> [2]	0.030	1.000	0.770	0.053	0.021	-0.291	-0.667	0.333	-0.062	-0.267	-0.159	-0.244	-0.027	-0.606
<i>IA_{P1}</i> [3]	0.066	0.982	1.000	-0.018	-0.061	-0.118	-0.402	0.252	0.030	-0.181	-0.133	-0.112	-0.024	-0.282
<i>V_{MTB}</i> [4]	-0.141	-0.083	-0.110	1.000	0.871	0.018	-0.205	0.091	-0.465	-0.134	-0.147	-0.017	0.026	-0.046
<i>V_{TobinsQ}</i> [5]	-0.125	-0.051	-0.070	0.937	1.000	-0.006	-0.181	0.077	-0.671	-0.044	-0.042	-0.027	0.038	-0.071
<i>LnSize</i> [6]	-0.108	-0.878	-0.894	0.159	0.098	1.000	0.186	-0.267	0.112	0.088	0.007	0.370	0.050	0.589
<i>LnTurnover</i> [7]	0.028	-0.733	-0.748	-0.040	-0.039	0.457	1.000	0.089	0.137	0.083	0.083	0.186	0.084	0.560
<i>LnVolatility</i> [8]	0.058	0.369	0.334	0.007	0.031	-0.372	0.072	1.000	-0.117	-0.286	-0.126	-0.094	0.008	-0.301
<i>LnLeverage</i> [9]	0.068	-0.145	-0.143	-0.565	-0.745	0.109	0.160	-0.114	1.000	-0.035	-0.040	0.018	-0.082	0.182
<i>ROE</i> [10]	0.012	-0.235	-0.242	0.288	0.273	0.190	0.090	-0.261	-0.134	1.000	0.608	0.069	0.044	0.120
<i>LnGrowth</i> [11]	0.018	-0.108	-0.118	0.044	0.079	0.035	0.095	-0.075	-0.061	0.569	1.000	0.023	0.019	0.017
<i>PatentApplications</i> [12]	-0.029	-0.382	-0.394	0.154	0.156	0.367	0.320	0.033	-0.084	0.057	0.040	1.000	0.012	0.343
<i>InstitutionalInvestors</i> [13]	-0.056	-0.089	-0.098	0.151	0.143	0.049	0.139	-0.007	-0.085	0.054	0.017	0.025	1.000	0.025
<i>AnalystsFollowing</i> [14]	0.028	-0.887	-0.889	0.067	0.010	0.836	0.660	-0.282	0.194	0.128	0.008	0.385	0.078	1.000

two information asymmetry measures and the two firm value measures are respectively positively correlated, indicating that they are measuring the same theoretical concepts. In addition, the content level of quarterly reporting is weakly negatively correlated with *LnSize*, *LnLeverage*, *PatentApplications* and *InstitutionalInvestors*. *QLevel* is only weakly positively correlated with *LnTurnover*, *LnVolatility*, *ROE*, *LnGrowth* and *AnalystsFollowing*, indicating that multicollinearity is not a severe problem.

5.2 Regression results

Table 5 presents regression results for our information asymmetry measures with bid–ask spreads as the dependent variable in panel A and price impact as the dependent variable in panel B. The “Pooled” column reports results of the OLS regression with index fixed effects, the “Fixed Effects” column reports results from the OLS fixed effects panel regression, and “2SLS” reports the results of our IV fixed effects approach. In panel A, we find negative coefficients for our variable of interest *QLevel* across all regression models. Its value ranges from -0.037 to -0.079 , suggesting that bid–ask spreads increase between 0.037 and 0.079 when quarterly reporting levels decrease by one level. The coefficient of *QLevel* is significant at the 1% level for our pooled OLS, fixed effects panel, and IV regression. In line with our expectation that lower quarterly reporting level increases bid–ask spreads (Fu et al. 2012; Hitz and Moritz 2019; Knappstein et al. 2020), these results provide evidence that information asymmetry increases when quarterly reporting level decreases. All regressions show statistically significant coefficients for our control variables *LnSize*, *LnTurnover*, *LnVolatility* and *AnalystsFollowing* at the 1% or 5% level, implying that they provide a significant contribution in explaining bid–ask spreads. The significance of the control variable *AnalystsFollowing* underlines the importance of considering the information environment separately in H2. Overall, the signs of the coefficients are in line with prior literature (Daske et al. 2008; Fu et al. 2012; Ernstberger et al. 2012; Knappstein et al. 2020).

In panel B, coefficients of *QLevel* in the OLS regressions are negative and significant at the 5% level for our fixed effects panel and IV regression. The statistically significant control variables have a similar impact and direction as in panel A. However, the signs of *InstitutionalInvestors* and *PatentApplications* change in panel B, and the coefficients are no longer significant. Hence, with regard to *bid–ask spreads* and *price impact*, we find a negative effect for firms that reduce the accuracy and quantity of information in quarterly reports in response to deregulation, which is in line with H1a (Fu et al. 2012; Knappstein et al. 2020).

Our findings are thus consistent with prior studies showing higher information asymmetries for firms that have eliminated quarterly reports in response to deregulation in the EU (Hitz and Moritz 2019; Knappstein et al. 2020). They are also consistent with results that highlight the relevance of accuracy and quantity of information to mitigate information asymmetries (Lang and Stice-Lawrence 2015). Our findings indirectly contrast with theoretical and empirical evidence that quarterly reporting increases private information in the market (Brown and Hillegeist 2007). Rather, less detailed quarterly reports lead to higher information asymmetries, presumably causing some investors to gather private information. Thus, we find evidence for and thus cannot reject H1a.

