Does Information Technology Reduce Corporate Misconduct?

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Abstract

This study examines whether information technology (IT) reduces corporate misconduct. Specifically, we study the effects of staggered facility-level rollouts of enterprise resource planning (ERP) systems on facility-level regulatory violations across a large sample of U.S. firms. Our results indicate that facility-level ERP adoption reduces local non-financial violations and penalties. Additional analyses suggest that the benefits of ERP adoption stem from the system's ability to enhance managerial monitoring and constrain employee choice. Overall, our results suggest that information technology plays a significant role in enhancing compliance outcomes across a wide range of non-financial violations that are relevant for firms' compliance with environmental, social and governance (ESG) regulations.

Keywords: corporate misconduct; compliance; information technology; ERP systems; ESG compliance.

JEL Classifications: M40, M41

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1. Introduction

Firms increasingly rely on information technology (IT) to strengthen compliance with laws and regulations. In this study, we examine the effects of one popular type of IT that has transformative implications for organizational control (Ittner and Larcker, 2001; Chapman, 2005): enterprise resource planning (ERP) systems. An ERP system is a large-scale information system that integrates information from a wide spectrum of business activities subject to regulations, thus making it relevant for a broad array of compliance issues, many of which are related to environmental, social, and corporate governance (ESG) issues. In particular, we examine the effects of staggered facility-level rollouts of ERP systems on facility-level violations across a large sample of U.S. firms.

Our central prediction is that ERP systems can improve compliance outcomes in an organization through at least two channels. First, an ERP system can enhance managerial monitoring as it reduces the cost of accessing and processing information by centralizing information and producing standardized reports with actionable insights (e.g., Dorantes et al., 2013; Bloom et al., 2014). As noted by Chapman and Kihn (2009), an ERP system provides managers with more "hierarchical visibility," which enables them to identify risk early. For example, consider a factory manager who might be concerned about ensuring that equipment is maintained in a timely fashion. ERP systems provide management with reports on the operational efficiency and maintenance requirements of such equipment (SAP, 2022). This information can help managers adhere to maintenance schedules and ultimately reduce workplace accidents and safety violations.

The second channel through which ERP systems can improve compliance outcomes relates to their ability to constrain employee behavior through process standardization (e.g., Orlikowski, 1991; Sotto, 1997). ERP systems help guide employees and alleviate agency problems by mapping out each employee's area of responsibility and by limiting choice alternatives (e.g., Boudreau and Robey, 2005). For example, an ERP system can impose constraints on handling hazardous materials and reduces employee autonomy through imposing training and documentation requirements as well as access and storage restrictions, thus reducing environmental violations (Panjwani, 2022). Such constraints on employee behavior can ultimately reduce errors and improve compliance outcomes.

We note, however, that our prediction is not without tension. Various frictions may limit the ability of ERP systems to improve compliance, thus lending support for a null result. First, better information access may not enhance compliance if the information is difficult to process. For instance, many executives acknowledge challenges with interpreting the complex information provided by an ERP system (Agostino, 2004), limiting the system's ability to enhance managerial monitoring.[1] Second, ERP systems may also be ineffective if end users do not use the system, as highlighted by models of user acceptance of new technology and prior ERP research (e.g., Venkatesh et al., 2003; Liang et al., 2012; Beasley et al., 2023). In such instances, employees are unwilling to follow system protocols, thus limiting the system's ability to constrain their behavior. Finally, ERP systems vary in scope and are implemented for many operational purposes that are potentially not related to compliance needs (e.g., Grabski et al., 2011). It is thus unclear if ERP systems will influence compliance.[2] Ultimately, whether and the extent to which ERP systems improve compliance are empirical questions.

Examining the effects of ERP systems poses several empirical challenges. First, ERP rollouts are typically unobservable across firms. Accordingly, prior studies tend to study ERP

[1] This idea is consistent with a long-standing body of literature examining the notions of bounded rationality (Simon, 1955) and limited attention (e.g., Merton, 1987; Hirshleifer and Teoh, 2003).
[2] Some ERP systems are implemented with a specific purpose, such as standardizing ledgers, while others aim to refigure entire organizational processes (Chapman and Chua, 2003).

rollouts at one specific company or across a small number of firms, raising questions about generalizability (e.g., Chapman and Kihn, 2009). We build on recent research in management and economics (e.g., Forman et al., 2012; Bloom et al., 2014) and obtain detailed facility-level technology adoption data from Aberdeen's Computer Intelligence Technology Database (CiTDB). These data allow us to assess whether and at which point in time a facility implements an ERP system across facilities of a large sample of publicly traded firms.[3]

Second, extant research studying large-sample ERP adoption is unable to alleviate endogeneity concerns between ERP adoption and outcome, as prior studies typically study *firm-level* ERP adoption. The challenge with firm-level analyses is that the decision to adopt an ERP system is typically associated with other factors, many of which can affect the outcome of interest (such as compliance). We use a difference-in-differences specification to exploit the staggered facility-level (i.e., within-firm) adoption of ERP systems across 5,733 facilities in the United States for the period 2005 to 2017. Given that firms typically rollout ERP systems in phases (Caldwell, 2020), a facility-level analysis allows us to isolate the effects of technology adoption *within* a firm and control for time-varying firm effects that prior research is unable to account for.[4] In addition, the timing of ERP adoption at a facility is unlikely to be driven by facility-level compliance outcomes, further alleviating endogeneity concerns.[5]

