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Data visualization in 10-K filings☆

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ABSTRACT

The Securities and Exchange Commission encourages the presentation of information or data in graphical form to improve users' ability to understand financial disclosures. We find a dramatic increase in the disclosure of both qualitative and quantitative infographics in 10-K filings over time and substantial cross-sectional variation in firms' choices regarding image types, data content, and the placement of infographics within 10-Ks. We provide evidence on factors associated with firms' use of infographics and explore the persistence with which they are disclosed over time. Finally, we investigate the relation between the use of infographics and uncertainty in capital markets.

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> *"Words, graphics, and tables are different mechanisms with but a single purpose — the presentation of information."*
>
> The Visual Display of Quantitative Information, Tufte (2001, 181)

1. Introduction

The purpose of corporate financial disclosure is to communicate useful information to investors and other stakeholders. In recognition of this objective, the SEC's Plain English Handbook provides guidance on how to write *and design* clear disclosure documents (SEC 1998). Yet, the SEC remains concerned that financial reports have become unnecessarily lengthy, difficult to

understand and confusing (SEC 2003). Indeed, research finds a steady increase in narrative disclosure accompanied by a decrease in readability (e.g., Li 2008; Dyer et al., 2017). In response to these concerns, the SEC and the FASB initiated projects to improve the overall effectiveness of corporate disclosure (FASB 2012, SEC 2016).[1] Financial statement preparers are also considering ways to enhance disclosures, including using charts, graphs, and other illustrations (FERF/EY 2015; Teach 2016). Despite the growing interest in the visual display of information in financial reports, we are the first to systematically examine attributes of infographics in 10-K filings, factors associated with their use, and the relation between infographics and uncertainty in capital markets.

The rising prominence of visuals in everyday life suggests that they provide an additional dimension to communication beyond text alone (Manjoo 2017). Financial disclosure is not immune to this broader societal trend, particularly in its use of infographics containing a visual representation of information or data (Tufte 2001). For example, General Electric redesigned its 10-K to make greater use of graphics, noting that "corporate disclosure is all words and no pictures. But where communication is going, it's all visuals and few words" (Monga 2016). Similarly, Intel updated its 10-K to include visual elements to help explain key points (Vermeer and Titera 2018).

Infographics are particularly well-suited to enhance corporate financial disclosure in several ways. Because of their high visual saliency (e.g., shape, color), infographics stand out relative to the surrounding text (Treisman and Gelade 1980; Wolfe 1989) and help to generate or reinforce mental models of textual information (Glenberg and Langston 1992).[2] As a result, people may comprehend and process information more readily when presented in visual rather than narrative or tabular form (Larkin and Simon 1987; Lewandowsky and Spence 1989; Pinker 1990; Winn 1991; Stenning and Oberlander 1995). Infographics also enhance recall and retention (Shepard 1967; Hockley 2008), are accessible to users with varying levels of financial acumen, and are largely independent of language. Overall, these arguments suggest that infographics potentially mitigate the costs of acquiring and analyzing financial disclosures (Blankespoor et al., 2020).

On the other hand, poorly designed infographics can alter users' perceptions and judgments (Arunachalam et al., 2002). Because many firms view the 10-K as a regulatory compliance activity (Dichev et al., 2013), they may pay little attention to proper graphic design. Even well-designed infographics will have limited usefulness if the information is irrelevant. In addition, people differ in their ability to understand information presented graphically (e.g., Okan et al., 2012; Okan et al., 2016). For example, Galesic and Garcia-Retamero (2011) find that only 85% of people can identify specific information in a graph, and only about two-thirds can identify associations in the data or draw inferences and make predictions from the data.

Our first research objective is to identify characteristics of infographics voluntarily disclosed in 10-Ks and trends in their use over the period 2003−2019. Although descriptive in nature, this analysis provides the first evidence on a previously unexplored aspect of corporate financial disclosure. The SEC encourages the use of graphics as an effective means of communicating numbers and concepts in a manner that investors can more easily understand (SEC 1998). However, the SEC did not allow firms to prepare regulatory filings in HTML format with embedded graphics until 2000 (SEC 2000), and few firms did so prior to 2003. Thus, we begin our sample in 2003 and extract every image included in 10-K filings through 2019. After excluding mandatory infographics (e.g., stock performance line graph) and images that are unlikely to contain meaningful information (e.g., logos, product images, executive and stock photos), we identify the image type of the remaining infographics as either quantitative (bar charts, pie graphs, line graphs, and data maps) or qualitative (process/ flow charts, strategy/business models, timelines, location maps, and organization charts). We further classify the data content of the quantitative infographics into five categories: (i) GAAP (e.g., revenues, net income, operating cash flow, earnings per share), (ii) non-GAAP (e.g., adjusted earnings, EBITDA, free cash flows), (iii) financial Key Performance Indicators (KPIs) (e.g., same-store sales, return on equity), (iv) non-financial KPIs (e.g., number of stores, number of units produced), and (v) macro (e.g., commodity spot prices). Our final sample consists of 35,577 infographics voluntarily disclosed by 6,584 firms (47,906 firm-years).

We find a substantial increase in the use of infographics during our sample period from 6.8% of firms including at least one infographic in their 10-K filing in 2003 to 23.8% in 2019. Among companies disclosing infographics, the average number of infographics per filing is about four. This distribution is positively skewed, however, with 11 infographics at the upper decile and a maximum of 135. Moreover, the percentage of firms using infographics increased by 248.8% over our sample period, compared to an increase in word count of 76.9%. We find this trend across all nine types of infographics, with the average use of infographics generally increasing four-fold over the sample period. Slightly more infographics contain KPI data (48%) than GAAP data (45%), while substantially smaller fractions present macro (5%) or non-GAAP (2%) data. Moreover, we find substantial variation by industry in both image type and data content, as well as their location within the 10-K. Overall, our evidence indicates that over time companies use infographics more frequently as part of their overall 10-K disclosure strategies, and frequently choose to highlight data not included in the GAAP financial statements.

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[1] Relatedly, the Plain Writing Act of 2010 requires all federal agencies, including the SEC, to produce clearly written documents that can be easily understood by the public. Following this directive, the Federal Plain Language Guidelines (https://plainlanguage.gov/guidelines/) suggest that illustrations can be effective in improving clarity. Similarly, the Public Company Accounting Oversight Board developed a new inspections report format utilizing charts and graphs as a tool to make the information more accessible to users (https://pcaobus.org/Inspections/Pages/default.aspx).

[2] For example, some of the most memorable accounting research papers include charts or graphs visually summarizing the key result (e.g., Ball and Brown 1968; Beaver 1968; Burgstahler and Dichev 1997; Sloan 1996).

Our second research objective is to examine why firms voluntarily disclose infographics. We find that several internal factors, including GAAP performance as well as business and operating complexity, are associated with the decision to use infographics. External factors also correlate with firms' use of infographics, including monitoring by a Big 4 auditor and the SEC, peer firms' use of infographics, and a focus on retail rather than institutional investors. Finally, we find that several 10-K factors are associated with the disclosure of infographics, including the propensity to use non-infographic images, bulleted lists, and tables. Inferences are similar regardless of the type of information (qualitative or quantitative) and data items disclosed.

Further, our evidence indicates that the use of infographics tends to be sticky over time. We find that 88% of firms disclosing an infographic also use infographics in the next year. Not only do firms continue to use infographics in general, but they also tend to use the same infographics. Specifically, we find that 67% of firms present the exact same infographic year-over-year. Finally, the results of hazard analyses indicate that the factors influencing the decision to begin disclosing infographics are generally similar to those that explain their continued use.

Our third research objective is to test the association between the use of infographics and uncertainty in capital markets following the release of the 10-K. We find evidence of elevated stock return volatility and analyst forecast dispersion after the filing of 10-Ks containing infographics. Overall, our results are consistent with complex firms using infographics when they expect investors and analysts to have greater difficulty understanding 10-K content rather than intentionally or unintentionally increasing information uncertainty. However, we cannot rule out the possibility that some infographics may be difficult to interpret and could thus contribute to market uncertainty.

Our results are relevant to the current debate on disclosure effectiveness. Regulators and standard-setters recognize the demand for more relevant and user-friendly corporate disclosures (e.g., SEC 1998, 2016; FASB 2012). Infographics are increasingly becoming a more common aspect of firm disclosures, yet research provides little systematic evidence on their use. The disclosure of non-GAAP and KPI measures in financial reports is also a topic of interest and concern (e.g., Golden 2017, SEC 2018, 2020; PCAOB 2018), with the SEC recently issuing interpretative guidance on considerations for KPIs disclosed in MD&A (SEC 2020). We present new evidence on the use of infographics to highlight these alternative performance metrics. We also find that firms frequently present KPI infographics, and in particular non-financial KPI infographics, outside of the MD&A, and thus outside of the intended scope of the SEC's guidance. Thus, the SEC may want to reconsider whether its guidance should encompass other sections of the 10-K.

We also contribute to the disclosure literature along multiple dimensions. For example, our analyses explore how changes in technology and regulations regarding how firms file financial reports with the SEC affect the disclosure landscape (Miller and Skinner 2015). We find an increasing trend in infographics disclosed in 10-K filings after the SEC began allowing firms to use HTML formatting with embedded graphics. More generally, we extend the voluntary disclosure literature to include infographics as an emerging disclosure element in financial reports.

Our results complement a robust stream of textual analysis research (e.g., Li 2010; Loughran and McDonald 2016), which excludes graphical elements of financial disclosures. Our focus on infographics that are intended to communicate key performance data also complements a recently evolving research stream examining the use of attention-grabbing images in SEC filings. Overall, our results advance the disclosure literature by presenting comprehensive, large-sample evidence on the evolution of infographics in corporate financial reports, the determinants of their use and content, and their association with market participants' processing of 10-K information.

2. Background and related research

2.1. Regulatory disclosure environment

Firms can satisfy nearly every 10-K disclosure requirement by providing the information in narrative or tabular form.[3] Additional information (e.g., KPIs) can also be disclosed in non-graphical form. Yet, the SEC suggests that graphics can make disclosures easier to read and understand because they "often illuminate information more clearly and quickly than text" (SEC 1998, 49). To facilitate their use in regulatory filings, the SEC updated the Electronic Data Gathering, Analysis, and Retrieval (EDGAR) system in 2000 to allow HTML files to contain embedded tags for graphic or image files (SEC 2000).[4]

Infographics disclosed in regulatory filings are subject to SEC review and comment. However, we find that SEC comments on graphics in 10-Ks are relatively infrequent (untabulated). The examples in Appendix B illustrate that when the SEC does comment, it is typically to suggest that the company include infographics to make concepts and financial data more easily understandable or request revisions or clarification to existing infographics. These comments are consistent with the SEC's stated view that infographics are a useful investor communication tool.

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[3] We are aware of only two requirements in Regulation S−K mandating specific infographics: (i) the stock return performance line graph (Item 201(e)), and (ii) location maps of significant properties for companies in extractive industries (Item 102, Instruction 3(B)). Because our focus is on the *voluntary* disclosure of infographics, we exclude these two types of infographics from our sample and analyses.

[4] The SEC continues to prohibit audio or video material, including animated graphics. Companies presenting required information in graphics that are not text-searchable must also present the same information as searchable text or a table within the filing. Additional information that the company chooses to include in the filing may be presented graphically without a separate text-searchable presentation (SEC 2015).

Fig. 1 organizes the disclosure elements of a typical 10-K into four quadrants on a visual-data continuum, following Wong (2010). Elements in the top row have high visual impact. The infographics in the upper left quadrant (timelines, process/flow charts, strategy/business models, location maps, and organization charts) contain qualitative information, and hence, we refer to these elements as qualitative infographics. In contrast, we refer to the elements in the upper-right quadrant (bar charts, line graphs, pie graphs, and data maps) as quantitative infographics because they incorporate data into the visual presentation. Quantitative infographics also vary with the type of data illustrated. In addition to GAAP measures, these data could include non-GAAP metrics, financial KPIs, non-financial KPIs, or industry or macro-economic data (SEC 2003; 2020).

In contrast to the infographics in the top row of Fig. 1, the 10-K elements in the bottom row have low visual impact. Specifically, narrative text and bulleted lists in the lower-left quadrant lack both visual impact and rich data. In the lower-right quadrant, tables and numerical text provide rich data but in a format that lacks visual appeal. Infographics could act as a substitute for these low visual impact elements (e.g., presenting information in a graph rather than a table) or as a complement (e.g., including a flow chart to illuminate complex textual narrative).

2.2. Related research

Research in accounting and finance has expanded in recent years beyond its traditional focus on quantitative data in financial reports, represented by the lower-right quadrant in Fig. 1, to textual analysis of narrative disclosures, represented by the lower left quadrant. Within the textual analysis literature, researchers have employed increasingly more sophisticated techniques to investigate a variety of disclosure attributes such as readability, tone, risk sentiment, and boilerplate. Most of this research examines cross-sectional determinants of narrative disclosure attributes (Li 2010; Loughran and McDonald 2016). More recently, Dyer et al. (2017) analyze trends in the content and attributes of 10-K textual disclosure from 1996 to 2013.

We take the next step in advancing 10-K disclosure research by focusing on infographics, represented in the top row in Fig. 1. Researchers are beginning to recognize the potential importance of infographics in corporate financial disclosures. For example, Loughran and McDonald (2016, 1193) suggest that "given the amount of resources spent on graphic design, presumably the presence of non-textual materials (pictures, graphs, and tables) enhances the ability of the reader to understand the intended message." This observation leads them to recommend the inclusion of visual design elements as variables of interest in disclosure studies. Bonsall et al. (2017) find that the total file size of pictures and PDFs in 10-Ks increased from 2003 to 2011, but, as in prior textual analysis research, they exclude this content from their analyses.
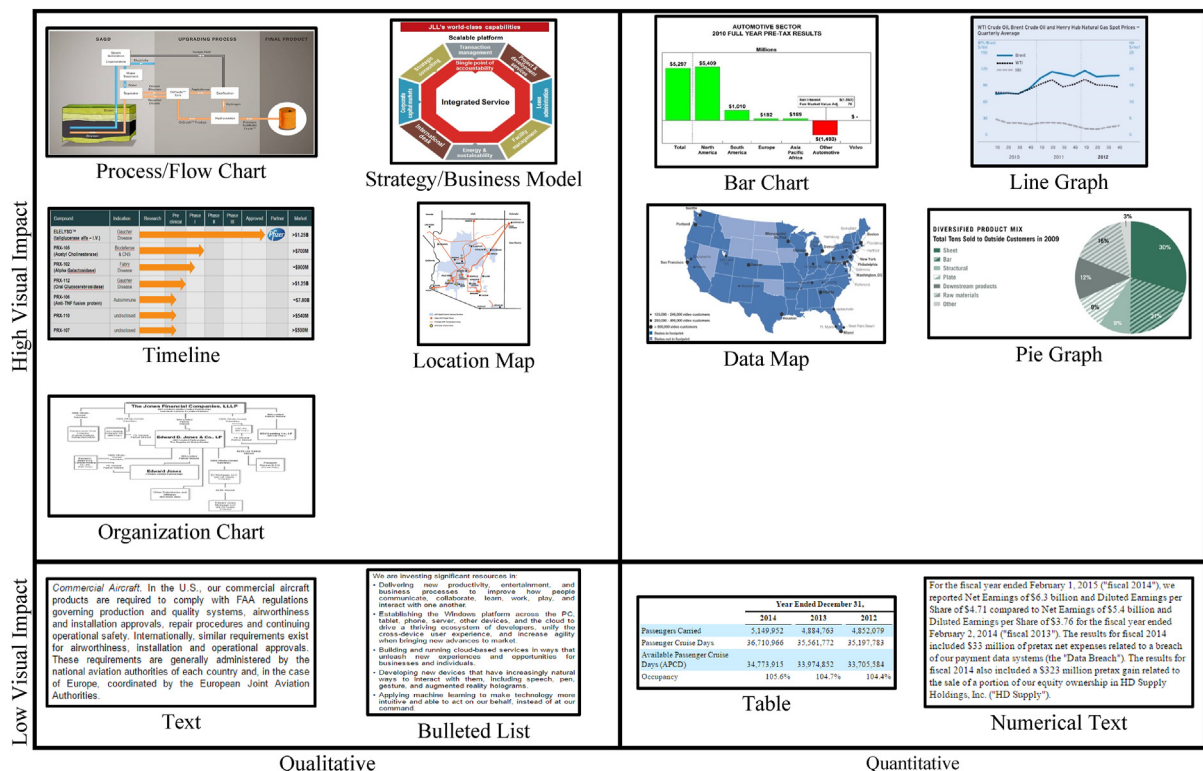

Fig. 1. Elements of 10-K disclosure. We organize the disclosure elements of a typical 10-K into four quadrants on a visual-data continuum, following Wong (2010), and include examples of each type from our dataset. We provide additional information on infographic types in Appendix A. (See the Web version of this article for the color version of this figure.)