While an increase in information asymmetry is also evident in prior research, the question remains whether increased liquidity comes at the cost of reduced firm value

Table 5 Information asymmetry models

Panel A: bid-ask spread as dependent variable				Panel B: price impact as dependent variable			
$IA_{Spread}/IA_{Price\ Impact} = \alpha + \beta_1 QLevel_{it} + \beta_2 LnSize_{it} + \beta_3 LnTurnover_{it} + \beta_4 LnVolatility_{it} + \beta_5 InstitutionalInvestors_{it} + \beta_6 AnalystsFollowing_{it} + \beta_7 PatentApplications_{it} + \epsilon_{it}$							
Variable	Pooled	Fixed effects	2SLS	Variable	Pooled	Fixed effects	2SLS
<i>QLevel</i>	−0.037*** (0.005)	−0.042*** (0.014)	−0.079*** (.019)	<i>QLevel</i>	−0.648 (0.387)	−1.232** (0.606)	−1.609** (0.798)
<i>LnSize</i>	−0.387** (0.088)	−0.327*** (0.029)	−0.399*** (0.013)	<i>LnSize</i>	−9.373** (3.04)	−6.267*** (1.193)	−9.647*** (0.549)
<i>LnTurnover</i>	−0.497** (0.111)	−0.381*** (0.034)	−0.503*** (0.012)	<i>LnTurnover</i>	−11.544** (3.82)	−8.453*** (1.814)	−11.675*** (0.520)
<i>LnVolatility</i>	0.906* (0.390)	0.599*** (0.074)	0.918*** (0.042)	<i>LnVolatility</i>	23.886 (13.412)	14.156*** (2.807)	24.153*** (1.804)
<i>InstitutionalInvestors</i>	0.070 (0.284)	0.280 (0.264)	0.027 (0.217)	<i>InstitutionalInvestors</i>	−3.178 (8.439)	9.720 (12.422)	−4.160 (9.364)
<i>AnalystsFollowing</i>	0.021** (0.005)	0.011*** (0.003)	0.023*** (0.003)	<i>AnalystsFollowing</i>	0.794* (0.349)	0.464*** (0.124)	0.836*** (0.117)
<i>PatentApplications</i>	−0.014 (0.016)	0.049*** (0.016)	−0.020 (0.025)	<i>PatentApplications</i>	0.077 (0.827)	1.219** (0.476)	−0.064 (1.068)
<i>Fixed Effects</i>	<i>Index</i>	<i>Firm</i>	<i>Index</i>	<i>Fixed Effects</i>	<i>Index</i>	<i>Firm</i>	<i>Index</i>
<i>R² (overall)</i>	0.721	0.707	0.719	<i>R² (overall)</i>	0.286	0.278	0.284
<i>R² (within)</i>	0.600	0.422	0.593	<i>R² (within)</i>	0.303	0.125	0.302
<i>R² (between)</i>	0.825	0.743	0.824	<i>R² (between)</i>	0.675	0.367	0.675
F-statistic/Wald Chi ²	0.459	32.81	9175.99	F-statistic/Wald Chi ²	19.87	5.45	1058.89
<i>N</i>	1807	1807	1807	<i>N</i>	1807	1807	1807

The regressions include 1,807 firm-year observations for the period 2012–2019. IA_{Spread} (Panel A) and IA_{PI} (Panel B) are our measures of information asymmetry. The “Pooled” column reports the results based on OLS regressions. The “Fixed Effects” column reports the results based on OLS regression with index fixed effects. The “2SLS” column reports results based on simultaneous estimated two-stage least squares approach for panel data with firm fixed effects. The table reports OLS, fixed effects and 2SLS estimates and, in parentheses, robust standard errors for the OLS and clustered standard errors at the firm level for fixed effects and 2SLS estimates. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels (two-tailed), based on *t*-statistics

(Bushee and Leuz 2005; Iliev 2010; Breuer 2021). Table 6 reports the results of our firm value models with *MTB* as the dependent variable in panel A and *Tobin's Q* as the dependent variable in panel B. In panel A, we find a positive relationship between *MTB* and our variable of interest *QLevel* in all regression models. In the preferred IV regression, the coefficient is significant at the 1% level. As expected, the effect of quarterly reporting level on firm value is positive and a decrease in the quarterly reporting level by one reduces *MTB* by between 0.185 and 0.812. Hence, our results evidence a decrease in firm value if quarterly reporting level declines. Our control variables show robust signs across all regression models and are mostly statistically significant at the 1% and 5% levels. While the negative effect of *LnLeverage* and *LnGrowth* on valuation can be attributed to the possible uncertainty of firms with a high leverage and growth firms, the negative sign of *ROE* is rather unexpected. In Appendix Table 10 we have therefore excluded *ROE* and repeated the regression. The results for *QLevel* remain consistent with our full model including *ROE*.

Using *Tobin's Q* as the dependent variable in panel B, our variable of interest *QLevel* is again positive across all models. Most importantly, the coefficient of *QLevel* is significant at the 1% level in the preferred IV regression. Its value ranges between 0.057 and 0.265, indicating that *Tobin's Q* decreases between 0.057 and 0.265 if quarterly reporting declines by one. The coefficients of our control variables are mostly statistically significant for the IV regression at the 1% and 5% levels, and signs are consistent with theoretical predictions. *LnGrowth* is statistically significant across all models in panel A, while *LnLeverage* is generally statistically significant in both panels and across all models.

Overall, results for our firm value models are in line with our theoretical expectation, indicating that a lower level of quarterly reporting decreases information in the market after all. The decrease in information leads to an increase in the cost of equity and investors demanding a higher-risk premium (Daske et al. 2008; Ernstberger et al. 2012). Our results indirectly show that increased liquidity does not come at the cost of reduced firm value (Bushee and Leuz 2005; Iliev 2010; Breuer 2021). Evidence by Hitz and Moritz (2019) that quarterly reporting has a negative impact on long-term investments and firm value is not supported by our analysis. Moreover, our firm value results give no indication of managerial short-termism, which is often associated with quarterly reporting (Ernstberger et al. 2017; Kraft et al. 2018; Fu et al. 2020). Rather, our results are consistent with Greenstone et al. (2006) and Downar et al. (2018), who also find an increase in firm value due to additional disclosure requirements. Following these results, H1b is supported by evidence that lower quarterly reporting levels lead to lower firm value.