Finally, data on firm outcomes in general and compliance outcomes in particular are typically unavailable, requiring prior research to rely on questionnaires capturing *perceived* ERP benefits, which may be biased (e.g., Chapman and Kihn, 2009). We use data from

[3] Facilities include distribution centers, factories, mines, stores, and warehouses, among others.
[4] Common ERP-implementation choices include "Big Bang," where the rollout occurs instantly across the firm; "Phased Rollouts," where change occurs over a longer period of time; and "Parallel Adoption," where both legacy and ERP systems run at the same time as users migrate over (Caldwell, 2020).
[5] We validate this conjecture in an analysis examining the determinants of facility-level ERP adoption in Section 6.1.

Violation Tracker, which provides facility-level violations and penalties issued by federal agencies across a wide range of regulations for which ERP systems may offer benefits, such as those related to workplace safety, labor codes, or environmental requirements. Our final sample includes 11,550 violations resulting in almost $23 billion in fines across our sample period. Our analyses assess how the number of violations and penalties change following ERP adoption at a facility.

Our main results suggest that investments in ERP systems enhance compliance. Specifically, we find that ERP rollouts are associated with a reduction in facility-level violations of approximately 1.1% and a reduction in facility-level penalties of approximately 17%. These reductions in violations and penalties are likely lower-bound estimates, as they are based only on detected misconduct and do not capture litigation and reputational costs.[6]

As discussed above, prior research suggests that ERP systems enhance compliance outcomes through increasing managerial monitoring and imposing constraints on employees' actions. In our subsequent cross-sectional analyses, we provide additional evidence to help validate these channels.

We first explore the validity of the managerial monitoring mechanism by examining the role of information processing constraints. Such constraints should reduce the efficacy of ERP systems in enabling managerial monitoring as managers may be unable to process the wealth of data produced by the technology. We examine variation in the ERP rollout's inclusion of Business Intelligence and Data Warehousing (BI-DW) software, which is a common software deployed with ERP that helps managers process data and find patterns in the data that ERP systems collect. Prior academic studies and evidence from practice suggests that

[6] For example, workplace safety violations can result in costs related to litigation, wage premiums, damaged reputation, and a reduced ability to attract and retain talent (Caskey and Ozel, 2017).

BI-DW is useful as it "analyzes and contextualizes information […] to generate actionable insights" and reduces information overload (e.g., Agostino, 2004; Chou et al., 2005). Consistent with expectations, we find that our results are concentrated among facilities with ERP adoptions with BI-DW software. These findings suggest that the compliance benefits of ERP systems vary with managers' ability to use the information provided by the system to monitor employees.

Our second cross-sectional analysis validates the employee constraint channel. In these tests, we focus on frictions associated with end user adoption. Prior studies note that ERP systems often face implementation challenges and fail, in part because workers are resistant to new technologies, and find ways to circumvent the constraints that the ERP system imposes on them (e.g., Aladwani, 2001; Boudreau and Robey, 2006). We expect that ERP rollouts offer fewer compliance benefits for facilities with a more technology-resistant workforce, as such employees' actions are less likely to be constrained by the ERP system. We construct a local-level composite measure of technology resistance based on known determinants of openness to technology, i.e., age and concentration of STEM jobs in a facility's locality (e.g., Bénabou et al., 2015, 2021). Our results are concentrated in facilities located in counties with a population that is more open to technology, suggesting that the compliance benefits of ERP systems vary with the system's ability to constrain employee behavior.

We conduct a large number of additional analyses, in part to address endogeneity critiques that a facility's ERP adoption is potentially correlated with local misconduct. We first explore the determinants of ERP presence within a facility. Anecdotal evidence suggests that ERP systems are adopted for a variety of strategic and operational reasons that do not necessarily relate to compliance. We aim to capture these reasons by including proxies for facility growth, firm size, leverage, and profitability, prior misconduct history, the quality of local IT infrastructure, and industry pressure. We find that larger firms and facilities are more likely to introduce an ERP system. In addition, prior violations do not affect ERP presence, validating our earlier claim that facility adoption is unlikely to be driven by compliance demands. Finally, facilities located in areas with better IT infrastructure and facilities of firms operating in industries with large IT budgets are more likely to install ERP systems.

Next, we build on the findings of the determinants analysis and introduce two instrumental variables: the industry demand for ERP and the presence of connections to the Advanced Research Projects Agency Network (ARPANET) network.[7] The rationale for the first instrument is that peer firms in the same industry likely influence a facility's ERP adoption, but are unlikely to influence a facility's misconduct levels.[8] Similarly, it is unlikely that ARPANET nodes are endogenous to facility-level misconduct. Both instrumented ERP variables are associated with fewer violations.

In additional tests, we show that our results are robust to the inclusion of various fixed effects accounting for other types of unobserved heterogeneity. Our results also hold using an entropy-balancing research design (Hainmueller, 2012) as well as alternative sample-selection, measurement, and research-design choices. These analyses establish a stronger link between ERP adoption and misconduct, and, collectively, help to alleviate endogeneity concerns.