To date, research on visuals in financial reporting is limited. Experimental evidence indicates that a mapping of financial data onto facial features, a graphic technique known as a Chernoff face (Chernoff 1973), enables users to make quicker and more accurate assessments of a firm's financial condition relative to tabular displays (Moriarity 1979; Stock and Watson 1984). More recently, Asay et al. (2018) find that including a CEO's photo in an earnings release magnifies the reaction to both good and bad news. However, they also suggest that photos are unlikely to have the same effect in other disclosures, such as the 10-K, in which the CEO's presence is inherently less salient. In a social media platform setting, Brown et al. (2019) find that nonprofessional investors rely more on non-GAAP earnings that are displayed with an eye-catching stock photo, regardless of the textual prominence of GAAP or non-GAAP earnings.

Early archival research examines graphs included in annual reports using small samples typically containing a single year of data for large firms. This evidence indicates that graphs selectively highlight favorable GAAP performance measures (e.g., sales, earnings, dividends) (Beattie and Jones 2008) and that firms are more likely to start using graphs when performance is increasing (Beattie and Jones 2000). In more recent research, Ben-Rephael et al. (2021) find that the use of visuals in S&P 1500 annual reports is positively associated with firm size, annual returns, and news coverage, and negatively associated with institutional holdings. Nekrasov et al. (2021) find that including images or videos in Twitter earnings announcements increases retweets, abnormal Google search volume, and the initial return response to earnings news, followed by a price reversal around the next earnings announcement. Similarly, Gu et al. (2022) find that the use of dynamic images (i.e., GIF images) on the social media platform Stocktwits is associated with greater retail investor attention and bullish sentiment than text or static images.

Our paper differs from prior and concurrent research along several dimensions. First, we focus on the 10-K as the primary financial disclosure document and examine the evolution of visual content over time. In this regard, we complement and extend Dyer et al.'s (2017) evidence on the evolution of 10-K textual disclosure attributes. Second, we concentrate on infographics that are intended to "communicate numbers and concepts visually" and to "stimulate a deeper or quicker understanding and appreciation of a situation than words alone" (SEC 1998, 53). In contrast, recent research primarily considers attention-grabbing images. Third, we delve into the data content of quantitative infographics. Our analyses contribute to research examining managers' voluntary disclosure of information in nongraphical form, including non-GAAP metrics (e.g., Black et al., 2021; Laurion 2020), key performance indicators (e.g., Francis et al., 2003; Rajgopal et al., 2003; Curtis et al., 2014), and macroeconomic information (e.g., Brochet et al., 2018). Finally, we examine the association between infographics and uncertainty in the information environment, thus extending research on information uncertainty and textual readability (e.g., Loughran and McDonald 2014; Bonsall et al., 2017). In sum, we provide the first in-depth examination of 10-K infographics and lay the foundation for researchers, regulators, and practitioners to understand this emerging disclosure phenomenon.

3. Sample selection and description

3.1. Sample selection

Table 1, Panel A summarizes our sample selection process.[5] We begin by identifying 64,837 firm-years filing a 10-K in HTML on EDGAR between 2003 and 2019, from which we extract 122,410 embedded images.[6] We then remove firm-years (and the associated images) that do not have the necessary data in Compustat, CRSP, and Audit Analytics for the variables in our empirical analyses. These restrictions leave a sample of 47,906 firm-year observations and 89,388 images.

Next, we identify the type of each image. Because we focus on the voluntary disclosure of infographics, we first eliminate 29,538 mandatory graphics containing stock performance graphs (27,993) and location maps for companies in extractive industries (1,545). Second, we exclude 1,063 images typically encoded in the HTML text, specifically tables (1,011) and bulleted lists (52), and reclassify these elements with the tables and bulleted lists extracted from the 10-K text. Third, we exclude 9,322 images containing common 10-K components: signatures (6,926), annual report covers (2,306), company contact information (38), and audit opinions (52). Finally, we exclude 13,888 images lacking any meaningful content: logos (10,505), icons such as check marks and bullet points (2,416), and other miscellaneous images (967). After these exclusions, our final sample consists of 35,577 images. Table 1, Panel B indicates that the number of images generally increases over time, even as the number of 10-K filings declines toward the end of our sample period.

To convey a sense of different approaches for using infographics in 10-Ks, we provide several examples from the final year of our sample period (2019). Almost one-quarter (22.48%) of our sample observations do not disclose infographics, not even the stock price performance chart (e.g., Fluor, Hasbro, Shutterfly, Veru).[7] Approximately one-half (53.56%) only include the performance chart (e.g., Coca-Cola, Footlocker, JetBlue Airways, T-Mobile US). Of the remaining observations, 8.97% only disclose quantitative infographics (e.g., Caterpillar, Johnson & Johnson, Nike, Target) while another 9.50% only disclose

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[5] See Appendix A for additional detail regarding our data collection and coding procedures.

[6] Relatively few firms file 10-Ks using HTML in 2000−2002, and only 2 disclose infographics in 2000, 25 in 2001, and 79 in 2002. Untabulated results indicate that inferences are robust to the inclusion of these additional observations.

[7] Companies may disclose the stock price performance graph in the annual proxy statement rather than the 10-K. We find that 98.0% of all sample observations embed at least one image in a Form 10-K/Q, 8-K, DEF 14A, or S-1 filed prior to the sample year. Thus, the absence of images in a 10-K in any firm-year is generally not because the firm lacks the capability to create or embed images. In untabulated analyses, we find that excluding the remaining 2% of observations does not affect our inferences.

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Table 1
Sample composition.

Panel A: Sample selection		
Criteria	Firm-years	Images
HTML 10-Ks filed from 2003 to 2019	64,837	122,410
Less missing Compustat data	(6,694)	(16,323)
Less missing CRSP data	(8,276)	(13,026)
Less missing Audit Analytics data	(1,961)	(3,673)
Final sample	47,906	89,388
Less mandatory graphics		(29,538)
Less alternatives to 10-K HTML encoding		(1,063)
Less other common 10-K components		(9,322)
Less images lacking content		(13,888)
Total images		35,577
Panel B: Observations by year		
Year	Firm-years	Images
2003	1,893	855
2004	2,453	1,204
2005	2,736	1,388
2006	2,913	1,765
2007	3,100	1,910
2008	3,106	1,760
2009	2,829	1,694
2010	3,043	1,718
2011	2,963	1,563
2012	2,927	1,590
2013	2,870	1,770
2014	2,920	1,933
2015	2,876	2,095
2016	2,813	2,716
2017	2,878	3,904
2018	2,944	4,133
2019	2,642	3,579
Total	47,906	35,577

This table reports the sample composition. Panel A presents the sample selection criteria. Panel B presents the number of firm-years and images by year.

qualitative infographics (e.g., Cigna, Idacorp, Mastercard, Ralph Lauren). Finally, 5.29% disclose at least one quantitative and one qualitative infographic (e.g., Allstate, Citigroup, Hertz, Intel).

3.2. Descriptive evidence on the use of infographics in 10-K filings

Of the 35,577 images in our sample, Table 2 indicates that 30,620 are infographics. Further, 6,732 of the 47,906 firm-years in the sample (or 14.05%) include at least one infographic. Among firms disclosing an infographic, the mean (median) number of infographics per 10-K is 4.55 (2.0) (untabulated), suggesting right-skewness in the distribution. This result is also evident in Fig. 2, which indicates that most firm-years include one or two infographics, although some include 10 or more infographics.

We classify infographics into four quantitative image types (bar charts, pie charts, line graphs, and data maps) and five qualitative image types (location maps, organizational charts, process/flow charts, strategy/business model diagrams, and timelines).[8] Table 2 indicates that there are more than three times as many quantitative (23,906) as qualitative (6,714) infographics in the sample. However, the number of firms and the percentage of firm-years with at least one infographic is similar for both quantitative (3,961 or 8.27%) and qualitative infographics (3,889, or 8.12%). This evidence suggests that firms are likely to disclose multiple quantitative infographics within a single 10-K but only one or two qualitative infographics.

In contrast to infographics, other images in the 10-K (product images, photos of executives and other people, and stock photos) primarily increase the aesthetic appeal of the filing. Table 2 indicates that sample firms disclose only 4,957 other images, with just 882 of the 47,906 firm-years (or 1.84%) including at least one of these other image types. Thus, we find that 10-K filings overwhelmingly emphasize infographics over other images.

Fig. 3 plots trends over time in firms' use of infographics and other images in 10-K filings. We find that the proportion of filings containing at least one infographic increases approximately three-fold from 6.8% in 2003 to 23.8% in 2019, with a similar trend in both quantitative and qualitative infographics. In contrast, the proportion of filings with at least one of the other image types is relatively low and fairly constant over time. Fig. 4 plots the trend for each type of infographic as well as

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[8] Data maps overlay data points, such as number of customers or sales, on map locations while location maps indicate the physical location of company assets or operations, such as buildings or trucking routes. Organization charts illustrate the structure of the organization and/or the relationships and relative ranks of positions within the organization.

Table 2
Classification of 10-K images by type.

	(1)	(2)	(3)
	Images	Firms-years with at least one infographic	% of firms-years with at least one infographic
Infographics			
Quantitative:			
Bar Chart	13,154	2,392	4.99%
Pie Graph	7,306	1,647	3.44%
Line Graph	3,044	1,186	2.48%
Data Map	402	296	0.62%
Total quantitative	23,906	3,961	8.27%
Qualitative:			
Location Map	1,694	798	1.67%
Organizational Chart	1,610	1,412	2.95%
Process/Flow Chart	1,541	986	2.06%
Strategy/Business Model	1,142	783	1.63%
Timeline	727	537	1.12%
Total qualitative	6,714	3,889	8.12%
Total Infographics	30,620	6,732	14.05%
Other Images			
Executive Photo	1,679	330	0.69%
Product Image	1,578	395	0.82%
Stock Photo	1,274	380	0.79%
Other Person Photo	426	117	0.24%
Total other images	4,957	882	1.84%
Total Images	35,577	7,014	14.64%

This table reports the classification of 10-K images. Column 1 reports the number of infographics and other images by type. Column 2 (3) reports the number (percentage) of firm-years with at least one infographic or other image. The sample consists of 10-K filings for 47,906 firm-year observations from 2003 to 2019.

Fig. 2. Frequency of infographics per 10-K filing. The sample consists of 47,906 10-K filings from 2003 to 2019. We define all variables in Appendix C and provide additional information on infographic types in Appendix A.

the non-graphical 10-K elements, organized into the same quadrants as in Fig. 1. The evidence reveals an increasing trend over time for all nine infographic types. The non-graphical elements in the lower row of Fig. 4 also generally increase over the sample period. Of specific interest, the increase in *BOG* indicates a decline in readability, consistent with prior research (e.g., Li 2008; Dyer et al., 2017). However, the remaining non-graphical elements generally plateau in the later part of the sample period.[9]

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[9] Because of the inherently different measurement of the low visual impact variables in Fig. 4, we do not standardize the scale of these plots. We also examine plots indexing the data using 2003 as the base year with no change in inferences (untabulated).

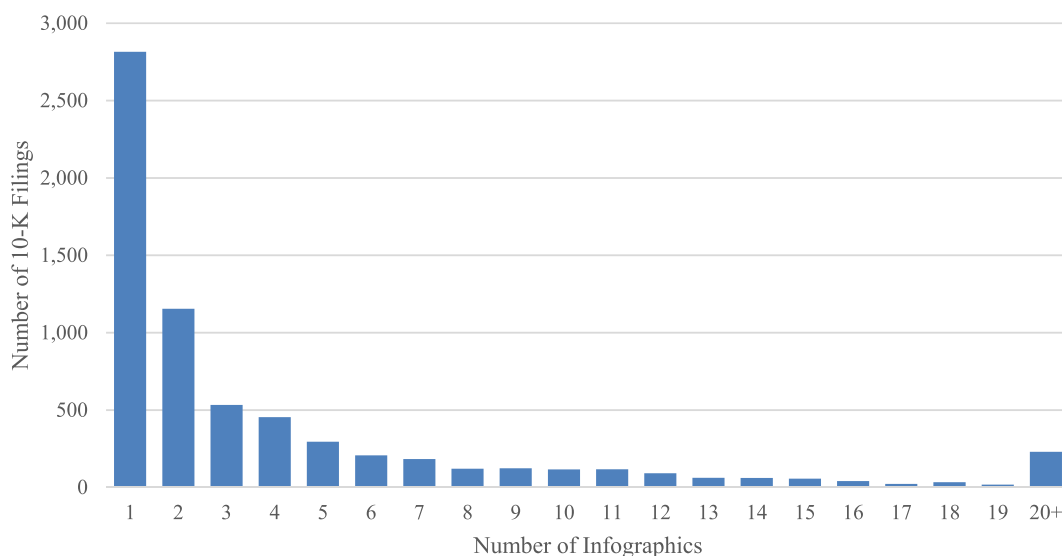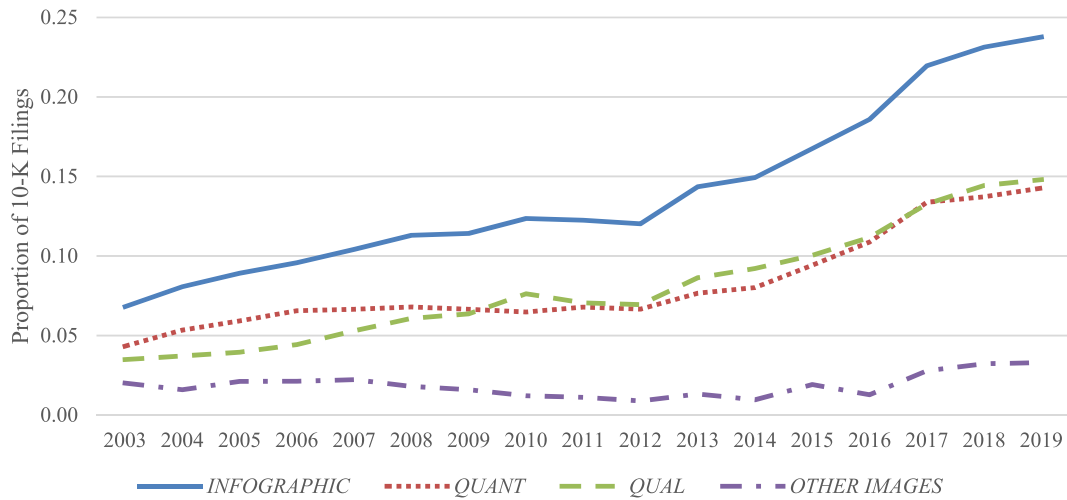**Fig. 3.** Trend over time in the proportion of 10-K filings containing at least one infographic or other image. The sample consists of 47,906 10-K filings from 2003 to 2019. We define all variables in Appendix C and provide additional information on infographic types in Appendix A. (See the Web version of this article for the color version of this figure.)
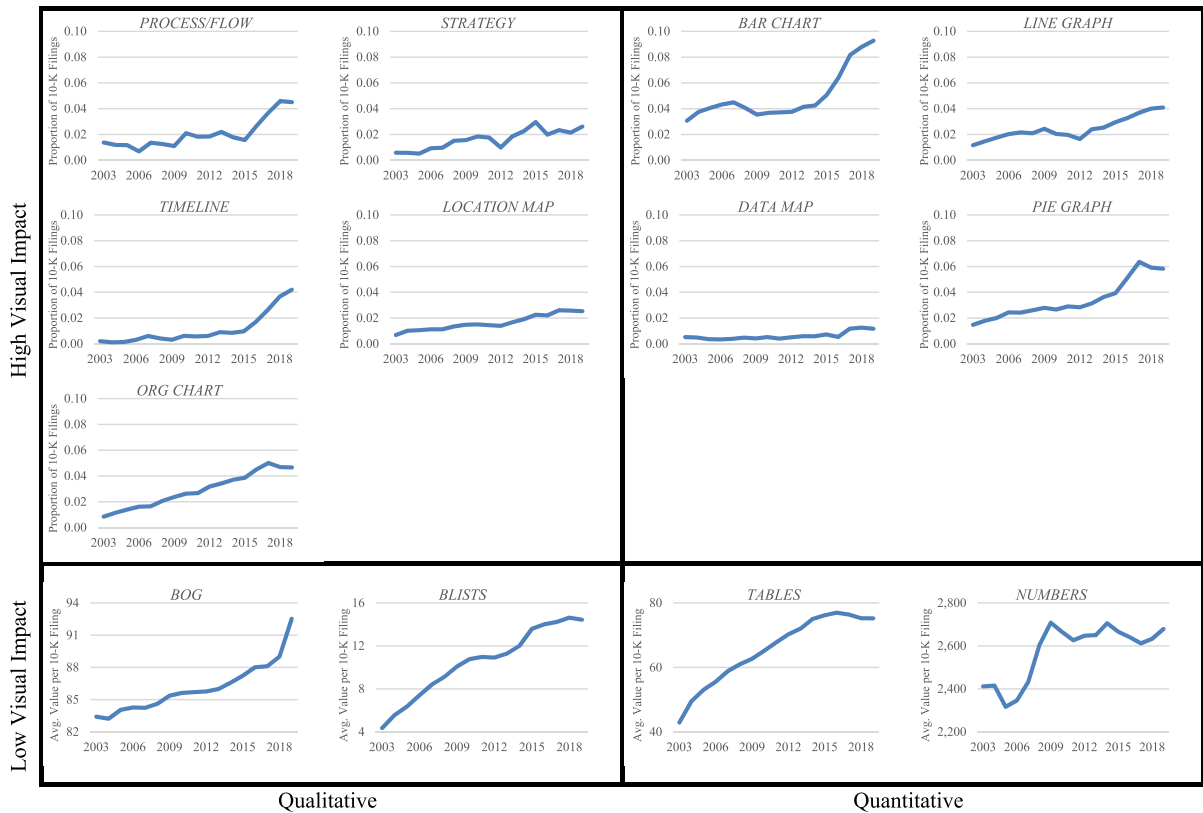
Fig. 4. Trend over time in the proportion of 10-K filings containing each type of infographic (upper row of the grid) and the average value per 10-K filing of each non-graphical 10-K characteristic (lower row of the grid). The sample consists of 47,906 10-K filings from 2003 to 2019. We define all variables in Appendix C and provide additional information on infographic types in Appendix A.