In general, while previous studies relate capital market effects directly to the regulatory change, we link the observed capital market effects to the extent of reduced quarterly reporting levels subsequent to deregulation. Our results reveal an increase in information asymmetry and a decrease in firm value for firms with lower quarterly reporting levels. Therefore, we find evidence that mandatory quarterly reporting is beneficial for market participants overall. Eliminating the cost of compliance is apparently not sufficient to outweigh the positive impact of having to provide information on an ongoing basis.

Table 6 Firm value models

Panel A: market-to-book ratio as dependent variable				Panel B: Tobin's Q as dependent variable			
$V_{MTB}/Tobin's\ Q = \alpha + \beta_1 QLevel_{it} + \beta_2 LnLeverage_{it} + \beta_3 LnSize_{it} + \beta_4 LnGrowth_{it} + \beta_5 ROE_{it} + \beta_6 InstitutionalInvestors_{it} + \beta_7 AnalystsFollowing_{it} + \beta_8 PatentsApplications_{it} + \epsilon_{it}$							
Variable	Pooled	Fixed effects	2SLS	Variable	Pooled	Fixed effects	2SLS
<i>QLevel</i>	0.195* (0.089)	0.185 (0.121)	0.812*** (0.148)	<i>QLevel</i>	0.057* (0.025)	0.069	0.265*** 0.048
<i>LnLeverage</i>	-2.762** (0.673)	-2.562** (1.301)	-2.795*** (0.129)	<i>LnLeverage</i>	-1.557*** (0.219)	-1.482*** 0.447	-1.569*** 0.042
<i>LnSize</i>	1.153** (0.37)	0.779 (0.486)	1.307*** (0.096)	<i>LnSize</i>	0.366* (0.142)	0.232	0.418*** 0.031
<i>LnGrowth</i>	-1.541** (0.406)	-3.101*** (0.729)	-1.465*** (0.441)	<i>LnGrowth</i>	-0.109 (0.127)	-0.412** 0.188	-0.083 0.143
<i>ROE</i>	-0.024 (0.012)	0.009 (0.010)	-0.026*** (0.005)	<i>ROE</i>	-0.006 (0.005)	0.001 0.003	-0.007*** 0.002
<i>InstitutionalInvestors</i>	0.948 (1.913)	-2.247 (3.414)	1.658 (1.784)	<i>InstitutionalInvestors</i>	-0.091 (0.819)	-0.554 1.173	0.148 0.578
<i>AnalystsFollowing</i>	-0.091 (0.051)	-0.054** (0.027)	-0.111*** (0.021)	<i>AnalystsFollowing</i>	-0.030 (0.019)	-0.009 0.008	-0.037 0.007
<i>PatentApplications</i>	-0.509 (0.422)	-0.015 (0.149)	-0.424** (0.202)	<i>PatentApplications</i>	-0.235 (0.137)	-0.043 0.04	-0.206 0.065
<i>Fixed Effects</i>	<i>Index</i>	<i>Firm</i>	<i>Index</i>	<i>Fixed Effects</i>	<i>Index</i>	<i>Firm</i>	<i>Index</i>
R^2 (overall)	0.275	0.257	0.252	R^2 (overall)	0.488	0.472	0.468
R^2 (within)	0.313	0.250	0.294	R^2 (within)	0.505	0.380	0.490
R^2 (between)	0.173	0.221	0.218	R^2 (between)	0.241	0.474	0.140
F-statistic/Wald χ^2	5.43	5.43	1846.48	F-statistic/Wald χ^2	42.00	11.71	5477.92
<i>N</i>	1806	1806	1806	<i>N</i>	1806	1806	1806

The regressions include 1,806 firm-year observations for the period 2012–2019. V_{MTB} (Panel A) or $V_{Tobin's\ Q}$ (Panel B) are our measures for firm valuation. The “Pooled” column reports the results based on OLS regressions. The “Fixed Effects” column reports the results based on OLS regression with firm fixed effects. The “2SLS” column reports results based on simultaneous estimated two-stage least squares approach for panel data with index fixed effects. The table reports OLS, fixed effects and 2SLS estimates and, in parentheses, robust standard errors for the OLS and clustered standard errors at the firm level for fixed effects and 2SLS estimates. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels (two-tailed), based on *t*-statistics

5.3 Robustness

To test the robustness of our results and to consider possible endogeneity concerns, we adopted a matched control sample approach. Panel A of Table 7 reports the results of our information asymmetry measures, bid–ask spread and price impact. We find significant, positive coefficients for the interaction term in the bid–ask spread and price impact regression, which provides some evidence that the increase in information asymmetry is not exclusively due to selection effects. Thus, firms opting for a lower quarterly reporting level show higher bid–ask spreads and price impact than control group firms, which indicates higher information asymmetries. This result provides evidence in line with H1a.

Panel B of Table 7 shows the results for our valuation measures *MTB* and *Tobin's Q*. The interaction term is not statistically significant, indicating that deregulation has no impact on firm value itself. In Table 11, this result remains consistent even after the exclusion of the unexpected negative coefficient for ROE. We consider at least three explanations for this. First, because here we are investigating the regulatory change as such rather than the change in firms' quarterly reporting, the non-significant results might be due to confounding effects. Second, the matching procedure has reduced the sample size, which negatively affects the power of our statistical analysis. Third, according to Fu et al. (2012), market participants perceive an increase in reporting as a permanent change, but a reduction in reporting only as a temporal policy measure. Nevertheless, our results provide evidence of higher information asymmetries among firms that reduce their quarterly reporting level (H1a) but do not provide additional evidence of reduced firm value (H1b).