Our study contributes to the literature across several dimensions. Our primary contribution is to the growing literature examining management control systems that help curtail corporate misconduct. While recent studies have explored how control systems, such as

[7] The first instrument is measured as the average IT budget across firms in the same two-digit SIC industry as the facility of interest. The second instrument is an indicator for the presence of ARPANET nodes, which is the predecessor of the Internet. Forman et al. (2012) find that firms in counties with ARPANET nodes invest more in technology because the local infrastructure is better.

[8] For instance, high demand for ERP adoption among firms in the manufacturing sector should not directly explain misconduct in a 3M facility operating in Kentucky, absent its effect on ERP adoption.

compliance trainings, codes of conduct, management visits, and whistleblower programs, affect misconduct (e.g., Kaptein and Schwartz, 2008; Heese and Pérez Cavazos, 2020; Park, 2020; Stubben and Welch 2020; Soltes, 2020), there is limited evidence on the role of information technology in enhancing compliance outcomes. Our findings complement concurrent work by Charoenwong et al. (2021), who examine how IT investments reduce customer complaints in the broker-dealer industry. Ultimately, our study addresses a gap in the literature by showing that ERP systems reduce misconduct across a wide range of violations in many industries. Our findings are particularly important as prior literature suggests that other control systems are often ineffective (e.g., Kaptein and Schwartz, 2008; Park, 2020).

Second, our study extends the accounting literature examining potential benefits of ERP systems. While prior research provides some evidence to suggest that ERP systems enhance financial reporting outcomes (e.g., Brazel and Dang, 2008; Dorantes et al., 2013), the effects of ERP systems on non-financial outcomes is largely unexplored.[9] Our study complements this line of research by demonstrating how ERP systems enhance non-financial and compliance outcomes, which is an important but understudied area (Ittner and Larcker, 2001).[10] Moreover, we show that compliance benefits depend on the system's ability to improve managerial monitoring and constrain employee choice, thus providing large-sample evidence for long-standing arguments proposed by management accounting researchers studying how ERP systems affect organizational control (e.g., Chapman and Kihn, 2009). More broadly, our

[9] Prior studies also show that ERP systems generate firm-level benefits, such as improved profitability (e.g., Hayes et al., 2001; Nicolaou, 2004; Ranganathan and Brown, 2006; Tian and Xu, 2015).
[10] In their review of the management accounting literature, Ittner and Larcker (2001) find that senior executives rate customer relations, operational performance (such as safety), public image, environmental compliance, and employee relations as important drivers of their firms' long-term success. They also argue that information technologies—in particular, ERP systems—have important effects for the management of these non-financial value drivers.

results are also relevant to researchers examining the benefits of higher quality internal information (e.g., Gallemore and Labro, 2015; Hope et al., 2020; Labro et al., 2022).

Our findings are also relevant for practitioners, as many firms move toward adopting advanced technology as a means for improving their compliance with laws and regulations – increasingly with a focus on compliance with ESG regulations (KPMG, 2023). A central part of this move is to create a system to capture, store and interpret data (Mutoh, 2023). Our study demonstrates the benefits of ERP systems for enhancing compliance with non-financial regulation relevant for ESG issues.

2. Related Literature and Hypothesis

2.1. Management Control Systems and Compliance

Determining the efficacy of management control systems to curtail misconduct within an organization has been the focus of a long line of research in accounting. As Merchant and Van der Stede (2007) note, management control systems ensure that employees act in accordance with the organization's objectives. As "almost everything in the organization is included as part of the overall control system" (Merchant and Otley, 2007, p. 785), the challenge lies in determining which practices work and how they interact with each other (Grabner and Moers, 2013).

A subset of this literature focuses on designing management control systems to prevent employees from exposing the organization to excessive risk (e.g., Sandino, 2007; Campbell et al., 2009). A recent stream of studies focuses on specific control systems that help deter misconduct. For example, Heese and Pérez Cavazos (2020) examine the effects of management oversight on misconduct and show that site visits reduce violations. Stubben and Welch (2020) conduct a descriptive analysis of whistleblowing systems using proprietary data on nearly two million whistleblowing reports and show that a larger volume of internal reports is associated with fewer fines and lawsuits. Similarly, Park (2020) documents that compliance training can change employee behavior.

At the same time, the extant literature also suggests that there are limitations to existing compliance mechanisms. For example, Soltes (2020) finds that the whistleblowing hotlines of many firms have impediments that prevent the reporting of misconduct, and Dey et al. (2021) show that firms often retaliate against employee whistleblowers. Similarly, Park (2020) demonstrates that compliance trainings only generate short-term benefits, and Kaptein and Schwartz (2008) suggest that codes of conduct are often ineffective.

We extend this literature by focusing on the role of IT investments as an alternative management control system that can improve monitoring and reduce compliance risk. In particular, we examine the potential compliance benefits associated with ERP systems, which represent a significant IT investment for many firms.

2.2. ERP as a Management Control System

Prior research in accounting and information systems literature has long been interested in understanding the potential benefits of ERP systems, given their ability to centralize information in an organization. For example, Nicolaou (2004) demonstrates that firms with ERP systems exhibit better performance, and Tian and Xu (2015) show that ERP systems reduce earnings volatility. Announcements of ERP systems generally also lead to positive market reactions (Hayes et al., 2001; Ranganathan and Brown, 2006; Hendricks et al., 2007), suggesting that ERP systems enhance firm value.