Firms may differ in their use of infographics depending on the characteristics of the industry in which they operate. Consistent with this notion, the evidence in Fig. 5 indicates that firms in the Utilities industry disclose more infographics, both qualitative and quantitative, than any other industry. Firms in the Chemicals industry also disclose a relatively high number of infographics, while infographics are least common in the Business Equipment sector. Fig. 6 plots the frequency of each type of
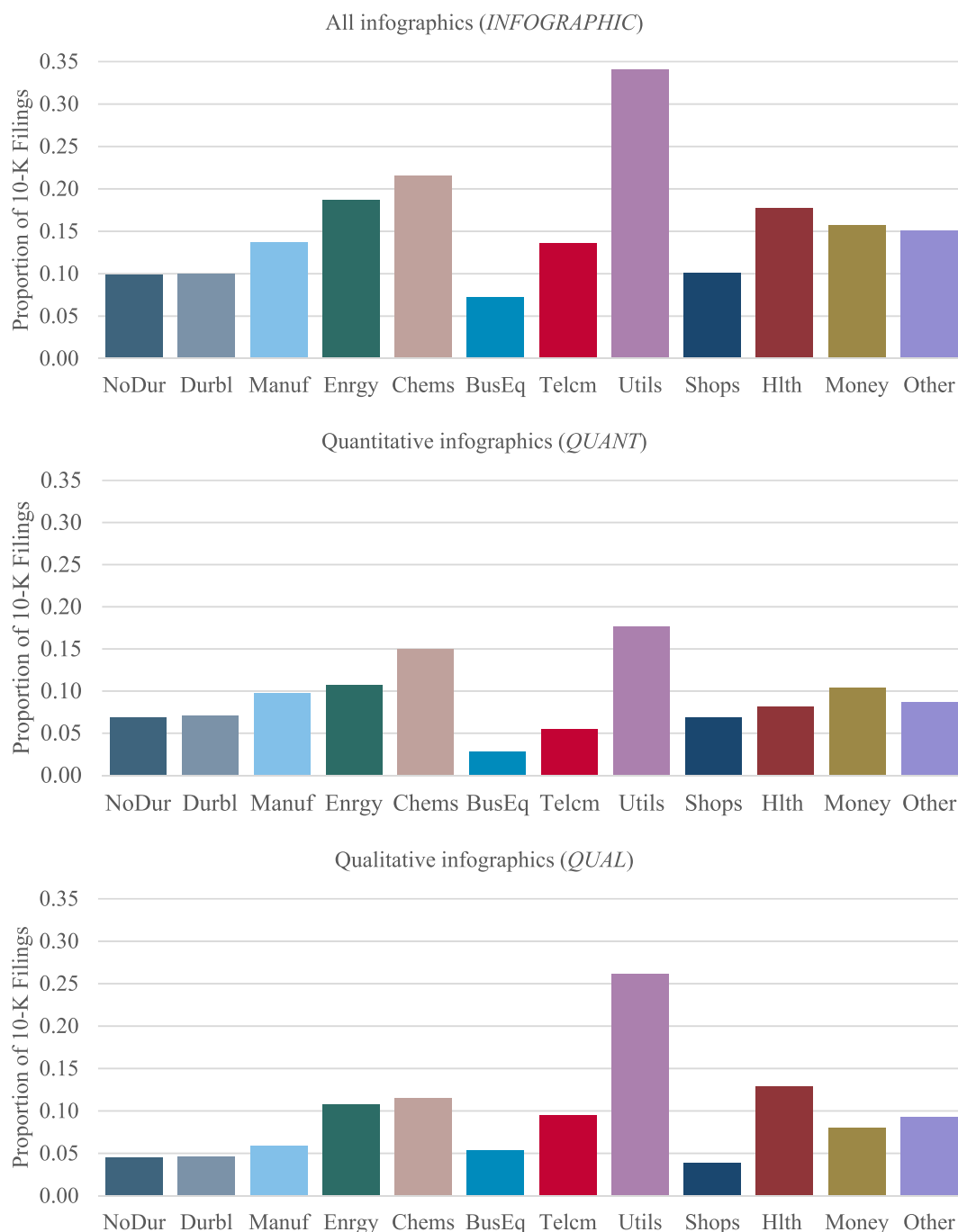
Fig. 5. Proportion of 10-K filings containing infographics by industry. The sample consists of 47,906 10-K filings from 2003 to 2019. We define all variables and Fama-French 12 industry categories in Appendix C and provide additional information on infographic types in Appendix A. (See the Web version of this article for the color version of this figure.)

infographic by industry as well as the non-graphical 10-K elements. Consistent with its overall dominance in Fig. 5, Utilities ranks among the top three industries for every type of qualitative and quantitative infographic except timelines. Chemicals is also among the top users of a variety of different infographic types. Other industries are more likely to use just a few infographic types. For example, Health discloses more timelines and process/flow charts, consistent with the use of graphics to illustrate processes used to develop drugs and conduct clinical trials. Business Equipment discloses a high concentration of strategy/business models, consistent with the importance of strategy differentiation in this sector. Finally, Money, (Non) Durables, Manufacturing, and Energy tend to use quantitative infographics, particularly bar charts, line graphs, and pie

Fig. 6. Proportion of 10-K filings containing each type of infographic (upper row of the grid) and the average value per 10-K filing of each 10-K characteristic (lower row of the grid) by industry. The sample consists of 47,906 10-K filings from 2003 to 2019. We define all variables and Fama-French 12 industry categories in Appendix C and provide additional information on infographic types in Appendix A. (See the Web version of this article for the color version of this figure.)
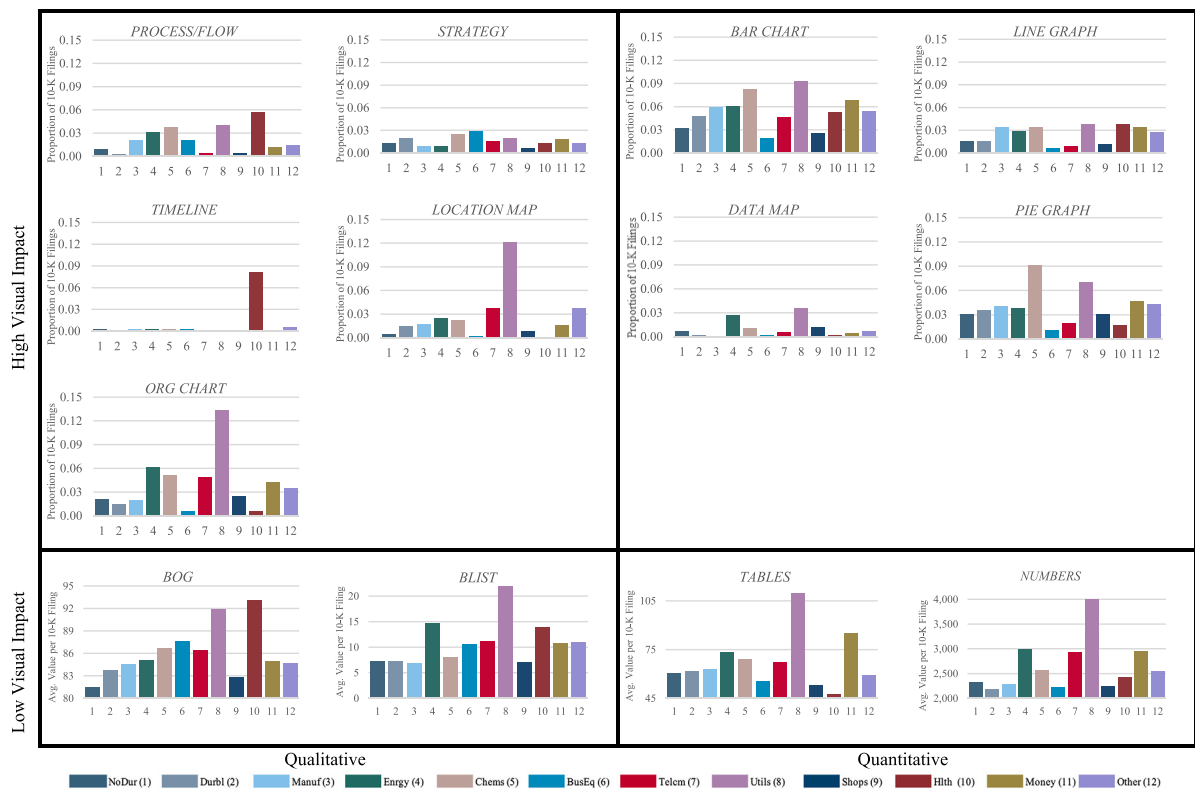
graphs. Overall, these results suggest the targeted use of different infographic types consistent with industry characteristics. In contrast, we find relatively little industry variation in the non-graphical elements in the bottom row of Fig. 6, except 10-K text is less readable for Healthcare and Utilities, and Utilities use more bulleted lists, tables, and numerical text.

In addition to the type of graphic, an important dimension of quantitative infographics is the nature of the data items presented, which we code into one or more of five categories (see Appendix A): (i) GAAP, (ii) non-GAAP, (iii) financial KPI, (iv) non-financial KPI, or (v) macro. Table 3 reports statistics both in aggregate for all quantitative infographics and for each image type, while Fig. 7 graphically illustrates the percentages reported in column 2 of this table.[10] We find that 45.18% of quantitative infographics report GAAP information, slightly less than financial and non-financial KPIs combined (47.98%). Macro data represent 4.75% of all data items. Perhaps surprisingly given their prevalence in other disclosure venues (e.g., earnings press releases), relatively few infographics report non-GAAP data (2.09%). This same relative distribution of data items is evident in the two most common quantitative infographic types (bar charts and pie graphs). In contrast, line graphs contain a disproportionately high percentage of financial and non-financial KPIs and macro data while non-financial KPIs dominate data maps.

Fig. 8, Panel A plots trends over time for each type of data item in quantitative infographics. The results indicate an increase in the proportion of 10-Ks containing infographics with GAAP and KPI data (both financial and nonfinancial). In contrast, there is relatively little change in non-GAAP and macro infographics over time. Panel B presents data items by industry. We find a relatively high proportion of GAAP and KPI infographics in Chemicals and Utilities. GAAP and financial KPI infographics are prevalent in Money, while Health and Energy disclose a disproportionate share of non-financial KPI infographics. Finally, Manufacturing, Utilities, and Energy disclose a high proportion of macro infographics.

Similar to textual disclosure that tends to be "sticky" over time (e.g., Brown and Tucker 2011; Dyer et al., 2017), firms may provide the same infographics in successive 10-K filings. To examine the persistence of infographics, Table 4, Panel A presents

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[10] The total number of data items in Table 3 (26,843) exceeds the total number of quantitative infographics in Table 2 (23,906) because some infographics contain multiple data items (e.g., a single bar chart may contain both GAAP and financial KPI data).

T.E. Christensen, K.E. Fronk, J.A. Lee, K.K. Nelson

Table 3
Classification and frequency of data items in quantitative infographics.

	(1) Total Items	(2) % of Total Items
All quantitative infographics		
GAAP	12,129	45.18%
NONGAAP	561	2.09%
FKPI	7,118	26.52%
NFKPI	5,761	21.46%
MACRO	1,274	4.75%
By type of quantitative infographic		
Bar Chart:		
GAAP	7,118	45.90%
NONGAAP	458	2.95%
FKPI	4,450	28.69%
NFKPI	3,056	19.70%
MACRO	427	2.75%
Pie Graph:		
GAAP	4,560	60.42%
NONGAAP	78	1.03%
FKPI	1,638	21.70%
NFKPI	1,200	15.90%
MACRO	71	0.94%
Line Graph:		
GAAP	419	12.55%
NONGAAP	25	0.75%
FKPI	1,012	30.31%
NFKPI	1,116	33.42%
MACRO	767	22.97%
Data Map:		
GAAP	32	7.14%
NONGAAP	0	0.00%
FKPI	18	4.02%
NFKPI	389	86.83%
MACRO	9	2.01%

This table reports the classification and frequency of data items in the 23,906 quantitative infographics (3,961 firm-years). The total number of data items (26,843) exceeds the total number of infographics because some infographics contain multiple data items. Column 1 reports the number of data items. Column 2 reports the relative percentage of data items within each quantitative infographic type. We define all variables in Appendix C and provide additional information on infographic type in Appendix A.
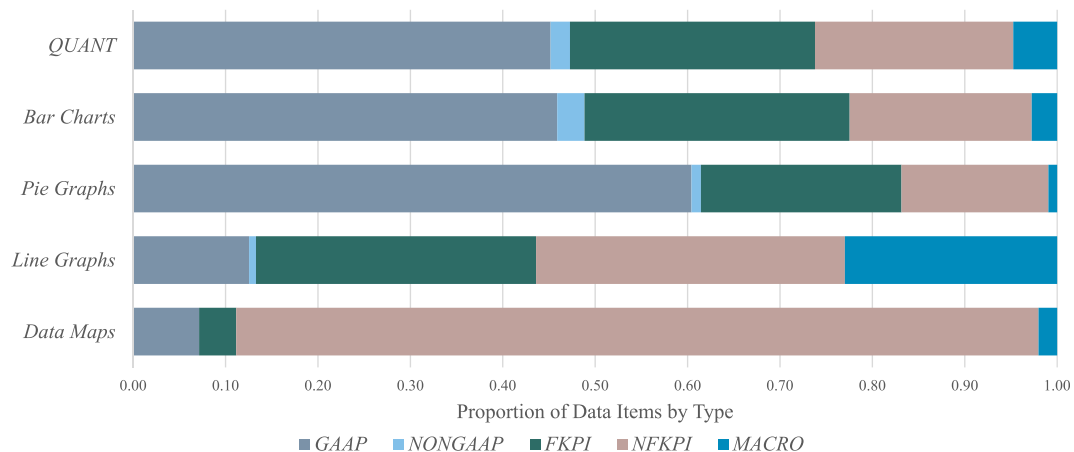
Fig. 7. Proportion of data items in quantitative infographics (*QUANT*) and by type of infographic. The sample consists of 47,906 10-K filings from 2003 to 2019. We define all variables in Appendix C and provide additional information on infographic types in Appendix A. (See the Web version of this article for the color version of this figure.)

Panel A: Over time
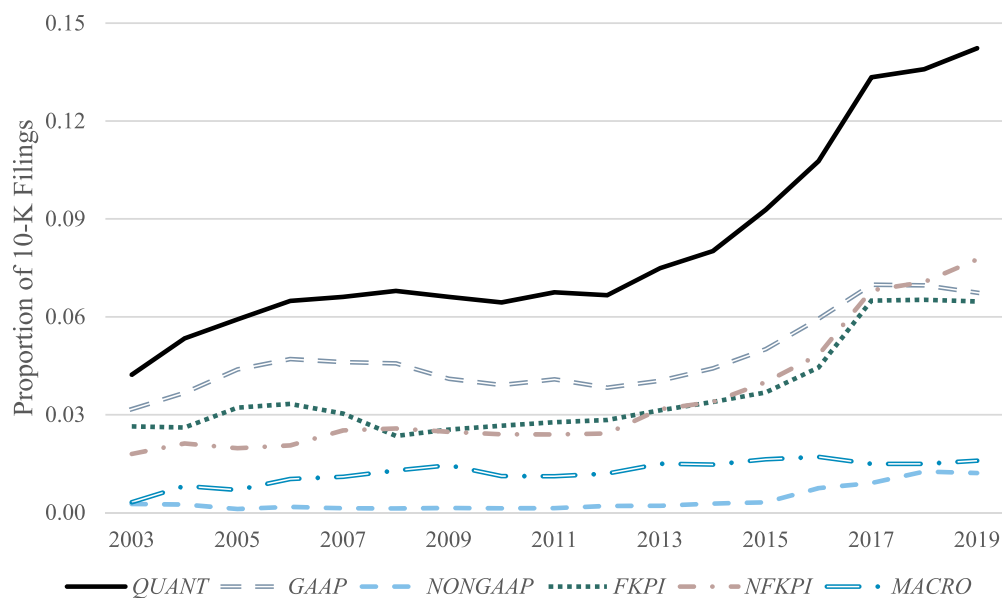
Panel B: By industry
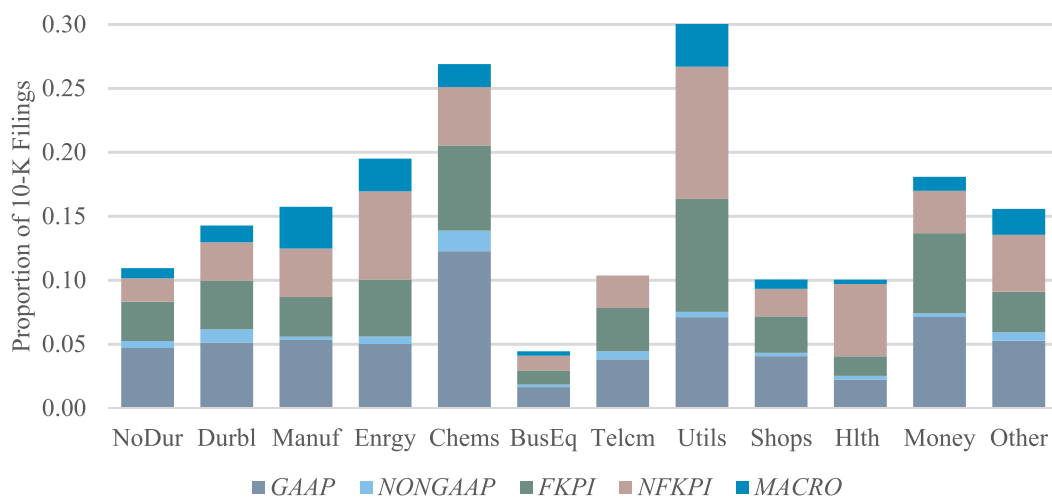
Fig. 8. Proportion of 10-K filings containing each data item over time (Panel A) and by industry (Panel B). The sample consists of 47,906 10-K filings from 2003 to 2019. We define industries using the Fama-French 12-industry classification. We define all variables in Appendix C and provide additional information on infographic types in Appendix A. (See the Web version of this article for the color version of this figure.)

autocorrelations between the disclosure of an infographic by firm i in year t and each of the next two years.[11] The first column indicates that 87.7% (80.7%) of firms disclosing an infographic in year t also disclose an infographic in $t+1$ ($t+2$).[12] Moreover, persistence is slightly higher for quantitative than qualitative infographics, and among quantitative infographics, *GAAP* (*NONGAAP*) infographics are the most (least) persistent.