5.4 Information environment

In this section, we examine whether giving firms more leeway with regard to disclosure is an efficient alternative to mandatory disclosure. First, in all of our models, we controlled for the information environment using *AnalystsFollowing* and found a statistically significant positive impact of our dependent variables for information asymmetry (Tables 5 and 7 panel A). For our measures of firm value, we find statistically significant negative effects for the number of analysts covering a firm. Second, we test the impact of the information environment as an interaction effect with *QLevel*. Our variables of interest are therefore the interaction term between the quarterly reporting level (*QLevel*) and, respectively, index membership (*Index*), above-median media coverage (*High_MC*), and above-median analyst coverage (*HighAnalystCoverage*).

Table 8 reports the results of our regressions with information asymmetry measures as the dependent variable in panel A and firm value measures as the dependent variable in panel B. In panel A, we find that the coefficient of *QLevel* × *Index* has a negative value of -0.050 for *bid–ask spreads* and is statistically significant at the 5% level. For our second measure, *price impact*, we also find a negative effect of quarterly reporting level on *price impact* if the firm is part of an index. The coefficient of *QLevel* × *Index* has a value of -1.814 and is significant at the 10% level. Both coefficients of *QLevel* are non-significant in our regressions with *bid–ask spreads* and *price impact*, indicating that for the non-index firms in our sample, information asymmetries are unrelated to quarterly reporting levels. In Table 8, this finding is further confirmed when we include all measures for the information environment, where we find a significant negative effect for the interaction term *QLevel* × *Index*, but not for *QLevel* itself. The more concentrated ownership structure of non-index firms is a plausible explanation for why we do not observe any drawbacks of lower levels of quarterly financial reporting (Jensen and Meckling 1976; Kajüter et al. 2019).

Table 7 Matching model

Panel A: information asymmetry measures			Panel B: valuation measures		
$IA_{Spread, Price Impact} = \alpha + \beta_1 Post_{it} + \beta_2 Treat_{it} + \beta_3 Post \times Treat_{it} + \beta_4 LnSize_{it} + \beta_5 LnTurnover_{it} + \beta_6 LnVolatility_{it} + \beta_7 InstitutionalInvestors_{it} + \beta_8 AnalystsFollowing_{it} + \beta_9 PatentsApplications_{it} + \varepsilon_{it}$			$V_{MTB, TobinQ} = \alpha + \beta_1 Post_{it} + \beta_2 Treat_{it} + \beta_3 Post \times Treat_{it} + \beta_4 LnSize_{it} + \beta_5 LnLeverage_{it} + \beta_6 ROE_{it} + \beta_7 LnGrowth_{it} + \beta_8 InstitutionalInvestors_{it} + \beta_9 AnalystsFollowing_{it} + \beta_{10} PatentApplications_{it} + \varepsilon_{it}$		
Variable	IA_{Spread}	IA_{PI}	Variable	V_{MTB}	V_{TobinQ}
Post	-0.021 (0.058)	-6.107*** (2.259)	Post	-0.905** (0.431)	-0.259* (0.141)
Treat	-0.200*** (0.051)	-9.499*** (2.316)	Treat	-0.322 (0.346)	0.022 (0.116)
Post × Treat	0.166*** (0.062)	9.148*** (2.472)	Post × Treat	0.509 (0.374)	0.051 (0.131)
LnSize	-0.353*** (0.015)	-6.334*** (0.674)	LnSize	0.830*** (0.233)	0.289*** (0.078)
LnTurnover	-0.471*** (0.016)	-8.367*** (0.716)	LnLeverage	-2.555*** (0.295)	-1.483*** (0.115)
LnVolatility	0.829*** (0.060)	18.603*** (2.612)	ROE	-0.019** (0.009)	-0.005 (0.003)
InstitutionalInvestors	0.328 (0.260)	4.798 (12.492)	LnGrowth	-1.570** (0.657)	-0.193 (0.196)
AnalystsFollowing	0.042*** (0.003)	1.214*** (0.137)	InstitutionalInvestors	0.402 (1.357)	-0.021 (0.485)
PatentApplications	0.060*** (0.024)	1.675*** (0.602)	AnalystsFollowing	-0.113*** (0.040)	-0.037*** (0.013)
			PatentApplications	-0.342** (0.168)	-0.188*** (0.043)
R^2	1473	1473	R^2	0.306	0.501
F-statistics	0.475	18.67	F-statistics	19.09	42.71
N	1473	1473	N	1472	1472

Table 8 Effect of information environment

Panel A: information asymmetry measures

$IA_{Spread, Price Impact} = \alpha + \beta_1 QLevel_{it} + \beta_2 LnSize_{it} + \beta_3 LnTurnover_{it} + \beta_4 LnVolatility_{it} + \beta_5 InstitutionalInvestors_{it} + \beta_6 PatentApplications_{it} + \beta_7 InteractionVariable + \beta_8 QLevel \times Interaction Variable + \varepsilon_{it}$						
Interaction variable	Index		High_MC		AnalystsFollowing	
Dependent variable	IA_{Spread}	IA_{PI}	IA_{Spread}	IA_{PI}	IA_{Spread}	IA_{PI}
<i>QLevel</i>	-0.005 (0.024)	0.162 (1.045)	-0.017 (0.023)	-0.112 (1.034)	-0.041* (0.022)	-1.540 (0.949)
<i>LnSize</i>	-0.315*** (0.030)	-6.869*** (1.272)	-0.323*** (0.031)	-6.739*** (1.268)	-0.315*** (0.030)	-6.115*** (1.224)
<i>LnTurnover</i>	-0.366*** (0.034)	-9.081*** (1.864)	-0.376*** (0.033)	-8.831*** (1.788)	-0.376*** (0.035)	-8.500*** (1.829)
<i>LnVolatility</i>	0.606*** (0.074)	14.983*** (2.881)	0.604*** (0.075)	15.034*** (2.898)	0.595*** (0.075)	14.253*** (2.834)
<i>InstitutionalInvestors</i>	0.371 (0.265)	16.368 (11.620)	0.371 (0.267)	17.842 (11.731)	0.283 (0.265)	10.296 (12.428)
<i>PatentApplications</i>	0.042** (0.017)	0.842 (0.529)	0.040** (0.017)	0.988* (0.522)	0.047*** (0.016)	1.214** (0.516)
<i>Index</i>	0.081 (0.085)	10.916*** (3.720)			0.158* (0.089)	11.358*** (3.123)
<i>QLevel</i> × <i>Index</i>	-0.050** (0.023)	-1.814* (0.994)			-0.073*** (0.024)	-1.967*** (0.731)
<i>High_MC</i>			0.127 (0.080)	8.751*** (3.300)	0.048 (0.074)	4.565* (2.360)
<i>QLevel</i> × <i>High_MC</i>			-0.032 (0.023)	-1.321 (0.963)	-0.007 (0.022)	-0.601 (0.670)
<i>HighAnalystCoverage</i>					0.046 (0.033)	4.776*** (1.267)
<i>HighAnalystCoverage</i> × <i>QLevel</i>					0.045 (0.073)	3.336*** (1.063)
					0.204*** (0.068)	8.996*** (2.394)