In contrast, evidence on how ERP systems generate benefits for firms is more limited. Several studies focus on how ERP systems affect financial outcomes, with a focus on financial reporting quality. These studies generate mixed findings. For example, Brazel and Dang (2008) show that ERP adoption leads to increases in absolute discretionary accruals or lower financial reporting quality, in part because ERP implementations are associated with reductions in traditional control systems. On the other hand, two studies also provide evidence consistent with ERP systems improving financial reporting quality. Morris (2011) finds that ERP systems help to reduce the likelihood of internal control weaknesses. In addition, Dorantes et al. (2013) examine the benefits of ERP systems for management forecast production and find that firms that adopt these systems issue more accurate forecasts.

In contrast, there is limited research examining the non-financial benefits of ERP systems. This represents an important gap in the literature, given Masli et al.'s (2011) claim that "the most important IT benefits are not financial." For example, prior IT research suggests that non-financial benefits associated with ERP adoption may include improved customer satisfaction or stronger supplier relationships (e.g., Sambamurthy et al., 2003; Smith and Wright, 2004). Ittner and Larcker (2001) review the management accounting literature and also emphasize the potential importance of information technologies in helping firms manage non-financial value drivers. In particular, they highlight the importance of ERP systems, as such systems may contain data-mining capabilities that allow companies to better manage non-financial performance measures.

More broadly, our study is also related to the accounting literatures examining the role of information technology for improving internal controls and managing enterprise risk. For example, Masli et al. (2010) show that firms that implemented internal control monitoring technology in response to the internal control requirements of the Sarbanes-Oxley Act had a lower likelihood of internal control failures. More recently, Lawrence et al. (2018) find that operational control risks are leading indicators of financial reporting problems.[11] In light of the

[11] As noted by Lawrence et al. (2018), the Committee of Sponsoring Organizations of the Treadway Commission (COSO, 2013) has long recognized that controls over operations and compliance (in addition to reporting controls) are part of a comprehensive view of internal controls.

growing importance of information technology, studies have also begun studying how such technology can strengthen external control mechanisms, including auditors and analysts (e.g., Ashraf et al., 2020; Coleman et al., 2022).[12]

Overall, our study adds to the extant literature by examining how ERP systems enhance firms' compliance with regulations that are largely non-financial and *operational* in nature (e.g., safety-related, environment-related, consumer-protection-related, etc.). This focus allows us to extend the management accounting literature interested in understanding how ERP systems enhance operational decision-making. For example, Chapman (2005) highlights the importance of ERP systems for managerial accounting, noting that ERP systems are "fundamentally bound up with the work of accounting, and have been seen to have transformative implications for the nature of organizational integration and control." Prior research provides some evidence on how ERP systems influence operations, but often relies on site or survey data from one organization. For example, Chapman and Kihn (2009) conduct a survey that suggests that ERP systems enable better control. A related set of field studies also provide some evidence suggestive of ERP systems affecting management practice and control (e.g., Dechow and Mouritsen, 2005; Orlikowski, 1991). In addition, these studies also argue that ERP systems can improve organizational control by improving managerial monitoring and constraining employees' actions (e.g., Chapman and Kihn, 2009), but have not yet provided large-scale evidence consistent with these mechanisms. Our study contributes to this literature by providing a large-sample investigation of the effects of ERP systems on a specific management control outcome, i.e., compliance with non-financial regulation, and the mechanisms through which ERP systems can improve these compliance outcomes.

[12] For example, Ashraf et al. (2020) find that auditors' IT expertise improves clients' financial reporting, and Coleman et al. (2022) find that information technology can improve analyst research.

2.3. Hypothesis

Our central premise is that IT investments in general can have important benefits for compliance. While a growing subset of the accounting and information systems literature has examined the consequences of firm-level IT investments, and ERP systems more specifically, our understanding of how such investments impact firms' compliance remains limited.[13]

We focus on ERP systems, as such technology has the potential to significantly improve the usefulness of information available to managers and therefore improve monitoring (e.g., Bloom et al., 2014). For example, to articulate the benefits of ERP systems, Bloom et al. (2014) provide a simple illustration of how a unified computing system provided by an ERP system allows a plant manager to "easily access and compare data across a range of processes" and efficiently respond to "timely information at an unprecedented rate, empowering plant managers to make decisions on a wide range of activities" (see Appendix A.1 of Bloom et al., 2014). Our study extends this argument to a compliance setting. Specifically, we argue that the information provided by an ERP system also allows companies to identify and prevent potential regulatory infractions more effectively.

We predict that ERP systems can improve compliance outcomes in an organization through at least two channels. First, an ERP system can enhance managerial monitoring as it reduces the cost of accessing information. ERP systems centralize information and produce standardized reports with actionable insights, thus reducing information acquisition and processing costs (e.g., Dorantes et al., 2013; Bloom et al., 2014). Second, ERP systems can improve compliance outcomes by constraining employee behavior through process standardization (e.g., Orlikowski, 1991; Sotto, 1997). In doing so, the system can ensure that employees act in accordance with managerial objectives.

[13] For a review of the broader IT literature, please see Masli et al. (2011).