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[11] The number of observations in Table 4 is less than our full sample (Table 2) because we require observations to have sufficient data to be in the sample in the current and subsequent two years.

[12] As a rough comparison, Dyer et al. (2017, Table 7) find that the year-over-year "stickiness" in the text of the top three 10-K topics (risk factors, internal control, and fair value/impairment) ranges from 84% to 90%. As another point of comparison, we find in untabulated tests that the persistence of Other Images is only 66% (56%) in year t ($t + 1$).

Table 4
Persistence of infographics in 10-K filings.

Panel A: Infographic type							
	INFOGRAPHIC	QUANT	QUAL	GAAP	NONGAAP	FKPI	NFKPI	MACRO
t + 1	0.877	0.865	0.851	0.833	0.709	0.788	0.770	0.787
t + 2	0.807	0.789	0.774	0.730	0.631	0.698	0.672	0.680
# Firm-Years	4,880	2,886	2,750	1,768	103	1,285	1,169	469
Panel B: Specific infographic							
	INFOGRAPHIC	QUANT	QUAL	GAAP	NONGAAP	FKPI	NFKPI	MACRO
t + 1	0.671	0.681	0.636	0.692	0.628	0.688	0.695	0.709
t + 2	0.462	0.466	0.448	0.468	0.311	0.446	0.495	0.526
# Infographics	23,816	18,648	5,168	9,975	296	5,674	3,939	1,142

This table reports the persistence of infographics in 10-K filings. The sample includes all firm-years from 2003 through 2017 because we require 10-K filings for two subsequent years. Panel A reports the percentage of firm-year observations in our sample that continue using the particular type of infographic in years $t + 1$ and $t + 2$. Panel B reports the percentage of infographics that are identical (with updated information) to an infographic in years $t + 1$ and $t + 2$. We define all variables in Appendix C and provide additional information on infographic type in Appendix A.

Table 4, Panel A only considers whether the same *type* of infographic is disclosed in successive years, not whether the same *exact* infographic is disclosed (e.g., the same bar chart with the same data categories). Following the procedures for measuring infographic similarity described in Appendix A, we present a more granular analysis of infographic persistence in Table 4, Panel B. We find that 67.1% of firms present the same infographic in the next year's 10-K and 46.2% continue to present that infographic for a second year. Further, the persistence of quantitative infographics (68.1%) is again higher than qualitative infographics (63.6%), and among quantitative infographics, *MACRO* infographics are the most persistent (70.9%) while *NONGAAP* infographics are the least persistent (62.8%). Overall, the evidence in Table 4 indicates that, similar to textual disclosure, the disclosure of infographics is relatively persistent over time.

The location where firms choose to embed infographics in the 10-K helps to provide context for the disclosure. Fig. 9, Panel A indicates that most infographics are split in nearly equal proportions between the Business and MD&A sections. However, quantitative infographics appear disproportionately in MD&A while qualitative infographics are concentrated in the Business section. There are relatively few infographics in the remaining sections of the 10-K. Panel B summarizes the infographic location for each type of quantitative data item. We find that GAAP, non-GAAP and financial KPIs are slightly overrepresented in MD&A. In other words, quantitative infographics in general, and specifically those containing data most closely related to the GAAP financial statements, are highlighted in the MD&A. In contrast, nonfinancial KPI infographics are concentrated in the Business section of the 10-K. Macro infographics are split fairly evenly between the Business and MD&A sections.

Overall, in response to our first research objective, we provide extensive evidence indicating that companies increasingly choose to provide infographics as part of their overall 10-K disclosure strategy, consistent with incentives to visually highlight certain information. Moreover, they utilize a variety of different graphic forms and summarize a broad spectrum of information from qualitative to quantitative financial, non-financial, and macro data. Nevertheless, not all firms use infographics, and among those that do, the average number of infographics in the final year of our sample is 5. Given the novelty of visual disclosure in general, and particularly in 10-Ks where nearly every disclosure requirement amenable to an infographic can be satisfied by providing the information in narrative or tabular form, we do not necessarily expect a large number of voluntary infographics per filing.[13] However, we provide evidence of a dramatic increase in the number of filings containing at least one infographic. Further, we find that the use of infographics in 10-Ks is increasing at a faster rate than the number of non-infographic images and the number of words per filing. Our paper is the first to systematically catalog this emerging disclosure phenomenon and provide a baseline for future research in this area.

4. Research design and variable definitions

4.1. Factors associated with the use of infographics

The 10-K contains a broad mosaic of information communicated through both textual and non-textual elements. Prior research focuses on the numerical and textual elements of the 10-K. In contrast, the purpose of our second research objective is to analyze factors associated with the use of graphical elements in the 10-K. Specifically, using the following probit model, we empirically test the association between the use of infographics in 10-Ks and company-specific attributes or events (internal factors), attributes of the firm's reporting environment (external factors), and the firm's 10-K reporting strategy (10-K factors):

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[13] Further, despite the common adage that "a picture is worth a thousand words," linguists do not expect images to replace text, especially when it is necessary to convey large amounts of complex information concisely and accurately (Manjoo 2017).

Panel A. Infographic type
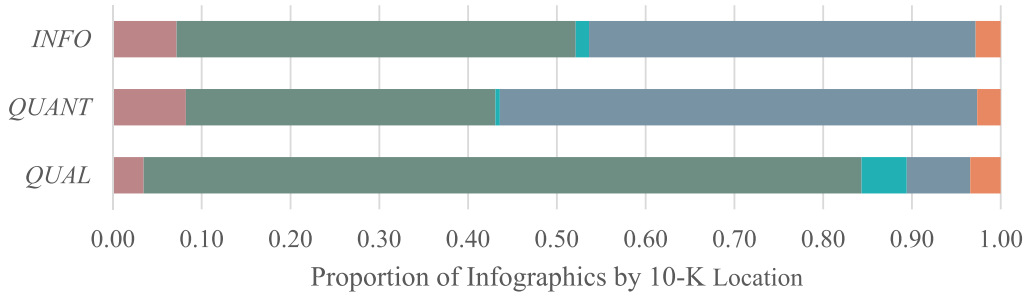
Panel B. Quantitative data item type
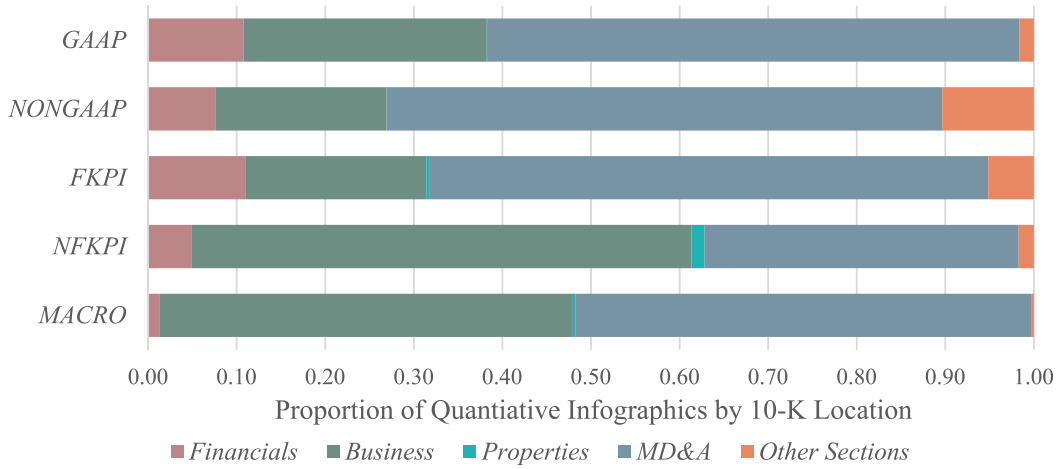
Fig. 9. Infographics by 10-K location. We define all variables in Appendix C and provide additional information on infographic types in Appendix A. (See the Web version of this article for the color version of this figure.)

$$INFOGRAPHIC\ VAR_{i,t} = \alpha_0 + \alpha_1 Internal\ factors_{i,t} + \alpha_2 External\ factors_{i,t} + \alpha_3 10\text{-}K\ factors_{i,t} + INDUSTRY\ FE \\ + YEAR\ FE + \varepsilon \tag{1}$$

INFOGRAPHIC VAR indicates whether the 10-K includes at least one infographic (*INFOGRAPHIC*), a quantitative (*QUANT*) infographic, or a qualitative (*QUAL*) infographic.[14] In addition, we examine the data content of quantitative infographics by defining *INFOGRAPHIC VAR* to indicate infographics displaying *GAAP*, *NONGAAP*, *FKPI*, *NFKPI*, or *MACRO* data. We discuss the variables we use to capture internal, external, and 10-K factors in detail subsequently. Importantly, we believe these variables primarily capture incentives to disclose infographics in 10-Ks rather than the technological capability or costs of doing so.[15] Finally, we include industry (*INDUSTRY FE*) and year (*YEAR FE*) fixed effects to account for variation in firms' use of infographics across industries and over time.

Because our descriptive evidence indicates that infographics are "sticky" over time, we also estimate a Cox proportional hazard model (Cox 1972) to examine factors associated with how quickly firms initiate the use of infographics:

$$h(t|x) = \{h_0(t)\exp(\beta_0)\}\exp(\Sigma\ \beta_i\ (Internal\ factors) + \Sigma\ \beta_j\ (External\ factors) + \Sigma\ \beta_k\ (10\text{-}K\ factors) + INDUSTRY\ FE + e \tag{2}$$

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[14] We define all variables in Appendix C. Because of skewness in the number of infographics per 10-K filing as shown in Fig. 2, all infographics variables are dichotomous. However, inferences are similar using the natural log of the number of infographics (untabulated).

[15] The technological ability to create and embed infographics is not restrictive in our setting, as discussed in footnote 7. Further, as the examples in Fig. 1 illustrate, 10-K infographics are typically not elaborate images that would require highly specialized skills or experience.

In this analysis, *t* is the number of years between the first year the firm is included in the sample and the first disclosure of an infographic.

4.1.1. Internal factors

We examine several company-specific attributes or events. Research suggests that firms are more likely to highlight favorable performance in annual report infographics (Beattie and Jones 2008). Thus, we separately include the magnitude of positive (|*POS ROA*|) and negative (|*NEG ROA*|) operating performance to examine the use of infographics in good and bad performance years, respectively. Research also finds that the complexity of the business or operating environment is a significant factor associated with the length and textual attributes of 10-K disclosures (e.g., Li 2008; Cazier and Pfeiffer 2016; Dyer et al., 2017). If firms use infographics to help readers understand this complexity, we expect that larger (*MVE*), less mature (*BTM*) firms with more volatile (*EARNVOL, RETVOL*) and complex (*BUSSEG, GEOSEG*) operations and higher litigation risk (*LITRISK*) will be more likely to provide infographics.

We also consider firms that engage in potentially disruptive events such as large acquisitions (*ACQ*) and restructurings (*RESTR*). On the one hand, firms may be more likely to include infographics to help explain the effects of these events. On the other hand, firms may be less likely to use infographics until the operational effects of the events have been absorbed. Finally, we examine internal factors associated with a firm's technological focus and sophistication. We expect that younger firms (*AGE*), firms employing a chief information officer (*CIO*), and firms referencing data analytics or data analysis (*DATA ANALYTICS*) in their 10-K are more likely to use infographics.

4.1.2. External factors

We also consider several attributes of the firm's external reporting environment. First, we consider the role of auditors and the SEC as third-party monitors. Prior research provides extensive evidence that *BIG4* auditors improve the quality of financial statements (DeFond and Zhang 2014), which could extend to the use of infographics in the 10-K. However, Dyer et al. (2017) find that readability and related attributes of 10-K textual disclosure are lower for firms with a *BIG4* auditor. The SEC also monitors the information firms present in 10-Ks. We expect that the more peer firms with a prior-year SEC comment letter related to infographics (*INDUSTRY CL*), the more likely the focal firm is to include infographics in its 10-K.

Firms may also consider other interested third parties when deciding whether to incorporate infographics in their 10-K filing. Regarding financial intermediaries, Lehavy et al. (2011) find that the demand for analysts is greater for firms with textual disclosures that are less readable. To the extent that the use of infographics makes disclosures easier to understand, as suggested by the SEC, we expect a negative association between infographics disclosure and analyst following (*ANALYSTS*). On the other hand, analysts may demand infographics to assist in their analyses, leading to a positive association. Allee et al. (2018) provide evidence that filing agents play an information intermediary role by improving the ability to automate the processing of firm disclosures. We expect the use of a top filing agent (*TOP* 25 *FA*) to be positively associated with the use of infographics. To provide evidence on the influence of industry peers, we include the number of firms in the industry that disclose the specific type of infographic in the prior year as the focal firm (*PEER*). We expect a positive association if firms tend to follow the reporting practices of their peers. We also include several variables to capture the firm's relative focus on retail investors. We expect that firms are more likely to use infographics when they focus on retail investors who are more likely to be attracted by and potentially benefit from visualizations than sophisticated users. Thus, we expect a positive association between the use of infographics and *SOCIAL MEDIA* and *RETAIL* and a negative association with *INSTOWN*.[16]

4.1.3. 10-K factors

Finally, we consider the firm's overall 10-K disclosure strategy. We include the Bonsall et al. (2017) Bog Index (*BOG*) to capture plain English disclosure. If firms use infographics to illuminate narrative discussion that is inherently complex (higher *BOG*), then we expect a positive association with the use of infographics.[17] However, we expect the association to be negative if firms increase transparency through the use of both plain English disclosure (lower *BOG*) and infographics. We also include the non-textual elements of 10-Ks in the bottom row of Fig. 1, namely the frequency of tables (*TABLES*), bulleted lists (*BLISTS*), and numerical text (*NUMBERS*). Firms using more of these elements may be more likely to use infographics to assist users in interpreting the information, or, alternatively, they may be less likely to use infographics if these elements substitute for visual content. Finally, we include the number of non-infographic images in the 10-K (*OTHER IMAGES*) and whether the firm prepares a "glossy" annual report for shareholders (*ANNUAL REPORT*) to capture firms' general proclivity to use visual content. We expect a positive association between these variables and the use of infographics.

4.2. Infographics and information environment uncertainty

Our third research objective is to examine the association between the use of infographics and uncertainty in the information environment. The SEC's primary role is to protect investors, maintain fair, orderly, and efficient markets, and facilitate

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[16] *RETAIL* identifies 10-Ks that mention retail, individual, or non-professional investors. In untabulated tests, we find that this variable is significantly negatively associated with institutional ownership and significantly positively associated with retail trading volume in the prior year.

[17] For example, see the SEC comment letter for CyberSource Corporation in Appendix B.

capital formation. To that end, the SEC seeks to establish and maintain a regulatory environment that promotes high quality disclosure. Consistent with this objective, Loughran and McDonald (2014) and Bonsall et al. (2017) find that more readable disclosures are associated with lower future market volatility. Infographics may play a similar role in reducing disagreement among market participants. However, while firms may include infographics to help explain complex information, people differ in their ability to understand graphics and are often unable to accurately draw inferences and make predictions from graphics, as discussed previously. As a result, infographics could be associated with greater post-filing disagreement. Further, similar to prior research, we recognize that self-selection is a potential factor in assessing the relation between infographics and capital market outcomes. For example, infographics may be related to greater post-filing disagreement if firms choose to include infographics in their 10-Ks when information is complex and difficult to process.