Table 8 (continued)

Panel A: information asymmetry measures									
$IA_{Spread, Price Impact} = \alpha + \beta_1 QLevel_{it} + \beta_2 LnSize_{it} + \beta_3 LnTurnover_{it} + \beta_4 LnVolatility_{it} + \beta_5 InstitutionalInvestors_{it} + \beta_6 PatentsApplications_{it} + \beta_7 InteractionVariable + \beta_8 QLevel \times Interaction Variable) + \varepsilon_{it}$									
Interaction variable	Index	High_MC		AnalystsFollowing		All			
Dependent variable	IA_{Spread}	IA_{PI}	IA_{Spread}	IA_{PI}	IA_{Spread}	IA_{PI}	IA_{Spread}	IA_{PI}	IA_{PI}
<i>Fixed Effects</i>	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
R^2 (overall)	0.680	0.258	0.678	0.258	0.262	0.692	0.704	0.278	0.278
R^2 (within)	0.415	0.126	0.411	0.124	0.125	0.419	0.427	0.136	0.136
R^2 (between)	0.710	0.330	0.710	0.329	0.350	0.730	0.740	0.374	0.374
F-statistics	36.69	5.65	32.18	5.13	4.92	29.82	28.45	3.95	3.95
N	1886	1886	1886	1886	1807	1807	1807	1807	1807
Panel B: valuation measures									
$V_{MTB, TobinsQ} = \alpha + \beta_1 QLevel_{it} + \beta_2 LnSize_{it} + \beta_3 LnLeverage_{it} + \beta_4 LnGrowth_{it} + \beta_5 ROE_{it} + \beta_6 InstitutionalInvestors_{it} + \beta_7 PatentsApplications_{it} + \beta_8 InteractionVariable + \beta_9 QLevel \times Interaction Variable) + \varepsilon_{it}$									
Interaction variable	Index	High_MC		AnalystsFollowing		All			
Dependent variable	V_{MTB}	$V_{TobinsQ}$	V_{MTB}	$V_{TobinsQ}$	V_{MTB}	$V_{TobinsQ}$	V_{MTB}	$V_{TobinsQ}$	$V_{TobinsQ}$
$QLevel$	0.225 (0.232)	0.102 (0.080)	0.181 (0.209)	0.093 (0.074)	0.254 (0.167)	0.088 (0.060)	0.203 (0.186)	0.093 (0.067)	0.093 (0.067)
$LnSize$	0.717* (0.376)	0.251* (0.134)	0.721** (0.362)	0.254** (0.128)	0.756 (0.476)	0.234 (0.169)	0.737 (0.491)	0.227 (0.175)	0.227 (0.175)
$LnLeverage$	-3.116** (1.449)	-1.582*** (0.495)	-3.117** (1.428)	-1.577*** (0.488)	-2.578** (1.295)	-1.483*** (0.446)	-2.588** (1.314)	-1.486*** (0.452)	-1.486*** (0.452)
$LnGrowth$	-3.578*** (0.791)	-0.388** (0.182)	-3.581*** (0.789)	-0.391** (0.181)	-3.091*** (0.729)	-0.410** (0.189)	-3.080*** (0.734)	-0.408*** (0.189)	-0.408*** (0.189)

Table 8 (continued)

Panel B: valuation measures

$V_{MTB, TobinsQ} = \alpha + \beta_1 QLevel_{it} + \beta_2 LnSize_{it} + \beta_3 LnLeverage_{it} + \beta_3 LnGrowth_{it} + \beta_4 ROE_{it} + \beta_5 InstitutionalInvestors_{it} + \beta_6 PatentsApplications_{it} + \beta_7 InteractionVariable + \beta_8 QLevel \times InteractionVariable + \epsilon_{it}$								
Interaction variable	Index		High_MC		AnalystsFollowing		All	
Dependent variable	V_{MTB}	$V_{TobinsQ}$	V_{MTB}	$V_{TobinsQ}$	V_{MTB}	$V_{TobinsQ}$	V_{MTB}	$V_{TobinsQ}$
<i>ROE</i>	0.005 (0.012)	0.001 (0.004)	0.005 (0.012)	0.001 (0.004)	0.009 (0.010)	0.001 (0.003)	0.009 (0.010)	0.001 (0.003)
<i>InstitutionalInvestors</i>	-2.880 (3.203)	-0.673 (1.110)	-2.898 (3.262)	-0.677 (1.135)	-2.262 (3.429)	-0.559 (1.176)	-2.397 (3.417)	-0.562 (1.169)
<i>PatentApplications</i>	-0.000 (0.136)	-0.043 (0.037)	0.012 (0.137)	-0.045 (0.038)	-0.036 (0.147)	-0.049 (0.040)	-0.031 (0.145)	-0.049 (0.038)
<i>Index</i>	0.273 (0.668)	0.109 (0.231)					0.320 (0.679)	0.128 (0.204)
<i>QLevel</i> × <i>Index</i>	-0.076 (0.219)	-0.045 (0.075)					-0.054 (0.208)	-0.035 (0.056)
<i>High_MC</i>			-0.030 (0.596)	0.074 (0.202)			-0.546 (0.571)	-0.024 (0.143)
<i>QLevel</i> × <i>High_MC</i>			0.010 (0.197)	-0.029 (0.067)			0.203 (0.163)	0.013 (0.043)
<i>HighAnalystCoverage</i>					-0.286 (0.237)	-0.086 (0.080)	-0.274 (0.202)	-0.099 (0.066)
<i>HighAnalystCoverage</i> x <i>QLevel</i>					-0.716 (0.566)	-0.168 (0.171)	-0.979 (0.620)	-0.120 (0.169)
<i>Fixed Effects</i>	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
<i>R² (overall)</i>	0.217	0.451	0.217	0.449	0.247	0.471	0.247	0.468
<i>R² (within)</i>	0.262	0.402	0.262	0.402	0.250	0.380	0.251	0.380
<i>R² (between)</i>	0.169	0.441	0.170	0.438	0.211	0.472	0.213	0.470