The potential for ERP systems to enhance regulatory compliance is also well-supported by practitioner evidence. For example, WorkWise, a supplier of ERP systems, notes that "ERP platforms are designed to keep track of regulations within the industry and monitor changes in compliance. This allows users, and businesses at large, to stay abreast with laws, regulations, guidance, and specifications as it relates to business processes" (Aptean, 2019). Software Advice, an advisory firm, argues that ERP systems are vital to achieving regulatory compliance as such systems "increase visibility and control within the firm, protect the security of data, and enhance traceability and quality control" (Hale, 2019). In addition, one prominent consulting firm recently noted that "[a]lmost all of the facts that have to be recorded and accounted for in regulatory compliance can be maintained in the corporate ERP system and its database(s)" (Jackson, 2021).[14] More specifically, ERP systems also generate information on production emissions (Deacom, 2018) or maintenance requirements that prevent workplace injuries (SAP, 2022), thus reducing regulatory violations related to these activities. Formally, we state our central hypothesis as follows:

Hypothesis: Facility-level ERP rollouts are associated with a reduction in facility-level violations and penalties.

While the above discussion suggests that ERP systems can improve firms' regulatory compliance, we note that this relationship is not obvious ex ante. First, managers may still face information processing costs that impedes decision making after an ERP system is implemented. Such costs stem from the idea that the ERP system produces a wealth of information that may be difficult to process. Second, ERP systems may be ineffective in constraining employee behavior if end users do not adopt the new technology. This is a

[14] Similarly, many vendors (such as SAP) note the benefits of ERP systems for minimizing the risk of misstatements or fraud.

common theme in models of user acceptance of new technology and prior ERP research (e.g., Davis et al., 1989; Venkatesh et al., 2003; Liang et al., 2012).[15] Third, ERP systems are implemented for various operational purposes (e.g., Grabski et al., 2011), and it is not clear if such systems will influence compliance outcomes.[16]

3. Empirical Methodology and Data

3.1. Data

3.1.1. Violation Tracker Data

We obtain data from two primary sources. First, we collect federal corporate misconduct data from Violation Tracker. This dataset is maintained by Good Jobs First, a non-profit organization that focuses on promoting corporate and government accountability.[17] The dataset contains violations beginning in 2000 and is sourced from a large number of regulatory agencies responsible for a wide array of regulatory areas, including banking, consumer protection, environmental, health and safety, and workplace discrimination, among others.[18] However, we restrict the Violation Tracker sample to those occurring after 2005 only, as the ERP data (discussed below) are only available beginning in that year.

We drop violations from financial institutions and retain all observations for all other facilities with a publicly traded parent company. We match the Violation Tracker data to the

[15] Recent survey evidence by Beasley et al. (2023) also emphasizes the role of resistance within an organization as an important impediment towards better risk management.

[16] For example, some ERP systems are implemented with a specific purpose such as standardizing ledger schemes, while others are implemented with broader objectives, such as refiguring entire organizational processes and workflows (Chapman and Chua, 2003).

[17] The Violation Tracker database can be found at https://www.goodjobsfirst.org/violation-tracker. A list of the agencies and the online locations of their data can be found at https://violationtracker.goodjobsfirst.org/pages/user-guide.

[18] The information is organized on Violation Tracker's website using a standardized set of categories. The companies named in the violations are linked to more than 3,000 parent companies. Users can search results free of charge. However, downloading search results and viewing several data fields requires a subscription. While Violation Tracker provides a parent-subsidiary matching table (based on the current parent), we also manually check this matching table for our sample of firms.

historical parent and match violations to the firm's headquarters when the location is ambiguous or unavailable.[19] In addition, since the Violation Tracker database only includes facilities with one violation during our sample period, we focus only on a sample of firms that have at least one violation (i.e., we do not consider firms without any violations in our primary sample).[20] We lose approximately 300 additional firms due to missing control variables and because either the firm or the facility included in Violation Tracker are not included in the Aberdeen dataset. Our final sample includes 12,071 violations with almost $23 billion in penalties sanctioned against 722 unique firms and 5,733 unique facilities.[21]

Table 1 describes our sample in more detail. Panel A describes the sample composition. In Panel B, we provide an overview of the number of violations and penalties by year. We observe meaningful variation in violations over time in terms of frequency and penalties. Similar to other studies using this data, we find that violations are more pronounced in recent years. In Panel C, we describe the types of violations in our sample in more detail. Our data include a wide set of offense types related to issues such as workplace safety and labor relations violations. As discussed above, these represent areas in which an ERP system can help improve compliance. In terms of the number of violations, workplace safety violations are the most common offenses, accounting for approximately 46% of total violations. Environmental violations received the largest penalties, representing 32% of all penalties.

– Insert Table 1 here –

3.1.2. ERP Data

[19] Our results are robust when we adjust for these research-design choices (see Section 6).

[20] In additional analyses, we also re-examine our primary results using a sample that also includes non-violation facilities that report sales, using information on the location of non-violation facilities from the Dun & Bradstreet Historical Duns Marketing Information (DMI) Files (see Section 6).

[21] The penalties represent the revised penalty amounts rather than those initially proposed to account for negotiations or adjustments. Observations with missing penalty amounts or amounts below $5,000 are not included in the sample.