Following Loughran and McDonald (2014) and Bonsall et al. (2017), we test whether infographics are associated with post-filing return volatility (*POST-FILING VOL*), the magnitude of one-year-head analyst forecast errors (|*UNEXP EARN*|), and analyst forecast dispersion (*DISPERSION*). These variables capture how well investors and analysts understand and interpret the information in 10-Ks, and thus are directly related to the SEC's focus on ensuring that financial reports provide useful information. We estimate the following OLS model for each of these dependent variables (*DEPVAR*):

$$DEPVAR_{i,t} = \rho_0 + \rho_1 INFOGRAPHIC\ VAR_{i,t} + \rho_2 BOG + \Sigma\rho_i CONTROLS_{i,t} + INDUSTRY\ FE + YEAR\ FE + \varepsilon \qquad (3)$$

INFOGRAPHIC VAR is our primary variable of interest, defined as *INFOGRAPHIC, QUANT*, or *QUAL*. We control for textual readability with *BOG*, and include a vector of control variables following Loughran and McDonald (2014) and Bonsall et al. (2017): *PRE-FILING ALPHA, PRE-FILING VOL,* |*CAR*|, ln(*BTM*), ln(*MVE*), *NASDAQ,* and, in the regressions with |*UNEXP EARN*| and *DISPERSION* as the dependent variable, ln(*ANALYSTS*). We expect a negative (positive) ρ_1 coefficient if infographics are associated with less (more) market uncertainty.

5. Empirical results

5.1. Descriptive statistics

Table 5 presents descriptive statistics. We find that 14.1% of the 10-Ks in our sample include at least one infographic (*INFOGRAPHIC*). Quantitative (*QUANT*) and qualitative (*QUAL*) infographics occur in approximately 8% of the filings. Focusing on data content, 4.8% of sample observations present an infographic containing *GAAP* data, slightly higher than the frequency of either *FKPI* (3.7%) or *NFKPI* (3.5%) infographics. In contrast, infographics containing *MACRO* or *NONGAAP* data occur in around 1% or less of the sample 10-Ks.

Regarding internal factors, the mean (median) |*POS ROA*| is 0.05 (0.03), while the mean (median) |*NEGROA*| is 0.05 (0.00). The mean *MVE* is $4.3 billion, compared to a median of $678 million. Approximately 7% of the firm-years have significant acquisition activity. The mean (median) *AGE* of sample firms is approximately 20 (15) years, and 10.8% (6.9%) of our sample 10-Ks reference a chief information officer (data analytics).

Descriptive statistics for the external factors indicate that 75% of sample firms have a *BIG4* auditor and 22.3% have an industry peer that received an infographics-related comment letter in the prior year. The mean (median) number of *ANALYSTS* is 7 (5) while the mean (median) number of peer firms disclosing an infographic is 30 (18). The mean (median) institutional ownership is 55.4% (63.4%). Sample firms reference *RETAIL* investors and *SOCIAL MEDIA* in 3.8% and 0.7% of their 10-Ks, respectively. Approximately two-thirds of the sample use a top filing agent.

Only 1.8% of sample 10-Ks include non-infographic *OTHER IMAGES* but 35.5% of the sample prepares a separate glossy *ANNUAL REPORT* for shareholders. *BOG* has a mean and median of 86, which is slightly higher than reported by Bonsall et al. (2017) for their sample ending in 2011. However, this result is consistent with the continued upward trend in this variable through 2019 (Fig. 3, Panel B), indicating a decline in the readability of 10-K text over time. Finally, firms include an average of 10 bulleted lists and 66 tables in the 10-K.

The variables for our capital market tests indicate that the average post-filing stock return volatility is 2.09, the absolute value of unexpected earnings is 0.55, and analyst forecast dispersion is 0.28. These statistics are consistent with Bonsall et al.'s (2017) evidence for the latter half of their sample period (2003−2011). The summary statistics for the control variables used in these tests are also consistent with Bonsall et al. (2017).

5.2. Factors associated with the use of infographics in 10-K filings

Table 6, Panel A presents summary statistics for the estimation of Eq. (1). We first discuss the results in column 1 with *INFOGRAPHIC* as the dependent variable.[18] Regarding internal factors, we find that the magnitude of operating performance, whether positive or negative, is positively associated with the decision to include infographics in 10-K filings. In other words,

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[18] The model explanatory power of 14.3% compares favorably to similar models examining other 10-K attributes with year and industry fixed effects. For example, using the Fog Index of textual readability as the dependent variable, Li (2008) reports an adjusted R^2 of 8% while Dyer et al. (2017) report an adjusted R^2 of 11%. Inferences are unchanged in untabulated analyses excluding industry fixed effects (model adjusted $R^2 = 12.6\%$).

Table 5
Descriptive statistics.

Variables	Mean	Std. Dev.	Q1	Median	Q3
Infographic variables					
INFOGRAPHICS	0.141	0.348	0	0	0
QUANT	0.083	0.275	0	0	0
QUAL	0.081	0.273	0	0	0
GAAP	0.048	0.214	0	0	0
NONGAAP	0.004	0.062	0	0	0
FKPI	0.037	0.188	0	0	0
NFKPI	0.035	0.185	0	0	0
MACRO	0.013	0.111	0	0	0
Internal factors					
Performance:					
|POS ROA|	0.050	0.068	0.000	0.026	0.073
|NEG ROA|	0.046	0.136	0.000	0.000	0.004
Business and operating complexity:					
MVE	4,322.229	12,216.769	179.875	677.754	2,631.106
EARNVOL	0.071	0.116	0.012	0.029	0.077
RETVOL	0.113	0.069	0.065	0.095	0.141
GEOSEG	2.369	2.673	0	1	4
BUSSEG	2.222	2.123	1	1	4
LITRISK	0.049	0.064	0.017	0.031	0.057
BTM	0.628	0.497	0.295	0.510	0.810
Significant events:					
ACQ	0.073	0.261	0	0	0
RESTR	0.238	0.426	0	0	0
Technological focus:					
AGE	19.562	16.020	8.058	15.200	25.666
CIO	0.108	0.310	0	0	0
DATA ANALYTICS	0.069	0.253	0	0	0
External factors					
Monitoring:					
BIG4	0.750	0.433	0	1	1
INDUSTRY CL	0.223	0.416	0	0	0
Other interested third parties:					
ANALYSTS	7.110	6.970	2	5	10
PEER	30.097	38.110	7	18	39
INST OWN	0.554	0.344	0.239	0.634	0.861
SOCIAL MEDIA	0.007	0.083	0	0	0
RETAIL	0.038	0.192	0	0	0
TOP 25 FA	0.647	0.478	0	1	1
10-K factors					
Proclivity to use visual content:					
OTHER IMAGES	0.018	0.134	0	0	0
ANNUAL REPORT	0.355	0.479	0	0	1
Other 10-K characteristics:					
BOG	86.109	6.796	81	86	90
BLISTS	10.401	10.318	2	8	16
TABLES	65.551	30.717	44	60	81
NUMBERS	2,555.507	1,144.935	1,800	2,300	2,999
Capital market variables					
POST-FILING VOL	2.087	1.469	1.095	1.650	2.592
|UNEXP EARN|	0.549	1.173	0.062	0.180	0.488
DISPERSION	0.279	0.529	0.043	0.107	0.265
PRE-FILING ALPHA	0.022	0.159	−0.063	0.015	0.096
PRE-FILING VOL	2.488	1.455	1.437	2.104	3.109
|CAR|	0.031	0.039	0.007	0.017	0.037
NASDAQ	0.559	0.496	0	1	1

This table presents descriptive statistics for the variables used in the main empirical analyses. We define all variables in Appendix C and provide additional information on infographic type in Appendix A. We winsorize all continuous variables at the 1st and 99th percentiles. The sample consists of 47,906 firm-year observations from 2003 to 2019, except |UNEXP EARN| (30,506) and DISPERSION (22,352).

firms are more likely to include infographics when performance is extreme rather than only highlight favorable performance. We also find that greater business and operating complexity, as indicated by firms that are larger, less mature, and with higher return volatility and greater litigation risk, are positively associated with the use of infographics. In contrast, firms are less

Table 6
Factors associated with the use of infographics in 10-K filings.

Panel A: Infographic type

	(1)	(2)	(3)
	INFOGRAPHIC	QUANT	QUAL
Internal factors			
Performance:			
|POS ROA|	0.619**	0.566**	0.662**
	(2.433)	(2.017)	(2.110)
|NEG ROA|	0.422***	0.418***	0.393***
	(3.590)	(2.902)	(3.060)
Business and operating complexity:			
ln(MVE)	0.079***	0.077***	0.053**
	(4.019)	(3.383)	(2.351)
EARNVOL	0.198	0.234	0.063
	(1.137)	(1.345)	(0.285)
RETVOL	0.735***	0.433*	0.884***
	(3.541)	(1.767)	(3.742)
ln(GEOSEG)	−0.044	0.004	−0.056
	(−1.314)	(0.105)	(−1.416)
ln(BUSSEG)	0.019	0.026	0.007
	(0.601)	(0.703)	(0.190)
LITRISK	1.087***	1.347***	0.944***
	(4.314)	(4.879)	(3.219)
BTM	0.085**	0.068	0.088*
	(2.103)	(1.427)	(1.912)
Significant events:			
ACQ	−0.032	−0.072*	−0.010
	(−0.955)	(−1.716)	(−0.276)
RESTR	−0.143***	−0.071*	−0.171***
	(−4.307)	(−1.896)	(−4.406)
Technological focus:			
ln(AGE)	−0.191***	−0.058*	−0.286***
	(−7.297)	(−1.944)	(−9.342)
CIO	0.073	0.036	0.085
	(1.359)	(0.588)	(1.422)
DATA ANALYTICS	0.171***	0.040	0.234***
	(3.189)	(0.629)	(3.905)
External factors			
Monitoring:			
BIG4	0.128***	0.140**	0.075
	(2.580)	(2.381)	(1.321)
INDUSTRY CL	0.080***	0.066***	0.043*
	(4.176)	(2.898)	(1.915)
Other interested third parties:			
ln(ANALYSTS)	0.036	0.010	0.047
	(1.049)	(0.247)	(1.208)
ln(PEER)	0.081***	0.084***	0.139***
	(3.407)	(2.878)	(5.583)
INST OWN	−0.296***	−0.061	−0.386***
	(−4.816)	(−0.898)	(−5.486)
SOCIAL MEDIA	0.171	0.311*	0.018
	(1.127)	(1.881)	(0.112)
RETAIL	0.252***	0.196**	0.330***
	(3.045)	(2.080)	(3.578)
TOP 25 FA	0.040	0.001	0.076**
	(1.192)	(0.017)	(1.987)
10-K factors			
Proclivity to use visual content:			
ln(OTHER IMAGES)	1.780***	1.504***	1.343***
	(21.069)	(17.345)	(14.978)
ANNUAL REPORT	0.008	0.099**	−0.056
	(0.220)	(2.383)	(−1.330)
Other 10-K characteristics:			
BOG	0.006*	−0.007*	0.015***
	(1.801)	(−1.791)	(3.653)
ln(BLISTS)	0.085***	0.091***	0.063***
	(5.063)	(4.664)	(3.037)
ln(TABLES)	0.177***	0.270***	0.062
	(3.129)	(4.116)	(0.909)
ln(NUMBERS)	0.119**	0.014	0.245***
	(2.341)	(0.233)	(4.121)

Table 6 (*continued*)

Panel A: Infographic type

	(1)	(2)	(3)
	INFOGRAPHIC	QUANT	QUAL
INTERCEPT	−4.184***	−3.349***	−5.269***
	(−9.618)	(−6.590)	(−10.602)
Industry Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Observations	47,906	47,906	47,906
Pseudo R^2	0.143	0.136	0.169

Panel B: Data items in quantitative infographics

	(1)	(2)	(3)	(4)	(5)
	GAAP	NONGAAP	FKPI	NFKPI	MACRO
Internal factors					
Performance:					
|*POS ROA*|	0.397	0.449	0.206	0.365	0.686
	(1.028)	(0.576)	(0.489)	(1.051)	(1.396)
|*NEG ROA*|	−1.294***	−0.625	−0.806***	0.587***	0.447*
	(−3.969)	(−1.083)	(−2.813)	(3.472)	(1.746)
Business and operating complexity:					
ln(MVE)	0.075***	0.069	0.074**	0.100***	0.101**
	(2.655)	(1.378)	(2.379)	(3.520)	(2.362)
EARNVOL	0.112	−3.908***	0.305	0.419**	0.363
	(0.399)	(−3.471)	(1.061)	(2.166)	(1.218)
RETVOL	−0.337	0.294	0.251	1.094***	0.321
	(−0.984)	(0.329)	(0.694)	(3.666)	(0.762)
ln(GEOSEG)	0.093*	0.098	−0.083	−0.084*	−0.055
	(1.953)	(1.163)	(−1.601)	(−1.819)	(−0.759)
ln(BUSSEG)	0.013	−0.027	0.011	0.002	−0.029
	(0.289)	(−0.322)	(0.243)	(0.036)	(−0.404)
LITRISK	1.087***	1.011**	1.325***	0.950***	0.500
	(3.521)	(1.979)	(3.889)	(3.599)	(1.282)
BTM	0.130**	0.084	0.056	0.135**	0.186**
	(2.033)	(0.862)	(0.861)	(2.314)	(2.407)
Significant events:					
ACQ	−0.037	0.207**	0.019	−0.069	−0.021
	(−0.763)	(2.294)	(0.356)	(−1.345)	(−0.293)
RESTR	0.016	0.127	−0.114**	−0.163***	−0.138**
	(0.364)	(1.517)	(−2.248)	(−3.465)	(−2.156)
Technological focus:					
ln(AGE)	0.026	−0.095	0.042	−0.120***	0.000
	(0.715)	(−1.499)	(1.117)	(−3.352)	(0.009)
CIO	0.102	0.365***	0.152**	0.002	−0.272**
	(1.544)	(3.503)	(1.969)	(0.025)	(−2.401)
DATA ANALYTICS	0.054	0.154	0.072	0.056	−0.042
	(0.728)	(1.086)	(0.892)	(0.706)	(−0.369)
External factors					
Monitoring:					
BIG4	0.045	0.026	0.109	0.192***	0.362***
	(0.571)	(0.171)	(1.351)	(2.737)	(3.318)
INDUSTRY CL	0.087***	0.193**	0.060*	0.076**	−0.012
	(3.005)	(2.467)	(1.823)	(2.495)	(−0.262)
Other interested third parties:					
ln(ANALYSTS)	0.057	−0.101	0.024	−0.011	−0.138*
	(1.258)	(−1.029)	(0.482)	(−0.211)	(−1.836)
ln(PEER)	0.075**	−0.047	0.049	0.068*	−0.004
	(2.209)	(−0.553)	(1.216)	(1.777)	(−0.050)
INST OWN	0.007	0.215	−0.034	0.074	−0.195
	(0.082)	(1.331)	(−0.384)	(0.964)	(−1.545)
SOCIAL MEDIA	0.356*	−0.894***	0.582***	0.264	0.211
	(1.778)	(−3.395)	(3.144)	(1.542)	(0.480)
RETAIL	0.283***	0.138	0.162	0.178	−0.158
	(2.697)	(0.771)	(1.485)	(1.412)	(−0.982)
TOP 25 FA	−0.038	−0.285***	−0.010	0.012	0.012
	(−0.793)	(−2.666)	(−0.190)	(0.248)	(0.148)
External factors					
Proclivity to use visual content:					
ln(OTHER IMAGES)	1.548***	1.035***	1.392***	1.204***	0.678***
	(16.974)	(7.420)	(13.834)	(13.094)	(4.556)

Table 6 (*continued*)

Panel B: Data items in quantitative infographics

	(1)	(2)	(3)	(4)	(5)
	GAAP	NONGAAP	FKPI	NFKPI	MACRO
ANNUAL REPORT	0.122**	−0.045	0.109*	0.079	−0.030
	(2.356)	(−0.348)	(1.950)	(1.459)	(−0.410)
Other 10-K characteristics:					
BOG	−0.008*	0.005	−0.014***	−0.011**	−0.013*
	(−1.822)	(0.569)	(−2.740)	(−2.174)	(−1.778)
ln(*BLISTS*)	0.039	−0.025	0.084***	0.099***	0.062*
	(1.627)	(−0.495)	(3.254)	(3.771)	(1.676)
ln(*TABLES*)	0.283***	0.642***	0.377***	0.109	0.204
	(4.045)	(3.168)	(4.151)	(1.267)	(1.543)
ln(*NUMBERS*)	0.022	−0.033	−0.052	−0.067	0.173*
	(0.332)	(−0.238)	(−0.682)	(−0.925)	(1.667)
INTERCEPT	−3.679***	−5.582***	−3.028***	−2.332***	−4.858***
	(−6.204)	(−4.272)	(−4.519)	(−3.807)	(−4.841)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	47,906	47,906	47,906	47,906	46,961
Pseudo R^2	0.172	0.250	0.184	0.144	0.113

This table reports the results of regression analyses of factors associated with the use of infographics in 10-K filings by the type of infographic (Panel A) and type of data items for quantitative infographics (Panel B). The sample consists of 47,906 firm-year observations from 2003 to 2019. There are fewer observations in Column 5 because one of the industries (Telephone and Television Transmission) has no MACRO infographics during the sample period. The estimations include Fama-French 12-industry fixed-effects and calendar-year fixed effects and cluster standard errors by firm. We define all variables in Appendix C and provide additional information on infographic type in Appendix A. We winsorize all continuous variables at the 1% and 99% levels. *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively.

likely to include infographics when they have significant restructuring activities. Finally, younger firms and firms with a greater focus on data analytics are more likely to disclose infographics.[19]

Regarding the firm's external reporting environment, we find that heightened external monitoring by a Big 4 auditor or the SEC increases the likelihood that the firm will disclose infographics in 10-K filings. Further, while analyst following is not significantly associated with the use of infographics, having more peer firms that previously disclosed an infographic increases the likelihood that the focal firm will use infographics. Finally, firms with lower institutional investor ownership and those referencing retail investors in the 10-K are more likely to include infographics, suggesting that infographics are directed at less sophisticated users.