Table 8 (continued)

Panel B: valuation measures							
$V_{MTB, TobinsQ} = \alpha + \beta_1 QLevel_{it} + \beta_2 LnSize_{it} + \beta_2 LnLeverage_{it} + \beta_3 LnGrowth_{it} + \beta_4 ROE_{it} + \beta_5 InstitutionalInvestors_{it} + \beta_6 PatentsApplications_{it} + \beta_7 InteractionVariable + \beta_8 QLevel \times InteractionVariable + \epsilon_{it}$							
Interaction variable	Index		High_MC		AnalystsFollowing		All
Dependent variable	V_{MTB}	$V_{TobinsQ}$	V_{MTB}	$V_{TobinsQ}$	V_{MTB}	$V_{TobinsQ}$	V_{MTB} $V_{TobinsQ}$
F-statistics	6.20	13.48	5.25	11.18	5.03	11.30	4.55 9.47
N	1885	1885	1885	1885	1806	1806	1806 1806

The sample suitable for regression includes 1,886/1,807/1885/1,806 firm-year observations for the period 2012–2019. $IA_{Price Impact}$ and IA_{Spread} (Panel A) are our measures for information asymmetry and V_{MTB} and $Tobin's Q$ (Panel B) are our measures for firm valuation. ROE is return on equity. The variable $Index$ is coded as 1 for firms without Index listing. $High_MC$ equals 1 if the respective firm operates in a news environment with above-median media coverage and 0 otherwise. $HighAnalystCoverage$ equals 1 if the respective firm operates in an analyst's environment with above-median analyst coverage and 0 otherwise. $HighAnalystCoverage \times QLevel$ is divided by 100 for expositional purposes. The table reports firm fixed effects estimates and, in parentheses, clustered standard errors at the firm level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels (two-tailed), based on t -statistics

Overall, our results show stronger effects of lower quarterly reporting on information asymmetry for index firms than for non-index firms. In particular, our analysis shows that for index firms, a lower level of reporting increases information asymmetries, which supports the notion that index firms have higher agency costs that make quarterly reporting worthwhile. Higher agency costs presumably exist in index firms because of larger differences in informational demand due to a more dispersed ownership structure (Jensen and Meckling 1976). Presumably because index firms are more homogeneous across various firm characteristics, reducing quarterly reporting leads to an overall increase in information asymmetries. Our results are in contrast with those of Knappstein et al. (2020), who find an increase in information asymmetries in the short run especially for smaller firms that chose to stop quarterly reporting. Instead, our results are consistent with those of Kajüter et al. (2019), showing greater information benefits of mandatory quarterly reporting for larger, index-listed firms than for smaller, non-index firms.

Panel B of Table 8 shows results for the dependent variables *MTB* and *Tobin's Q*. First, in the regression with *MTB* as the dependent variable, we find a non-significant, negative coefficient of -0.076 for the interaction term $QLevel \times Index$. Regarding our second measure of firm value, regressions with *Tobin's Q* as the dependent variable provide similar results. The coefficient of $QLevel \times Index$ is -0.045 and not significant.

Next, we examine whether increased media attention affects mandatory disclosure (see again Table 8). Our variable of interest identifying the impact of the information environment is the interaction term between the quarterly reporting level (*QLevel*) and the extent of media coverage (*High_MC*). In panel A, we find that the coefficient of $QLevel \times High_MC$ has a value of -0.032 for *bid-ask spread* and -1.321 for *price impact*, but is not statistically significant at conventional levels.

Panel B of Table 8 shows the results for the dependent variables *MTB* and *Tobin's Q*. In our regression with *MTB* as the dependent variable, we find a positive coefficient of 0.010 for the interaction term $QLevel \times High_MC$. Regarding our second measure of firm value, regressions with *Tobin's Q* as the dependent variable find different results. The coefficient of $QLevel \times High_MC$ has a value of -0.029 . Both coefficients for *MTB* and *Tobin's Q* are not statistically significant.

Finally, panel A in Table 8 reports the effect of a change in a firm's disclosure level conditional on analyst coverage. Our variable of interest identifying the impact of the information environment is the interaction term $QLevel \times HighAnalystCoverage$. For our measures of information asymmetry, the *bid ask spread* and the *price impact*, we find a positive coefficient for the interaction term, although this is not statistically significant at conventional levels. When investigating the effect of the interaction term $QLevel \times HighAnalystCoverage$ on firm value in Table 8 panel B, we find no statistically significant effect.