Our second data source provides information on ERP systems and firms' IT investments. We follow the well-established literature in finance and economics and collect this data from Aberdeen's Computer Intelligence Technology Database (CiTDB) (e.g., Bresnahan et al., 2002; Beaudry et al., 2010; Tambe et al., 2012; Bloom et al., 2014; Tuzel and Zhang, 2021).[22] Aberdeen is an international marketing intelligence company that collects detailed hardware and software information to sell to large information technology firms, like IBM and Cisco, to use for marketing related to firms' current and future IT needs (Bloom et al., 2014). This exerts a strong discipline on the data quality, as major discrepancies in the data are likely to be detected by Aberdeen's customers. Aberdeen collects data through a variety of methods, including monthly surveys with IT professionals, and conducts extensive internal random quality checks on its own data, ensuring a high level of accuracy (Bloom et al., 2014).[23] These data include detailed information on the hardware, software, storage, networking, and telecom IT investments that firms make, including firms' ERP systems. We identify publicly listed firms in the Aberdeen dataset via name matching to Compustat. An advantage of the Aberdeen dataset is that it provides responses from an individual facility within a large firm (i.e., the Aberdeen data includes identifiers to match facilities to parent companies), including detailed information on the facility name as well as location. We use this data to identify when exactly each facility within a publicly listed firm indicates that it adopted an ERP system.

The Aberdeen survey does not contain responses from all facilities each year. We thus make several adjustments to backfill missing data in our sample. To start, we set our ERP

[22] This database was previously owned by Harte Hanks.

[23] Aberdeen may also indirectly infer some of the survey items through information in firms' URLs or hiring decisions. Unfortunately, Aberdeen does not provide a breakdown on how often the data is modeled versus obtained via surveys and telephone outreach. It is, however, important to note that we have no reason to believe that this potential noise in the data would introduce a systematic bias that would explain our results.

treatment variable to one for all future years once a facility first indicates the use of an ERP. We backfill missing years under the general assumption that ERP systems are rarely removed once instated.[24] Specifically, missing observations for facilities that indicate that they do not have an ERP system both *prior* to and *after* the missing observation are set to zero. Missing observations for facilities that indicate that they do not have an ERP system *before* but do have an ERP system *after* the missing years are coded based on when the firm (not facility) first introduced an ERP system.[25]

We match the Aberdeen data to our sample of facilities with at least one violation as per the Violation Tracker dataset based on facility location, facility name, and the facility's parent name.[26] Out of the 1,479 unique public firms included in Violation Tracker, there are only 3 firms that are not covered by Aberdeen. However, we lose 215 additional firms and 509 violations because the facilities of these firms never responded to the Aberdeen survey—even though they are included in Violation Tracker.

Figure 1 illustrates the evolution of ERP adoption across our sample over time. In particular, we mark counties in which more than 50% of the facilities in our sample have adopted an ERP system as of 2005, 2010, and 2017 in green, blue, and purple, respectively. Counties in which fewer than 50% of the facilities in our sample have adopted an ERP system are marked in red. The figure indicates substantial heterogeneity in ERP adoption across our sample, with no obvious geographic trend emerging.

[24] In fact, there are no facilities in our sample that indicate that they have an ERP system in earlier years but not in later years, thus supporting our claim that ERP systems are rarely dismantled.
[25] We also conduct a robustness test tabulated in Table 9, Panel B, which utilizes the raw Aberdeen data without any backfilling. While the sample is more limited, our results hold and remain similar in terms of economic magnitude.
[26] Facility addresses sometimes differ slightly across Aberdeen and Violation Tracker. In such instances, we match Aberdeen facilities to Violation Tracker facilities that are within the same 25-mile radius.

Table 2 provides descriptive statistics on the distribution of ERP vendors within our sample (Panel A), across two-digit-SIC-code industries (Panel B), and across facilities of different size (Panel C). Facilities in our sample use 31 unique ERP vendors, with the three most common brands being SAP (32.2%), Oracle (17.1%), and Microsoft (10.4%). Panel B shows the ranking of the top 10 ERP vendors by industry (i.e., for all industries that represent at least 5% of facilities in our sample). SAP is the most common brand in the manufacturing, transportation & public utilities, and retail trade industries, which together represent more than 70% of our sample, thus explaining the overall popularity of SAP within our sample. Panel C shows the top 10 ERP vendors by facility revenue size quartile. Across all quartiles, SAP, Oracle, and Microsoft are the top 3 ERP vendors, demonstrating the popularity of these ERP vendors across small and large facilities.