Considering the firms overall 10-K reporting package, we find that firms are more likely to use infographics when they also include more other aesthetically appealing images, consistent with a general focus on visual content. Moreover, firms are more likely to use infographics when the text of the 10-K is less readable (higher *BOG*) and when they include more bulleted lists, tables, and numerical text. These results are consistent with the prescription in the SEC's Plain English Handbook to illuminate text with graphics, tables, and bulleted lists.

Because of the increasing trend in the use of infographics (Fig. 3), we also examine whether the factors associated with their use are consistent in the first half of the sample period (2003−2011) compared to the latter half (2012−2019). In untabulated results, we find that *EARNVOL, RETVOL, BTM, DATA ANALYTICS,* ln(*PEER*), *RETAIL, INDUSTRY CL,* and *BOG* are insignificant in the first half, but are significantly positive in the later half. In contrast, *TOP* 25 FA, *SOCIAL MEDIA*, and ln(*NUMBERS*) are significantly positive in the first half of our sample period but insignificant in the later half. Moreover, despite having fewer observations in the later period (22,807 versus 25,036), the explanatory power of the model is somewhat higher (14.2% versus 13.1%) Although we do not have specific predictions regarding variation across the two periods, the results suggest that as the use of infographics evolves over time, the factors associated with their disclosure also evolve.

Focusing on infographics in general may mask important differences across infographic types. Thus, Table 6, Panel A also presents separate results for quantitative (column 2) and qualitative (column 3) infographics. Our evidence is generally consistent across infographic types with four primary exceptions. First, we find that the positive association between infographics and *DATA ANALYTICS* is attributable to *qualitative* infographics, suggesting a focus on business process, strategy, and organization analytics. In contrast, the positive coefficient on *BIG4* is primarily attributable to *quantitative* infographics, consistent with a focus by auditors on quantitative data in the 10-K. Similarly, firms that file a glossy *ANNUAL REPORT* are more

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[19] In untabulated analyses, we also examine several manager characteristics: young executive (i.e., bottom quartile of CEO or CFO tenure), experienced executive (top quartile of CEO or CFO tenure), CEO duality (i.e., CEO is also chairperson of the board), CEO outside work experience prior to becoming CEO, and CEO pay sensitivity. However, these variables are not significantly related to the disclosure of infographics in 10-Ks.

likely to use quantitative infographics.[20] Finally, we find a significantly negative (positive) association between *BOG* and quantitative (qualitative) infographics. These results suggest that quantitative infographics complement more readable narrative while firms use qualitative infographics in conjunction with less readable narrative, perhaps because of the inherently complex information they depict.[21]

5.2.1. Data items presented in quantitative infographics

Firms disclosing quantitative infographics can emphasize a variety of different data items. To examine the factors associated with this decision, Table 6, Panel B presents the results from separately estimating Eq. (1) for *GAAP*, *NONGAAP*, *FKPI*, *NFKPI*, and *MACRO* infographics. For brevity, we focus our discussion on notable differences in the results relative to the general determinants of quantitative infographics in Table 6, Panel A.

We find that firms with extremely negative earnings performance are less likely to disclose *GAAP* and *FKPI* infographics but more likely to disclose *NFKPI* and *MACRO* infographics, suggesting a shift in focus away from financial statement results to other performance-related data. Similarly, young firms and firms with greater operating volatility are more likely to disclose *NFKPI* infographics. In contrast, significant restructuring activity dampens the disclosure of *FKPI*, *NFKPI* and *MACRO* infographics. Interestingly, we find that the overall positive association between quantitative infographics and *BIG4* is attributable to *NFKPI* and *MACRO* infographics, suggesting that firms with a high-quality auditor are more likely to use infographics to highlight data that can provide context for the financial statements.

Distinctive factors associated with the use of *GAAP* infographics include the number of industry peers that previously disclosed a *GAAP* infographic and references to retail investors in the 10-K. Firms turn to *NONGAAP* infographics when they have significant acquisition activity, a factor that often leads to non-GAAP earnings exclusions (e.g., Black et al., 2021). Further, firms are more likely to use *NONGAAP* infographics when GAAP earnings volatility is lower and when industry peers receive more SEC comment letters related to infographics.

Although all sample firms present GAAP financial statements from which they may choose to highlight certain measures in an infographic, firms are likely to highlight the other data items in an infographic only when they relate to information discussed elsewhere in the 10-K. Therefore, we narrow the analysis in Table 6, Panel B to subsamples of firms discussing *NONGAAP*, *FKPI*, or *NFKPI* data, which we identify by a keyword search of related terms or the inclusion of an infographic of that type in the 10-K.[22] In untabulated tests, we find that results are robust for all variables in the *NONGAAP* and *FKPI* subsample. In the *NFKPI* subsample, *EARNVOL*, ln*(GEOSEG)*, *BTM*, and *BOG* are insignificant while the coefficients on *DATA ANALYTICS*, *INST OWN*, and ln*(TABLES)* are significantly positive and ln*(NUMBERS)* is significantly negative. Given the high level of sample attrition in the non-financial KPI subsample, it is possible that the insignificant results are attributable to the difficulty of comprehensively capturing relevant words and phrases for *NFKPI* metrics used by the firm. Although these keyword lists are admittedly an imperfect control for the relevance of each data item for our sample firms, this evidence generally confirms that the factors in our model are associated with the decision to highlight certain data in graphical form incremental to the decision to discuss the data in the text of the 10-K.

5.2.2. Factors associated with the initial disclosure of infographics

Because our evidence indicates that the disclosure of infographics is relatively persistent (Table 4), we next examine the decision to begin disclosing infographics. Table 7, Panel A presents the results of the multivariate hazard model in Eq. (2), where a positive coefficient indicates that the factor is associated with the firm initiating disclosure sooner after first entering the sample.[23] We find that firms with more negative operating performance initiate the disclosure of quantitative infographics earlier, but no relation between positive operating performance and the decision to initiate disclosure. Thus, relative to the cross-sectional tests in Table 6, Panel A, performance is less of a consideration in the decision to initiate disclosure. Stated differently, extreme performance relative to other firms matters mostly after firms have already begun disclosing

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[20] During our sample period, firms could mail their "glossy" annual report to the SEC or submit it electronically on EDGAR. In 2016, the Division of Corporation Finance began allowing firms to post an electronic version of the "glossy" annual report on their corporate website in lieu of filing with the SEC. Thus, *ANNUAL REPORT* captures the intended construct with noise. On June 2, 2022, the SEC adopted updated filing requirements mandating electronic submission of "glossy" annual reports to EDGAR, which will serve as an electronic repository of these reports regardless of whether companies post them to their corporate websites (SEC 2022). To the extent that the decision to file glossy annual reports on EDGAR is positively correlated with the decision to include infographics in 10-K filings, the measurement error in *ANNUAL REPORT* could induce a false positive association in our empirical tests. However, our finding that the association exists only for quantitative infographics casts doubt on this explanation.

[21] We also estimate the empirical model using a linear probability model (untabulated) and find inferences that are generally consistent with our tabulated results. Specifically, we find that results are unchanged for all variables in the *INFOGRAPHIC* model. In the *QUANT* model, we find that the coefficient on *BTM* is significantly positive at the 0.10 level, but *RETVOL*, ln*(AGE)*, *SOCIAL MEDIA*, and *BOG*, which are significant at the 0.10 level in the tabulated results, are insignificant. Results are unchanged in the *QUAL* model, except the coefficient on ln*(GEOSEG)* is significantly negative at the 0.10 level.

[22] Specifically, the *NONGAAP* subsample (40,218 observations) includes 10-Ks with a *NONGAAP* infographic or a keyword from Laurion (2020). Similarly, the *FKPI* and *NFKPI* subsamples (46,497 and 18,788 observations, respectively) include 10-Ks with a *FKPI* or *NFKPI* infographic or a financial or nonfinancial KPI keyword from Givoly et al. (2019), which we supplement with additional terms from our data (e.g., minerals per mile).

[23] The number of observations in the *INFOGRAPHIC* regression in column 1 is less than either the *QUANT* or *QUAL* regressions in columns 2 and 3, respectively, because observations are included through the first year a firm discloses *any* infographic. For example, once a firm discloses a quantitative infographic, any subsequent disclosure of a qualitative infographic is not included. In contrast, the *QUANT* (*QUAL*) regressions include observations through the first year a firm discloses a quantitative (qualitative) infographic. The same logic applies to the different types of quantitative infographics in Table 7, Panel B.

Table 7

Factors associated with the initial use of infographics in 10-K filings.

Panel A: Infographic type

	(1)	(2)	(3)
	INFOGRAPHIC	QUANT	QUAL
Internal factors			
Performance:			
|POS ROA|	0.425	0.165	0.769
	(1.030)	(0.292)	(1.548)
|NEG ROA|	0.241	0.459*	0.253
	(1.282)	(1.736)	(1.174)
Business and operating complexity:			
ln(MVE)	0.074***	0.097***	0.058*
	(2.664)	(2.695)	(1.712)
EARNVOL	0.263	0.115	0.024
	(1.148)	(0.349)	(0.088)
RETVOL	1.450***	1.336**	1.878***
	(3.577)	(2.377)	(3.969)
ln(GEOSEG)	−0.198***	−0.156***	−0.216***
	(−4.603)	(−2.798)	(−4.101)
ln(BUSSEG)	0.121***	0.131**	0.146**
	(2.682)	(2.335)	(2.542)
LITRISK	1.298***	1.538***	1.436***
	(3.686)	(3.548)	(3.465)
BTM	−0.047	−0.172*	0.044
	(−0.734)	(−1.916)	(0.585)
Significant events:			
ACQ	0.059	−0.153	0.195*
	(0.637)	(−1.148)	(1.780)
RESTR	−0.145**	−0.173*	−0.191**
	(−2.069)	(−1.914)	(−2.168)
Technological focus:			
ln(AGE)	−0.275***	−0.093**	−0.428***
	(−8.529)	(−2.269)	(−10.487)
CIO	0.169**	0.101	0.294***
	(2.037)	(0.993)	(2.826)
DATA ANALYTICS	0.060	−0.127	0.163
	(0.686)	(−1.059)	(1.641)
External factors			
Monitoring:			
BIG4	0.439***	0.448***	0.407***
	(6.087)	(4.661)	(4.646)
INDUSTRY CL	0.193***	0.146*	0.242***
	(3.149)	(1.786)	(3.361)
Other interested third parties:			
ln(ANALYSTS)	0.092*	0.053	0.060
	(1.825)	(0.812)	(0.952)
ln(PEER)	−0.143***	−0.065	−0.054
	(−4.737)	(−1.570)	(−1.551)
INST OWN	−0.531***	−0.238**	−0.610***
	(−6.575)	(−2.278)	(−6.189)
SOCIAL MEDIA	−0.180	−0.095	−0.197
	(−0.843)	(−0.334)	(−0.815)
RETAIL	0.324***	0.272**	0.367**
	(2.875)	(2.004)	(2.543)
TOP 25 FA	0.175***	0.125*	0.272***
	(3.134)	(1.751)	(3.866)
10-K factors			
Proclivity to use visual content:			
ln(OTHER IMAGES)	1.541***	1.788***	1.514***
	(16.781)	(16.639)	(14.346)
ANNUAL REPORT	0.528***	0.621***	0.481***
	(8.647)	(7.852)	(6.121)
Other 10-K characteristics:			
BOG	−0.012***	−0.027***	0.000
	(−2.832)	(−4.858)	(0.057)
ln(BLISTS)	−0.009	0.021	−0.007
	(−0.364)	(0.678)	(−0.253)
ln(TABLES)	0.003	0.227**	−0.111
	(0.032)	(2.182)	(−1.081)
ln(NUMBERS)	0.224***	0.187*	0.341***
	(2.768)	(1.789)	(3.323)

Table 7 (*continued*)

Panel A: Infographic type

	(1)	(2)	(3)
	INFOGRAPHIC	QUANT	QUAL
INTERCEPT	−0.012***	−0.027***	0.000
	(−2.832)	(−4.858)	(0.057)
Industry Fixed Effects	Yes	Yes	Yes
Observations	39,922	42,966	43,111

Panel B: Data items in quantitative infographics

	(1)	(2)	(3)	(4)	(5)
	GAAP	NONGAAP	FKPI	NFKPI	MACRO
Internal factors					
Performance:					
|POS ROA|	−1.294	0.803	−0.261	0.970	3.462***
	(−1.521)	(0.293)	(−0.296)	(1.330)	(2.722)
|NEG ROA|	−3.953***	−1.804	−2.252***	0.936***	1.835**
	(−4.375)	(−0.543)	(−3.117)	(2.913)	(2.412)
Business and operating complexity:					
ln(MVE)	0.080	0.191	0.077	0.174***	−0.016
	(1.529)	(1.203)	(1.441)	(3.585)	(−0.183)
EARNVOL	0.532	−10.241**	−0.413	0.559	−0.663
	(0.852)	(−2.061)	(−0.606)	(1.452)	(−0.691)
RETVOL	−0.272	1.576	2.914***	2.416***	0.899
	(−0.269)	(0.526)	(3.239)	(3.440)	(0.636)
ln(GEOSEG)	0.090	−0.049	−0.117	−0.250***	−0.308**
	(1.154)	(−0.237)	(−1.425)	(−3.255)	(−2.220)
ln(BUSSEG)	0.092	0.264	0.049	0.152*	0.260**
	(1.282)	(1.483)	(0.666)	(1.908)	(1.977)
LITRISK	1.356**	1.618	1.771***	1.694***	2.342***
	(2.044)	(0.957)	(2.808)	(3.287)	(2.814)
BTM	−0.130	0.339	−0.259**	0.032	0.158
	(−1.008)	(1.086)	(−1.995)	(0.268)	(0.881)
Significant events:					
ACQ	0.027	0.203	−0.017	−0.187	−0.030
	(0.163)	(0.526)	(−0.094)	(−0.957)	(−0.096)
RESTR	0.015	0.241	−0.009	−0.311**	−0.239
	(0.132)	(0.869)	(−0.078)	(−2.345)	(−1.061)
Technological focus:					
ln(AGE)	0.087	0.005	0.128**	−0.215***	0.020
	(1.556)	(0.034)	(2.159)	(−3.727)	(0.195)
CIO	0.134	1.000***	0.211*	0.167	−0.511*
	(1.093)	(3.721)	(1.658)	(1.155)	(−1.659)
DATA ANALYTICS	−0.082	0.137	0.030	0.069	−0.235
	(−0.496)	(0.378)	(0.185)	(0.473)	(−0.664)
External factors					
Monitoring:					
BIG4	0.349**	−0.126	0.432***	0.636***	0.811***
	(2.436)	(−0.290)	(3.028)	(4.727)	(3.307)
INDUSTRY CL	0.117	0.229	−0.006	0.181*	0.243
	(1.004)	(0.741)	(-0.047)	(1.656)	(1.239)
Other interested third parties:					
ln(ANALYSTS)	0.175*	−0.121	0.040	−0.026	−0.017
	(1.947)	(−0.464)	(0.432)	(−0.284)	(−0.109)
ln(PEER)	−0.007	0.117	−0.049	−0.034	−0.034
	(−0.120)	(0.466)	(−0.726)	(−0.563)	(−0.235)
INST OWN	−0.012	0.604	−0.232	−0.034	−0.470*
	(−0.078)	(1.400)	(−1.538)	(−0.231)	(−1.794)
SOCIAL MEDIA	−0.139	−1.975	0.229	0.418	−0.515
	(−0.304)	(−1.633)	(0.592)	(1.494)	(−0.508)
RETAIL	0.413**	0.703	0.260	0.285	−0.046
	(2.475)	(1.462)	(1.498)	(1.454)	(−0.121)
TOP 25 FA	−0.097	−0.470*	−0.049	0.237**	−0.002
	(−1.021)	(−1.719)	(−0.498)	(2.336)	(−0.009)
External factors					
Proclivity to use visual content:					
ln(OTHER IMAGES)	2.380***	2.339***	2.180***	1.662***	1.508***
	(18.567)	(7.018)	(16.325)	(11.888)	(5.292)
ANNUAL REPORT	0.669***	0.303	0.554***	0.746***	0.375**
	(6.359)	(0.954)	(4.919)	(6.389)	(2.009)

Table 7 (*continued*)

Panel B: Data items in quantitative infographics					
	(1)	(2)	(3)	(4)	(5)
	GAAP	NONGAAP	FKPI	NFKPI	MACRO
Other 10-K characteristics:					
BOG	−0.027***	0.000	−0.041***	−0.032***	−0.039***
	(−3.525)	(0.021)	(−5.133)	(−4.205)	(−2.800)
ln(BLISTS)	−0.068	−0.058	0.065	0.100**	0.038
	(−1.604)	(−0.487)	(1.419)	(2.260)	(0.479)
ln(TABLES)	0.283**	1.428***	0.605***	−0.028	0.463*
	(2.077)	(3.007)	(3.875)	(−0.188)	(1.734)
ln(NUMBERS)	0.175	−0.062	0.128	−0.001	0.447*
	(1.282)	(−0.143)	(0.869)	(−0.006)	(1.745)
INTERCEPT	−0.027***	0.000	−0.041***	−0.032***	−0.039***
	(−3.525)	(0.021)	(−5.133)	(−4.205)	(−2.800)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	44,669	47,609	45,260	45,629	47,014

This table reports the results of regression analyses of factors associated with the initiation of infographics in 10-K filings by the type of infographic (Panel A) and type of data items (Panel B). The sample includes observations from 2003 to 2019 with the necessary data to compute the model variables. Observations are included through the first year a firm discloses an infographic of the specified type. The estimations include Fama-French 12-industry fixed-effects and cluster standard errors by firm. We define all variables in Appendix C and provide additional information on infographic type in Appendix A. We winsorize all continuous variables at the 1% and 99% levels. *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively.

infographics. In contrast, Table 7, Panel A indicates that firms with greater business and operating complexity (e.g., large firms with high operating volatility and litigation risk), less restructuring activity, and a technological focus (e.g., young firms with a CIO) generally begin disclosing infographics earlier and, as seen in Table 6, Panel A, continue to do so.