Overall, we find differential effects for firms whose disclosure and information are of public interest. First, the observed capital market effects of quarterly reporting levels on information asymmetries are stronger for index firms. Second, we do not find a difference in the effect of decreasing quarterly reporting levels for firms with above-median media and analyst coverage. While we do not find any significant interaction between the quarterly reporting level (*QLevel*) and information environment on firm value, we consistently find that the information environment itself (in the form of *AnalystsFollowing*) is a relevant factor determining firm value. Therefore, we find no evidence in support of H2 regarding firm value. Nevertheless, we find evidence that firms in the Prime Standard are generally subject to different information demands. We assume that index firms are more homogeneous across various firm characteristics (such as financial needs and ownership structure) that also come with higher agency costs. Firms with higher agency costs have a high information demand, making quarterly reporting more beneficial. Our findings are thus in line with those of Kajüter et al. (2019), that large firms benefit

from mandatory quarterly reporting. Moreover, our results emphasize the relevance of accuracy and quantity of quarterly reports for large firms. Arguably, the information demand of non-index firms is generally low. Consequently, they do not suffer from lower quarterly reporting levels.

6 Conclusion

The current trend towards deregulation of quarterly reporting worldwide once again raises the question of the optimal level of mandatory financial reporting. We address this issue by investigating an instance of deregulation for Prime Standard firms of the FSE in Germany in 2015, whereby the removal of mandatory quarterly financial reporting has led to widespread reductions in quarterly reporting levels. We use a new disclosure measure for quarterly reporting by manually examining the change in disclosure practices in quarterly reports after deregulation in 2015.

The evidence shows that reduced quarterly disclosure on average increases information asymmetry and diminishes firm value. Our findings are in line with and support prior empirical findings that the removal of quarterly reporting increases information asymmetries between investors (Hitz and Moritz 2019; Knappstein et al. 2020). We extend the existing literature by showing that the increase in information asymmetries also holds in the long run. We further find that accuracy and quantity of information provided to investors are crucial aspects for the extent of information asymmetries in the market (Brown and Hillegeist 2007). This finding is particularly relevant considering that firms rarely change their disclosure levels in the absence of external factors such as regulatory changes. Our results improve on prior empirical evidence by showing that capital market effects do not occur through deregulation per se, but through changes in firms' disclosure practices. In line with Greenstone et al. (2006) and Downar et al. (2018), our results indicate that disclosure requirements such as mandatory quarterly reporting increase firm value, and firms opting for lower quarterly reporting levels must accept a decrease in firm value. Compliance costs and managers' myopic behavior are apparently not sufficient to outweigh the positive effects of commitment to a steady flow of information.

Our results thus support the regulation of disclosure through quarterly reporting. We also find that first-tier stocks react more strongly to deregulation in terms of liquidity. Thus, our results also add to the understanding of heterogeneous responses to regulatory action, in the sense that quarterly reporting is more relevant for some stocks but not for others. More precisely, firms with high information demand benefit from quarterly reporting, whereas reducing quarterly reporting is irrelevant for smaller and less visible firms. Therefore, we provide evidence in favor of mandatory quarterly reporting at the previous highest level of a quarterly financial report for first-tier stocks.

Our results have clear limitations. Classification based on the content of quarterly reports is only one possible approach to measuring the extent and quality of quarterly reports. Therefore, our results may be affected by other characteristics of quarterly reports, such as their readability and complexity. Nevertheless, we find empirical support that our classification based on the content elements contained in quarterly reports is a valid measure for the quality dimension of disclosure—that is, the accuracy and quantity of information resulting from quarterly reports. Moreover, firm-specific missing variables such as the readability and complexity of reports will be captured by firm fixed effects in our empirical model.

While higher levels of disclosure appear to be on average beneficial for the liquidity of a firm's stock and the value of the firm, it is also important to emphasize the costs that come with a higher level of disclosure. In some cases, these costs could outweigh the benefits of disclosure

and prevent firms from maintaining a high level of disclosure. However, at least for Austrian firms there is recent empirical evidence that these costs are not high enough to be decisive when management chooses the adequate level of disclosure (Bornemann et al. 2023).

Firms may nevertheless choose to disclose more information to reduce the capital cost of external funding. As part of our analysis, we therefore examined the extent to which the amount of external funding influences the disclosure levels. We find that firms with external financing choose a higher disclosure level. However, the absolute difference is marginal and only significant at the 10% level. On the other hand, higher levels of corporate innovation could lead firms to choose lower disclosure standards. For example, Fu et al. (2020) provide evidence on the importance of corporate innovation in determining the suitable level of disclosure for a firm. We also show that firms with higher innovation capacity in the form of registered patents tend to disclose less. While we have identified how a change in disclosure affects the liquidity of a firm's stock and overall firm value, it was not the focus of our analysis to investigate the firm characteristics that affect the decision to change or maintain the level of disclosure. This is clearly a research question that should be analyzed in future studies and opens up paths for future research.

The usefulness of quarterly reporting has been called into question in Asia on the Singapore Stock Exchange, as well as in Europe and the US (European Commission 2013; Securities and Exchange Commission 2016; Singapore Exchange 2018). Our findings may therefore be of interest to regulators, exchange authorities, and firms worldwide. While quarterly reporting has previously been assumed to be an additional burden for small firms, the commitment costs are not so high as to outweigh the positive effects of regulating quarterly reporting. From the perspective of investor protection, regular and comprehensive reporting seems to be necessary, especially for firms subject to high demand for information.

Appendix

See Tables 9, 10 and 11.