– Insert Figure 1 and Table 2 here –

3.1.3. Other Data Sources

We source control variables from a variety of different data sources, including Dun & Bradstreet DMI files (which include annual establishment information), Compustat, and the Bureau of Labor Statistics (BLS). From Dun and Bradstreet, we construct facility-level controls, including the number of employees per facility (*Employees_Facility*) and the total sales per facility (*Sales_Facility*).[27] From Compustat, we construct firm-level controls, including firm's total assets (*Size*), the ratio of liabilities to total equity (*Leverage*), and profitability (*ROA*). These variables are described in more detail in the Appendix. Their inclusion in our models varies based on the fixed effects structure (e.g., firm-year control variables are not included in models with firm-year fixed effects). After requiring non-missing

[27] Facilities with violations included in the Violation Tracker are matched to the D&B dataset.

data for variables of interest and controls and after including facility, state-year, and firm-year fixed effects, our sample contains 5,733 facilities and 53,790 facility-year observations.[28]

3.2. Empirical Methodology

Our baseline regression model examines how ERP adoption at the facility level relates to misconduct using the following generalized DiD framework:

$$Y_{i,j,t} = \beta ERP_{i,j,t} + Controls + \gamma_i + \delta_t + \varepsilon_{i,j,t}, \tag{1}$$

where *i* indexes a facility, *j* indexes a firm (to which the facility belongs), and *t* indicates year. The dependent variable is either the natural logarithm of one plus the number of violations (*Violations*) or the natural logarithm of one plus the penalty amounts (*Penalties*) in a facility year. The variable, *ERP*, is an indicator variable that takes the value of one after an ERP system is adopted by a facility and zero prior to the adoption.

In the above framework, the first difference is the change in misconduct as measured in terms of penalties or number of violations in each facility prior to and following the adoption of ERP. Thus, the control group at time *t* consists of facilities that do not yet have ERP systems. The second difference is the change in misconduct within this control group. Therefore, the effect of *ERP* systems on facility-level misconduct is estimated as the difference in those two differences and is reflected in β in the above regression. The regression specification also controls for factors at the facility and firm level that may influence corporate misconduct (*Controls*). Facility factors include employees and sales, which both proxy for the size of the facility. At the firm level, we control for size, leverage, and profitability.[29] Our baseline specification includes facility fixed effects (γ_i) that account for time-invariant heterogeneity

[28] Our sample size varies slightly depending on the fixed-effects combinations.
[29] All variables are winsorized at the 1st and 99th percentile.

across facilities and year fixed effects (δ_t) that account for time-varying differences.[30] Standard errors are clustered by firm.[31] If ERP systems are associated with reductions in misconduct, we expect the dollar amount of penalties and the number of violations per facility to decrease following their adoption (i.e., $\beta < 0$).

Table 3 describes the sample with the most stringent fixed-effects combination used in our regression analyses in more detail. Panel A indicates that 58.3% of observations are associated with ERP adoptions. The average facility in our sample has approximately 0.22 violations per year and average penalties of $317,821. Facilities, on average, employ 807 employees and generate $4.7 million in sales, suggesting that they are relatively small. While ERP adoptions have become common in recent years, smaller facilities may experience slower adoption rates. Firms in our sample have, on average, $44 billion in assets, a return on assets of 4.4%, and leverage of 36.3%.

– Insert Table 3 here –

4. Main Results

We begin our analyses by examining the association between ERP rollouts and corporate misconduct. Table 4 provides the results from estimating equation (1). In Columns (1) through (4), we present the results for the natural log of one plus the total dollar value of penalties (*Penalties*). In Columns (5) through (8), we present the results for the natural log of one plus the number of violations (*Number_Violations*). In each set of results, we first present results from the baseline model as expressed in equation (1), which includes control variables and facility and year fixed effects (Column (1) and (4)). We then layer on state-year and firm-year fixed effects in subsequent columns.

[30] We also modify this model to include a wide set of additional fixed effects, including industry-year, firm-year, state-year, and county-year fixed effects.
[31] As described in Section 6, our results are robust to clustering by facility, by state, or by state and year.

Consistent with our prediction, the results from Table 4 indicate a negative and significant coefficient on *ERP* in each specification. The coefficients are also markedly stable across specifications, exhibiting marginal changes as we add additional fixed effects, suggesting that the baseline model accounts for many factors correlated with ERP adoption and misconduct rates. In terms of economic significance, we find that ERP adoption reduces the dollar value of penalties by approximately 17% (Column (4)) and the number of violations by approximately 1.1% (Column (8)). The stronger decline in penalties (in comparison to the decline in the number of violations) suggests that ERP systems help firms to avoid more severe violations, i.e., those violations that result in larger penalties. We also note that these results likely present a lower bound estimate of the effect of ERP rollout on facility-level misconduct, as we only observe misconduct for which regulators imposed a penalty. It is thus difficult to compare these compliance benefits to the direct costs of implementing ERP systems, which are estimated to be upwards of $750,000 for a mid-size business.[32] Overall, these results are consistent with ERP rollouts improving compliance in facilities, as both the number of violations and penalties decline after the rollout.

– Insert Table 4 here –

5. Mechanisms

Prior research suggests that ERP systems enhance compliance outcomes through increasing managerial monitoring and imposing constraints on employees' actions. We next conduct cross-sectional analyses to validate these two channels. First, we assess whether information processing costs reduce the ERP system's ability to improve managerial

[32] See https://www.erpfocus.com/erp-cost-and-budget-guide.html. Please note that companies invest in ERP systems for a variety of reasons, with compliance potentially not being the primary determinant.

monitoring. Second, we explore potential challenges related to end-user adoption. We discuss these tests in more detail below.