Regarding the external reporting environment, we find that firms begin disclosing infographics sooner when they employ a Big 4 auditor and when the SEC has issued prior infographics-related comment letters to peer firms. Interestingly, the results also indicate that firms are faster to initiate disclosure when fewer peer firms use infographics, even though disclosure is more likely on an ongoing basis when more peer firms disclose infographics (Table 6, Panel A). In other words, a firm that is quick to adopt infographics is likely to have fewer peer firms already using infographics, but in the long run industry peers follow similar infographics disclosure practices. We also find that firms using a top filing agent begin using infographics earlier than other firms.

Finally, firms are quicker to use 10-K infographics if they disclose other images in the 10-K or prepare a glossy annual report. We also find that firms with more readable textual disclosures (lower *BOG*), more tables, and more numerical text begin disclosing quantitative infographics sooner. These results are consistent with the earliest firms to disclose infographics doing so to clarify otherwise dense or complex textual, tabular, or numerical disclosures.

Table 7, Panel B reports hazard analyses for each type of quantitative infographic, analogous to the cross-sectional tests in Table 6, Panel B. The results are largely consistent across the two tables. However, we find that firm size only explains the initial adoption of *NFKPI* infographics even though it is a significant factor in the continued disclosure of all but *NONGAAP* infographics. Interestingly, we find that several variables related to the firm's external reporting environment explain the initial adoption of quantitative infographics but not their subsequent use. For example, except for *NONGAAP* infographics, Big 4 auditors are a significant factor in disclosure initiation for all types of quantitative infographics but their involvement only explains the continued disclosure of *NFKPI* and *MACRO* infographics. Similarly, analyst following explains the initial disclosure of *GAAP* infographics but not their continued use.

5.3. Capital markets tests

Our results to this point suggest that firms tailor the use of infographics, and the information and data captured in those infographics, to their internal operating circumstances, external reporting environment, and the overall 10-K reporting package. Our final research question examines the association between infographics and the information environment using the variables considered by Loughran and McDonald (2014) and Bonsall et al. (2017) in the context of 10-K textual readability. Specifically, Table 8 presents the results from estimating Eq. (3) for post-filing stock return volatility (*POST-FILING VOL*, Panel A), analyst forecast accuracy (|*UNEXP EARN*|, Panel B), and forecast dispersion (*DISPERSION*, Panel C).

In Panel A, we find that stock return volatility is significantly higher following the filing of 10-Ks containing an infographic. For example, the coefficient of 0.072 in column 1 indicates that firms disclosing infographics have a post-filing return volatility that is 3.4% higher than the unconditional mean (Table 5).[24] In column 2, we find results are similar whether infographics are quantitative or qualitative. Regarding the analyst variables, the results for forecast accuracy in Panel B are

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[24] Following Loughran and McDonald (2014) and Bonsall et al. (2017) we measure post-filing return volatility over the [+6, +28] trading window following the 10-K filing date. However, it is possible that volatility associated with the market's interpretation of infographics resolves sooner than for textual readability. Thus, we re-estimate Eq. (3) measuring volatility over the [0, +5] window with no change in inferences.

Table 8
Capital market tests of infographics in 10-K filings.

Panel A: POST-FILING VOL	(1)	(2)
INFOGRAPHIC	0.072***	
	(4.447)	
QUANT		0.065***
		(3.108)
QUAL		0.067***
		(3.156)
BOG	0.004**	0.004**
	(2.169)	(2.169)
PRE-FILING ALPHA	−0.891***	−0.890***
	(−4.952)	(−4.950)
PRE-FILING VOL	0.554***	0.554***
	(25.471)	(25.380)
|CAR|	3.403***	3.403***
	(7.650)	(7.637)
ln(BTM)	−0.029***	−0.029***
	(−3.396)	(−3.455)
ln(MVE)	−0.124***	−0.124***
	(−15.625)	(−15.618)
NASDAQ	0.012	0.012
	(0.635)	(0.627)
INTERCEPT	1.056***	1.060***
	(7.316)	(7.374)
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	47,906	47,906
Adj. R-squared	0.553	0.553

Panel B: |UNEXP EARN|	(1)	(2)
INFOGRAPHIC	0.026	
	(1.170)	
QUANT		0.040
		(1.660)
QUAL		0.023
		(0.818)
BOG	0.004*	0.004*
	(1.802)	(1.811)
PRE-FILING ALPHA	−1.059***	−1.058***
	(−5.224)	(−5.228)
PRE-FILING VOL	0.292***	0.292***
	(6.248)	(6.233)
|CAR|	1.487***	1.488***
	(3.980)	(3.983)
ln(BTM)	0.115***	0.115***
	(5.774)	(5.779)
ln(MVE)	−0.058***	−0.058***
	(−3.842)	(−3.884)
NASDAQ	−0.134***	−0.134***
	(−5.850)	(−5.859)
ln(ANALYSTS)	−0.053**	−0.054**
	(−2.853)	(−2.866)
INTERCEPT	0.173	0.176
	(0.918)	(0.927)
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	30,506	30,506
Adj. R-squared	0.202	0.202

Panel C: DISPERSION	(1)	(2)
INFOGRAPHIC	0.031**	
	(2.391)	
QUANT		0.023*
		(1.749)
QUAL		0.035*
		(1.966)
BOG	0.004***	0.004***
	(2.959)	(2.968)
PRE-FILING ALPHA	−0.568***	−0.568***
	(−7.940)	(−7.976)
PRE-FILING VOL	0.152***	0.151***

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Table 8 (*continued*)

Panel C: DISPERSION	(1)	(2)
	(7.287)	(7.243)
|CAR|	0.706***	0.706***
	(3.961)	(3.957)
ln(BTM)	0.054***	0.054***
	(5.752)	(5.740)
ln(MVE)	−0.029***	−0.029***
	(−3.925)	(−3.928)
NASDAQ	−0.047***	−0.047***
	(−3.680)	(−3.707)
ln(ANALYSTS)	0.052***	0.052***
	(3.939)	(3.911)
INTERCEPT	−0.220*	−0.214*
	(−1.836)	(−1.794)
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	22,352	22,352
Adj. R-squared	0.240	0.241

This table reports the results of regression analyses of the association between infographics in 10-K filings and post-filing stock return volatility (Panel A), analyst forecast accuracy (Panel B), and analyst forecast dispersion (Panel C). The sample consists of all observations from 2003 to 2019 with the necessary data to compute the model variables. The estimations include Fama-French 12-industry fixed-effects and calendar-year fixed effects and cluster standard errors by firm. We define all variables in Appendix C and provide additional information on infographic type in Appendix A. We winsorize all continuous variables at the 1% and 99% levels. *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively.

Table 9
Characteristics of infographics in 10-K filings and capital market outcomes.

Panel A: POST-FILING VOL

Infographic type		Data items		Infographic location	
BAR CHART	0.040	GAAP	0.023	FINANCIALS	0.001
	(1.466)		(1.137)		(0.027)
LINE GRAPH	0.112***	NONGAAP	−0.112*	BUSINESS	0.071***
	(4.244)		(−2.033)		(4.164)
PIE GRAPH	0.002	FKPI	−0.011	PROPERTIES	0.046
	(0.088)		(−0.417)		(0.592)
DATA MAP	0.040	NFKPI	0.108***	MD&A	0.042**
	(0.640)		(3.043)		(2.222)
LOCATION MAP	0.084**	MACRO	0.028	OTHER SECTIONS	0.061
	(2.205)		(0.601)		(1.554)
ORG CHART	0.013	QUAL	0.065***		
	(0.354)		(3.129)		
PROCESS/FLOW	0.040				
	(1.013)				
STRATEGY	−0.010				
	(−0.302)				
TIMELINE	0.240**				
	(2.791)				
Controls	Yes		Yes		Yes
Industry Fixed Effects	Yes		Yes		Yes
Year Fixed Effects	Yes		Yes		Yes
Observations	47,906		47,906		47,906
Adj. R-squared	0.554		0.554		0.553

Panel B: \|UNEXP EARN\|

Infographic type		Data items		Infographic location	
BAR CHART	−0.007	GAAP	0.027	FINANCIALS	−0.054
	(−0.245)		(0.655)		(−1.134)
LINE GRAPH	0.123**	NONGAAP	0.132	BUSINESS	0.025
	(2.331)		(1.227)		(1.100)
PIE GRAPH	0.034	FKPI	0.001	PROPERTIES	−0.122
	(0.780)		(0.026)		(−1.236)
DATA MAP	−0.070	NFKPI	−0.029	MD&A	0.049
	(−0.838)		(−0.582)		(1.471)
LOCATION MAP	−0.006	MACRO	0.134	OTHER SECTIONS	0.061
	(−0.130)		(1.735)		(0.718)

Table 9 (*continued*)

Panel B: |UNEXP EARN|					
Infographic type		Data items		Infographic location	
ORG CHART	0.086	QUAL	0.024		
	(1.683)		(0.838)		
PROCESS/FLOW	0.035				
	(0.558)				
STRATEGY	−0.068				
	(−1.095)				
TIMELINE	0.041				
	(0.594)				
Controls	Yes		Yes		Yes
Industry Fixed Effects	Yes		Yes		Yes
Year Fixed Effects	Yes		Yes		Yes
Observations	30,506		30,506		30,506
Adj. R-squared	0.202		0.202		0.202

Panel C: DISPERSION					
Infographic type		Data items		Infographic location	
BAR CHART	−0.006	GAAP	−0.020	FINANCIALS	−0.006
	(−0.380)		(−1.173)	BUSINESS	(−0.380)
LINE GRAPH	0.068**	NONGAAP	0.050		0.068**
	(2.690)		(1.271)		(2.690)
PIE GRAPH	0.004	FKPI	−0.002	PROPERTIES	0.004
	(0.210)		(−0.078)		(0.210)
DATA MAP	0.009	NFKPI	0.027	MD&A	0.009
	(0.214)		(0.818)		(0.214)
LOCATION MAP	0.022	MACRO	0.058	OTHER SECTIONS	0.022
	(0.940)		(1.449)		(0.940)
ORG CHART	0.073**	QUAL	0.036*		
	(2.672)		(1.985)		
PROCESS/FLOW	0.028				
	(1.090)				
STRATEGY	−0.065**				
	(−2.812)				
TIMELINE	0.067				
	(1.215)				
Controls	Yes		Yes		Yes
Industry Fixed Effects	Yes		Yes		Yes
Year Fixed Effects	Yes		Yes		Yes
Observations	22,352		22,352		22,352
Adj. R-squared	0.242		0.241		0.242

This table reports the results of regression analyses of the association between infographics in 10-K filings and post-filing stock return volatility (Panel A), analyst forecast accuracy (Panel B), and analyst forecast dispersion (Panel C) based on infographic type, the type of data items, and the location of the infographic in the 10-K filing. The sample includes all observations from 2003 to 2019 with the necessary data to compute the model variables. We include all controls, industry, and calendar-year fixed effects (unreported) and cluster standard errors by firm. We define all variables in Appendix C and provide additional information on infographic type in Appendix A. We winsorize all continuous variables at the 1% and 99% levels. *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively.

insignificant, but there is a significantly positive relation between analyst forecast dispersion and the use of infographics in 10-Ks in Panel C. For example, the coefficient of 0.031 in column 1 of Table 8, Panel C indicates that analyst forecast dispersion is 11.1% higher than the unconditional mean for firms disclosing infographics.[25] Across all three panels, we find that post-filing return volatility is higher for less readable 10-Ks (higher *BOG*), consistent with Loughran and McDonald (2014) and Bonsall et al. (2017).

To further explore these results, we re-estimate Eq. (3) replacing *INFOGRAPHIC* with the different types of infographics, data items, and, finally, the location in the 10-K. We report these results in Table 9. In Panel A, we find that post-filing return volatility is positively associated with all but strategy infographics, although the results are only significant for line graphs, location maps, and timelines. Regarding data items, non-financial KPIs and qualitative infographics are positively related to post-filing return volatility, while non-GAAP infographics are negatively related. Finally, infographics in the business and MD&A sections of the 10-K are positively related to post-filing return volatility.[26] In Panel B, we find that larger analyst

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[25] The tests in Table 8 include industry and year fixed effects, consistent with Loughran and McDonald (2014) and the evidence in Table 5 that infographics in 10-K filings are relatively sticky across time, resulting in little within-firm variation in our sample. Nevertheless, we also estimate Eq. (3) including firm and year fixed effects following Bonsall et al. (2017) and find qualitatively similar results for both infographics and quantitative infographics for the post-filing return volatility regressions. However, the relation between infographics and analyst forecast dispersion becomes insignificant with firm fixed effects.

[26] Although nearly all qualitative infographics are contained in the business section of the 10-K (Fig. 9, Panel A), the majority of quantitative infographics, and particularly line graphs, are in the MD&A.

forecast errors are significantly related to the use of line graphs. Finally, in Panel C, we find that line graphs and organization charts are associated with greater analyst forecast dispersion while strategy infographics are negatively associated with dispersion. Further, infographics presented in the business section of the 10-K are positively related to analyst forecast dispersion.

Recall that our evidence indicates that complex firms with extreme performance, lower institutional investor ownership, and a focus on retail investors are more likely to include infographics in 10-Ks. Thus, one interpretation of our capital markets tests is that firms with these characteristics self-select to provide infographics to supplement textual disclosure but the infographics do not fully ameliorate post-filing uncertainty since complex firms typically have increased post-filing volatility. As an example, timelines are often provided by pharmaceutical companies to illustrate the progress of drug trials (Fig. 6). Thus, firms that provide timelines may do so to increase transparency, but if the infographic does not compensate for the inherent complexity of pharmaceutical development, timeline infographics will coincide with greater post-filing return volatility (Table 9, Panel A).

However, we cannot conclusively rule out the possibility that infographics in the 10-K are difficult to interpret and thus increase investor and analyst uncertainty. As discussed previously, people differ in their ability to understand graphics and are often unable to accurately draw inferences and make predictions from graphics. As a result, firms may include infographics to help explain complex information, but because people have trouble interpreting those infographics, these disclosures can increase post-filing disagreement. Thus, including infographics in 10-K filings may be a double-edged sword.

6. Conclusion and directions for future research

We explore characteristics of infographics disclosed in 10-Ks and trends in their use from 2003 to 2019. We find a dramatic increase in the number of firms voluntarily disclosing either a qualitative or quantitative infographic over this period. However, we also find substantial variation in the specific types of infographics used, the information and data illustrated in those infographics, and their location within the 10-K. We also find a high degree of persistence over time in firms' specific use of infographics. After exploring *what* infographics firms disclose, we next examine *why* firms make these disclosure choices. We find that the decision to use infographics and the speed with which they are adopted is associated with several firm-specific characteristics and events, external factors related to the firm's financial reporting environment, and other attributes of the 10-K reporting package. Finally, we test the association between the use of infographics and uncertainty in the capital markets following the release of the 10-K. We find higher post-filing stock market volatility and analyst forecast dispersion after the filing of 10-Ks containing infographics. Although we cannot rule out the possibility that infographics contribute to greater market uncertainty, taken together our evidence appears to suggest that firms elect to provide infographics when their business model and operations are inherently complex.