Table 9 Testing the Validity of QLevel

$QLevel = \alpha + \beta_1 BinaryDisclosureMeasure_{it} + \beta_2 CardinalDisclosureMeasure_{it} + \varepsilon_{it}$	
BinaryDisclosureMeasure	1.970*** (0.028)
CardinalDisclosureMeasure	0.403*** (0.061)
R ²	0.862
F-statistics	2800.93
N	902

BinaryDisclosureMeasure is coded as 1 for firms with a complete quarterly financial report, following the method used by Knapstein et al. (2020). *CardinalDisclosureMeasure* is the number of pages of a firm's quarterly report divided by 100 to scale the coefficient to meaningful values. The table reports OLS estimates and, in parentheses, robust standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels (two-tailed), based on *t*-statistics

Table 10 Firm value models (Table 6) excluding ROE

Panel A: market-to-book ratio as dependent variable				Panel B: Tobin's Q as dependent variable			
$V_{M/B} = \alpha + \beta_1 QLevel_{it} + \beta_2 LnLeverage_{it} + \beta_3 LnSize_{it} + \beta_4 LnGrowth_{it} + \beta_5 InstitutionalInvestors_{it} + \beta_6 AnalystsFollowing_{it} + \beta_7 PatentsApplications_{it} + \varepsilon_{it}$							
Variable	Pooled	Fixed effects	2SLS	Variable	Pooled	Fixed effects	2SLS
<i>QLevel</i>	0.177* (0.082)	0.187 (0.119)	0.788*** (0.149)	<i>QLevel</i>	0.053* (0.023)	0.070 (0.044)	0.258*** (0.048)
<i>LnLeverage</i>	-2.743** (0.702)	-2.620** (1.249)	-2.774*** (0.129)	<i>LnLeverage</i>	-1.553*** (0.224)	-1.491*** (0.429)	-1.563*** (0.042)
<i>LnSize</i>	1.115** (0.356)	0.773 (0.484)	1.265*** (0.096)	<i>LnSize</i>	0.356* (0.135)	0.231 (0.172)	0.407*** (0.031)
<i>LnGrowth</i>	-2.789** (0.823)	-2.768*** (0.711)	-2.791*** (0.353)	<i>LnGrowth</i>	-0.428 (0.277)	-0.360** (0.169)	-0.429*** (0.114)
<i>InstitutionalInvestors</i>	0.625 (2.028)	-2.355 (3.334)	1.311 (1.792)	<i>InstitutionalInvestors</i>	-0.173 (0.888)	-0.570 (1.148)	0.057 (0.579)
<i>AnalystsFollowing</i>	-0.085 (0.049)	-0.054** (0.027)	-0.106*** (0.021)	<i>AnalystsFollowing</i>	-0.028 (0.018)	-0.010 (0.007)	-0.035*** (0.007)
<i>PatentApplications</i>	-0.508 (0.421)	-0.020 (0.151)	-0.423** (0.203)	<i>PatentApplications</i>	-0.234 (0.137)	-0.044 (0.040)	-0.206*** (0.066)
<i>Fixed Effects</i>	<i>Index</i>	<i>Firm</i>	<i>Index</i>	<i>Fixed Effects</i>	<i>Index</i>	<i>Firm</i>	<i>Index</i>
<i>R² (overall)</i>	0.262	0.269	0.240	<i>R² (overall)</i>	0.482	0.475	0.462
<i>R² (within)</i>	0.304	0.249	0.285	<i>R² (within)</i>	0.501	0.379	0.486
<i>R² (between)</i>	0.190	0.244	0.234	<i>R² (between)</i>	0.210	0.475	0.117
F-statistic/Wald χ^2	20.87	4.70	1804.89	F-statistic/Wald χ^2	44.64	8.06	5431.86
<i>N</i>	1807	1807	1807	<i>N</i>	1807	1807	1807

The regressions include 1,807 firm-year observations for the period 2012–2019. $V_{M/B}$ (Panel A) or $V_{Tobin's Q}$ (Panel B) are our measures for firm valuation. The “Pooled” column reports the results based on OLS regressions. The “Fixed Effects” column reports the results based on OLS regression with firm fixed effects. The “2SLS” column reports results based on simultaneous estimated two-stage least squares approach for panel data with firm fixed effects. The table reports OLS, fixed effects and 2SLS estimates and, in parentheses, robust standard errors for the OLS and clustered standard errors at the firm level for fixed effects and 2SLS estimates. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels (two-tailed), based on *t*-statistics

Table 11 Matching model—valuation measures (Table 7 Panel B) excluding ROE
$$V_{MTB, Tobin's Q} = \alpha + \beta_1 Post_{it} + \beta_2 Treat_{it} + \beta_3 Post \times Treat_{it} + \beta_4 LnSize_{it} + \beta_5 LnLeverage_{it} + \beta_6 LnGrowth_{it} + \beta_7 InstitutionalInvestors_{it} + \beta_8 AnalystsFollowing_{it} + \beta_9 PatentsApplications_{it} + \varepsilon_{it}$$

Variable	V_{MTB}	$V_{Tobin's Q}$
Post	-0.975** (0.455)	-0.276* (0.147)
Treat	-0.382 (0.367)	0.007 (0.119)
Post × Treat	0.621 (0.403)	0.079 (0.134)
LnSize	0.784*** (0.228)	0.278*** (0.075)
LnLeverage	-2.540*** (0.294)	-1.479*** (0.114)
LnGrowth	-2.489*** (0.807)	-0.417* (0.215)
InstitutionalInvestors	0.060 (1.409)	-0.104 (0.502)
AnalystsFollowing	-0.110*** (0.040)	-0.036*** (0.013)
PatentApplications	-0.339** (0.169)	-0.187*** (0.043)
R^2	0.298	0.499
F-statistics	21.28	45.70
N	1473	1473

The sample includes 1,473/1,472 observations for treatment firms and control firms 3 years before and after the event year during the period 2013–2019. Control firms are matched on industry, size, and year. *Treat* is a dummy variable coded as 1 for firms that change their quarterly reporting level and 0 for control firms; *Post* is a dummy variable coded as 1 for three years after the change in quarterly reporting level and 0 for three years before the change. The table reports OLS estimates and, in parentheses, robust standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels (two-tailed), based on *t*-statistics

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Conflict of interest We have no conflicts of interest to declare.

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