Our results are subject to some caveats, including that we do not directly consider potential distortion or misrepresentation in infographics. Beattie and Jones (2008) summarize three potential forms of "graphical infidelity," with selectivity, or bias in the selection of only favorable items, as the primary graphical choice. Conditional on the inclusion of a graphic, measurement distortion affecting how firms present numbers in graphs and presentational enhancement affecting the graphic design are issues to consider. While we cannot rule out these concerns, we find that the disclosure of infographics is associated with more extreme positive *and* negative performance. It is also important to note that our classification of infographics requires judgment and interpretation. While classification is often a straightforward task, our process includes several layers of verification. Thus, we do not believe our results are affected by systematic errors. Further, although we find a dramatic increase in the proportion of 10-K filings containing infographics, the number of infographics per filing is still generally low, possibly as a result of regulations requiring text or tabular disclosure. Given the absence of *a priori* expectations regarding the use of infographics, our evidence provides a useful baseline for future research. Finally, as with any archival study, our analyses are limited to testing associations rather than causality.

Overall, we provide rich evidence on the disclosure of infographics in 10-Ks, attributes associated with their disclosure, and their association with uncertainty in the capital markets. We believe our results provide an important foundation for continued research on data visualization in accounting and finance. Future research could explore how to integrate textual attributes with infographics to more fully understand firms' disclosure strategies. There is also a natural extension to other disclosure channels that will enable a more nuanced view of how firms use infographics in different settings, and whether the media or other information intermediaries are more likely to disseminate information captured in an infographic. Finally, researchers could build more sophisticated pattern recognition techniques to identify and process infographics and their content.

Appendix A. Description of data collection and coding procedures

Collecting and classifying graphics

We identify 10-K and 10-KSB filings using the "master.idx" files listed on the SEC EDGAR website (https://www.sec.gov/Archives/edgar/full-index/). These files contain the Central Index Key (CIK), filing date, form type, and URL for each filing since the inception of EDGAR. We merge this list with Compustat based on the CIK number and filing date, which produces an initial sample of 64,837 filings for 8,452 firms from 2003 to 2019. We then use Python to access and download the index page for

each 10-K filing. Firms submit graphics to the EDGAR system as additional files that are embedded in 10-K filings. EDGAR lists these files on the 10-K filing index page as a "GRAPHIC" in the "Type" column. The index page also provides a URL link to directly access each graphic. We use Python to extract the URL for each graphic, and use Python's built-in urllib.urlretrieve function to download each graphic. Our search identifies a total of 122,410 graphic files embedded in the 10-K filings in our 2003–2019 sample period.

We identify graphics in the following steps. First, the co-author team used an iterative process to manually classify a random sample of 5,000 graphics into 25 categories. Some graphic types were obvious (e.g., bar charts, line graphs, pie graphs, maps). Other graphic types became apparent as we gained experience viewing the graphics. The 25 graphic types we identified in our manual classification include: bar charts, pie graphs, line graphs, data maps, location maps, organization charts, process/flow charts, strategy/business models, timelines, product images, executive photos, stock photos, other person photos, required stock performance graphs, financial tables, non-financial tables, signatures, annual report pages, company contact images, audit opinion images, logos, icons, bulleted lists, and miscellaneous. Second, research assistants then manually classified the remaining 74,407 graphics into these 25 categories. Finally, one of our co-author team members then also manually verified each graphic included in each category, making corrections when needed. Thus, each graphic was verified by two independent researchers.

Infographics are visual representations of data or information. Based on this definition, we define quantitative infographics as those that contain data: bar charts, pie graphs, line graphs, and data maps. We discuss the coding of data items included in quantitative infographics in the next section. We define qualitative infographics as those that contain meaningful non-numerical information: location maps, process/flow charts, strategy/business model diagrams, timelines, and organization charts.

- **Location maps:** Inform investors about the location of significant company assets or operations, such as buildings or trucking routes.
- **Process/flow charts:** Inform investors about significant processes, such as the flow of their data, the process to extract/ create their products or offer their services, and scientific/chemical processes.
- **Strategy/business models:** Inform investors about how the company operates, competes in its defined markets, and creates value for its stakeholders.
- **Timelines:** Inform investors of the milestones and progress for specific projects or events.
- **Organization charts:** Inform investors of how the company and its management team is organized.

In addition to the quantitative and qualitative infographics, we identify several other types of embedded images and process them as follows.

- **Graphics required to be included in the 10-K:** We exclude two graphics that are required by the SEC: (i) stock performance line graphs, and (ii) location maps for companies in extractive industries (SIC codes 10–14).
- **Graphics embedded as alternatives to typical 10-K HTML encoding:** We reclassify images containing tables and bulleted lists with their respective non-graphical elements that we extract from the text of the 10-K, as discussed subsequently.
- **Graphics that capture common 10-K components:** We exclude images containing signatures, annual report pages, company contact images, and audit opinion images. These images do not reflect unique content but rather how the company prepares the 10-K filing.
- **Graphics that lack content:** We exclude generic images that contain logos, icons (e.g., check marks, bullets) and other miscellaneous images.
- **Graphics that make the 10-K more aesthetically appealing:** We classify product images, executive photos, stock photos, and other person photos as "Other Images" because they are unlikely to contain the same level of meaningful information or data as infographics but they are firm-specific disclosures that may provide some insights.

Our classification process results in 23,410 quantitative infographics, 6,495 qualitative infographics, and 29,905 other images. See Table 1 for additional detail on the selection and classification of sample images.

Classifying data content of quantitative infographics

We code each quantitative infographic based on whether it contains one or more of the following five data categories: (i) GAAP, (ii) non-GAAP, (iii) financial KPI, (iv) non-financial KPI, or (v) macro data. To ensure consistent classification, we first extract the data items included in each image (e.g., revenues, same store sales, etc.) and whether each data item is presented as a dollar amount (e.g., revenue) or as a percentage (e.g., percentage of sales by segment). Most often, the description of the data items in an image is included in the image itself. However, because the images are embedded within the 10-K, some data item descriptions are not included in the image itself, but rather in the surrounding HTML script. Thus, for each image we create separate HTML documents that include each image embedded in its surrounding HTML script of 100 words before and after each image. The co-author team and research assistants use these files to identify the data items and whether the items

are presented in dollars or percentages. The co-author team then used judgment and the following criteria to categorize each data item.

- **GAAP:** Measures calculated according to GAAP that appear in the financial statements (e.g., EPS, revenues, net income, operating cash flows).
- **Non-GAAP:** Measures of performance that are not calculated in accordance with GAAP but rather exclude (or include) amounts that would be found in the most directly comparable GAAP measure (e.g., adjusted EBITDA, earnings before stock-based compensation, free cash flow, adjusted net income).
- **Financial KPI:** Measures that a company uses to gauge its performance, including all financial statement ratios other than earnings-per-share, which is required by GAAP (e.g., current ratio, return on equity) and other measures that incorporate financial statement data (e.g., same store sales, revenue passenger miles, backlog).
- **Nonfinancial KPI:** Measures related to strategic or operational performance (e.g., units produced, units shipped) or other nonfinancial information (e.g., results of clinical trials, number of stores, number of customers, number of employees).
- **Macro:** Measures related to industry- or market-wide statistics (e.g., oil prices, market returns, population, foreign exchange rates, housing starts).

Extracting other 10-K elements

In addition to the graphical elements extracted from the 10-K, we also identify the following additional 10-K elements: the number of tables, the number of bulleted lists, and the Bonsall et al. (2017) Bog index of the 10-K text. We obtain the Bog Index directly from Brian Miller's personal website available at: https://host.kelley.iu.edu/bpm/activities/bogindex.html. We use a Python script to extract the number of tables and the number of bulleted lists. We identify the number of tables using the HTML table tags (i.e., "<table>") and the number of bulleted lists by searching for HTML and Unicode bullets (e.g., "•" and "•") within paragraph or content division tags (i.e., "<p>" and "<div>"). We consider several bullets within a single content division tag to be a single bulleted list. As discussed previously, we also include embedded images containing tables and bulleted lists with their respective elements.

Measuring infographic similarity

To measure the year-over-year similarity of individual infographics in our sample, we first compare to infographics of a similar type (e.g., bar chart, line graph) from the subsequent two 10-K filings. This process results in a total of 171,594 pairwise infographic comparisons. Of the 29,905 infographics in our sample, only 22,762 have sufficient data in the subsequent two years. The number of potential matches for this subset ranges from 1 to 91 with a mean of 5.9.

Next, we create three measures of the similarity of each pairwise comparison. First, we use the "average_hash" function from the ImageHash library in Python to create a similarity score based on the average hash of each image. Image hashes are designed to examine the extent to which two images appear similar. Second, we use the "image_to_string" function from the Python-tesseract library, an optical character recognition tool, to extract the text from each infographic. We then calculate the cosine similarity between the text embedded in each infographic and each potential infographic match. Third, we use Python to extract the 100 words in the HTML script before and after each embedded infographic within each 10-K filing and calculate the cosine similarity between the text surrounding each infographic and each potential infographic match.

In an iterative process, we then manually examine each infographic and the potential infographic match with the highest average score across the three similarity measures. If the infographics match, we do not examine the remaining pairwise comparisons. If the infographics do not match, we examine the next best potential match. We repeat this process until we identify a match or until all pairwise comparisons are exhausted.

Appendix B. Examples of SEC comments on the use of infographics in regulatory filings

CyberSource Corporation
Form 10-K for the fiscal year ended December 31, 2008
Your role in the payment process and the vocabulary used does not appear that it would be easily understood by investors unfamiliar with how card and other major payment systems function. **Diagrams or a graphical illustration of the payment process and the entities involved could be helpful.**
Ecology and Environment, Inc.
Form 10-K for Fiscal Year Ended December 31, 2016
Please consider revising this section in future filings to make it more accessible to your readers. In particular, **your discussion of the results of operations may be strongly improved through the use of charts presenting clearly the financial statistics you discuss in your narrative** as well as a more fulsome narrative discussion of the reasons for changes in your results of operations from period to period.
Carnival Corporation
Form 10-K for the fiscal year ended November 30, 2012
When there are many factors which had a material impact on the variance between periods, **it may be useful to provide these factors in a chart to facilitate the reader's understanding of the impact of certain items between periods.**
Access Integrated Technologies, Inc.

Form 10-K for the fiscal year ended March 31, 2008
> **Please consider adding a corporate organization chart that provides a graphic representation of the company's business and its three reporting segments.** To the extent material, please include the company's subsidiaries to show the relationship between the company and the entities you discuss in this section.

Twitter

Form 10-K for the fiscal year ended December 31, 2016
> You define average daily active user/usage ("DAUs") for a period as the average of the DAUs at the end of such period. **Please revise to clarify the period used to calculate average DAUs and its relationship to the Daily Active Users Year-over-Year Change chart.**

Appendix C. Variable definitions

Variable	Description
Infographics variables:	
All infographic variables are defined as an indicator variable equal to 1 if the 10-K has at least one infographic of the specified type, and 0 otherwise. See Appendix A for further discussion regarding the identification and classification of picture types and data content.	
INFOGRAPHIC	An infographic of any type.
Picture type:	
QUAL	Qualitative infographic consisting of one of the following picture types:
LOCATION MAP	Location map.
PROCESS/FLOW	Process/flow chart.
STRATEGY	Strategy or business model.
TIMELINE	Timeline.
ORG CHART	Organizational chart.
QUANT	Quantitative infographic consisting of one of the following picture types:
BAR CHART	Bar chart.
DATA MAP	Data map.
LINE GRAPH	Line graph.
PIE GRAPH	Pie graph.
Data items:	
FKPI	Financial key performance indicator.
GAAP	GAAP measure.
NFKPI	Non-financial key performance indicator.
NONGAAP	Non-GAAP measure.
MACRO	Macroeconomic measure.
10-K location:	
FINANCIALS	Annual Report.
BUSINESS	Business Overview (Item 1).
MD&A	Management Discussion and Analysis (Item 7).
PROPERTIES	Properties section (Item 2).
OTHER SECTIONS	Other than Items 1, 2, or 7 or the Annual Report.
Internal factors:	
ACQ	An indicator variable equal to 1 if the ratio of acquisitions to sales is greater than 5%, and 0 otherwise.
AGE	The number of years the firm has been listed in CRSP.
BTM	Book value of equity divided by market value of equity.
BUSSEG	The number of business segments.
CIO	An indicator variable equal to 1 if the term "chief information officer" or "cio" appears in the 10-K, and 0 otherwise.
DATA ANALYTICS	An indicator variable equal to 1 if the term "data analytic*" or "data analysis" appears in the 10-K, and 0 otherwise.
EARNVOL	Standard deviation of seasonally adjusted earnings over the preceding 5 years (requiring a minimum of 3 prior years).
GEOSEG	The number of geographic segments.
LITRISK	Ex ante litigation risk, calculated using the coefficients from model 3 in Kim and Skinner (2012).
MVE	The market value of equity of the firm at the end of the year.
|NEG ROA|	The absolute value of negative income before extraordinary items divided by total assets at the beginning of the year, if negative, and 0 otherwise.
|POS ROA|	The absolute value of positive income before extraordinary items divided by total assets at the beginning of the year, if positive, and 0 otherwise.
RESTR	An indicator equal to 1 if the firm-year is in the top quartile of after-tax restructuring costs divided by total revenues, and 0 otherwise.

(*continued*)

Variable	Description
RETVOL	Standard deviation of monthly returns over the 12 months of the fiscal year (requiring at least 6 months of returns).
External factors:	
ANALYSTS	The number of analysts following the firm.
BIG4	An indicator variable equal to 1 if the firm has a Big 4 audit firm (Deloitte, Ernst & Young, KPMG, and PricewaterhouseCoopers), and 0 otherwise.
INDUSTRY CL	An indicator variable equal to 1 if a firm in the same industry as the focal firm received an SEC comment letter related to infographics, and 0 otherwise.
INST OWN	The percentage of shares held by institutional owners.
PEER	The number of SIC two-digit peer firms that include the same type of infographic as the focal firm in the year prior to the filing.
RETAIL	An indicator variable equal to 1 if the term "retail investor*", "individual investor*", "nonprofessional investor*, or "non professional investor*" appears in the 10-K, and 0 otherwise.
SOCIAL MEDIA	An indicator variable equal to 1 if the term "social media" or "follow us" followed by "facebook", twitter", "instagram", "tiktok", "snapchat", "pinterest", "linkedin", "blog", or "social media" appears in the 10-K, and 0 otherwise.
TOP25 FA	An indicator variable equal to 1 if the firm used a top filing agent identified following Allee et al. (2018), and 0 otherwise.
10-K factors:	
ANNUAL REPORT	An indicator variable equal to 1 if the firm files Form ARS (annual report to shareholders) with the SEC, has an Exhibit 13 in the 10-K filing, or one of the extracted images is an annual report, and 0 otherwise.
BLISTS	The number of bulleted lists in the 10-K.
BOG	The BOG Index of the firm's 10-K filing from Bonsall et al. (2017).
NUMBERS	The number of numbers contained in the text of the 10-K filing.
OTHER IMAGES	The number of other images in the 10-K filing (executive photo, product image, stock photo, or other person photo).
TABLES	The number of tables in the 10-K.
Capital market variables:	
|CAR|	The absolute value of the market adjusted return over the two-day period starting on the 10-K filing date, following Bonsall et al. (2017).
DISPERSION	The standard deviation of analysts' forecasts from the 10-K filing date to the next earnings announcement date divided by the stock price from before the 10-K filing date multiplied by 100. Firm-years must have at least two analysts' forecasts to be included, following Bonsall et al. (2017).
NASDAQ	An indicator variable equal to 1 if the firm is listed on the NASDAQ stock exchange, and 0 otherwise.
POST-FILING VOL	The root mean squared error from a market model multiplied by 100. The model is estimated using trading days [6, 28] relative to the 10-K filing date, where a minimum of 10 observations are required to be included in the sample, following Bonsall et al. (2017).
PRE-FILING ALPHA	The alpha from a market model multiplied by 100. The model is estimated using trading days [-252, −6] relative to the 10-K filing date, where a minimum of 60 observations of daily returns must be available to be included in the sample, following Bonsall et al. (2017).
PRE-FILING VOL	The root mean squared error from a market model multiplied by 100. The model is estimated using trading days [-252, −6] relative to the 10-K filing date, where a minimum of 60 observations are required to be included in the sample, following Bonsall et al. (2017).
|UNEXP EARN |	The absolute value of analyst accuracy multiplied by 100. Analyst accuracy is defined as the actual earnings minus average expected earnings divided by the stock price for firm-years with at least one analyst forecast. We obtain the actual earnings and mean analyst forecast from the I/B/E/S unadjusted data files. To avoid stale forecasts, we include only forecasts occurring between the 10-K filing date and the next earnings announcement date. For analysts with more than one forecast reported during this time interval we retain only the forecast closest to the filing date in the sample, following Bonsall et al. (2017).
Fama-French 12 Industries:	
(1) NoDur	Consumer NonDurables
(2) Durbl	Consumer Durables
(3) Manuf	Manufacturing
(4) Enrgy	Oil, Gas, and Coal Extraction and Products
(5) Chems	Chemicals and Allied Products

(*continued*)

Variable	Description
(6) BusEq	Business Equipment
(7) Telcm	Telephone and Television Transmission
(8) Utils	Utilities
(9) Shops	Wholesale, Retail, and Some Services (Laundries, Repair Shops)
(10) Hlth	Healthcare, Medical Equipment, and Drugs
(11) Money	Finance
(12) Other	Other (Mines, Construction, Building Materials, Transportation, Hotels, Business Services, Entertainment)

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