5.1. Information Processing Costs and Managerial Monitoring

Our first cross-sectional analysis considers features of the ERP implementation that may increase information processing costs and thus limit its efficacy in enabling managerial monitoring. Specifically, we examine the role of additional software that can help process complex information produced by the ERP system. We focus on Business Intelligence and Data Warehousing (BI-DW) software that are often included in ERP implementations. These software incorporate advanced data analytics that can potentially help managers find patterns in the data that ERP systems collect. Practitioners note the challenges associated with interpreting complex information provided by ERP systems and highlight the value of BI-DW software for "analyz[ing] and contextualiz[ing] information […] to generate actionable insights" (Morris, 2021). Academic studies also argue that business intelligence software is an important component to gain more benefits from ERP systems (Carlsson and Turban, 2002). We expect that ERP systems that roll out with BI-DW software reduce processing constraints that managers face in analyzing complex information provided by ERP systems.

To implement this test, we collect data from Aberdeen containing information on facilities' adoption of BI-DW software in conjunction with their ERP system. We then test the effects of ERP system introduction with and without BI-DW software by bifurcating the ERP treatment into two variables: *ERP_with_BI-DW_Software* and *ERP_without_BI-DW_Software*.

The results from the BI-DW tests are provided in Table 5. Column (1) presents the results for *Penalties* and Column (2) presents the results for *Number_Violations*. We find a negative and significant coefficient on *ERP_with_BI-DW_Software* using either *Penalties* (p<0.05) or *Number_Violations* (p<0.10) as dependent variables. We also find that the coefficients on *ERP_without_BI-DW_Software* are statistically insignificant and have significantly smaller magnitudes than the coefficients on *ERP_with_BI-DW_Software* (p<0.10). These findings suggest that the compliance benefits of ERP rollouts are concentrated in rollouts that include BI-DW software. Overall, these results suggest that data analytics help reduce the processing costs associated with interpreting information from an ERP system.

– Insert Table 5 here –

5.2. Resistance to Technology and Constraints on Employee Behavior

Our next cross-sectional analysis considers frictions related to end user adoption. In particular, we explore how local resistance to technology may affect how facilities and users respond to ERP implementation and interface with the system. Indeed, a key challenge that firms face in ERP implementations relates to "change management," with technology resistance providing one common reason for an ERP failure. Prior academic research also suggests that social factors, such as user acceptance, have a strong effect on ERP system usage (Chang et al., 2008). We thus expect that ERP adoptions have a reduced effect on compliance when tech resistance at the facility is high, as users will not adopt the technology or use it inappropriately (e.g., managers may not invest in training, or users do not follow the protocol specified by the system), limiting the system's ability to constrain employee behavior.

We construct a composite measure reflecting local resistance to technology using data from two sources. In particular, we obtain data on a county's population age from the American Community Survey - which is run by the U.S. Census Bureau - and data on STEM jobs from the Occupational Employment and Wage Statistics of the U.S. Bureau of Labor Statistics. This measure is more likely to capture characteristics of the workers (instead of facility managers) as workers are likely more reflective of the general population in an area. We then test the interactive effects of ERP system adoption and resistance to technology using a similar model to equation (1). Specifically, we interact *ERP* with *High_Resistance*, which is set to one for facilities located in counties with below-median number of STEM jobs and above-median age and set to zero otherwise.

We tabulate the results in Table 6. Column (1) presents the results for *Penalties* and Column (2) presents the results for *Number_Violations*. We find a positive and significant coefficient on *ERP x High_Resistance* using either *Penalties* ($p<0.05$) or *Number_Violations* ($p<0.10$) as dependent variables. As the sum of the coefficients on *ERP* and *ERP x High_Resistance* is statistically insignificant from zero, these results suggest that ERP rollouts are only effective in reducing violations when facilities are located in areas where users are open to technological change, as the ERP system is less effective in constraining employee behavior.

– Insert Table 6 here –

6. Additional Tests

In this section, we present a wide set of additional tests, primarily focused on assessing the robustness of our results and alleviating endogeneity concerns. In these tests, we consider instrumental variables, parallel trends, entropy balancing, and alternative research designs. We discuss each of these tests in more detail below.

6.1. Determinants of ERP Adoption

We begin by examining potential drivers of ERP adoption. As discussed earlier, ERP systems are implemented for a variety of reasons, many of which may be unrelated to a firm's demand for a stronger compliance function. The goal of the determinants analysis is to shed light on some of the key forces driving ERP implementation, and also motivate two instrumental variables. As our study focuses on the within-firm ERP rollout (and not the adoption of an ERP system at the firm level), we design these tests to primarily shed light on determinants for adoption of ERP systems at the *facility*-level.

Our determinants analysis examines regressions of *ERP* on a wide set of facility, firm, and local characteristics that may influence ERP presence. These characteristics include prior misconduct history, proxies for growth (i.e., sales growth at the facility level), firm complexity (number of facilities), firm size, leverage, and profitability. We further consider two additional variables that will serve as instrumental variables in our subsequent analysis. The first is the average industry-level IT budget, which proxies for competitive pressure to adopt an ERP. The second is the quality of the local IT infrastructure, measured based on the presence of ARPANET nodes, which served as the foundational footprint of the internet. We discuss the validity of these instruments in more detail below. Finally, we include year fixed effects to account for any temporal trend in ERP adoption.

Table 7 presents the results from the determinants analysis. We note that the sample is reduced to 41,631 observations, as data on IT budgets is only available as of 2010.[33] Our findings ultimately suggest that facility size is strongly associated with the presence of an ERP system. In addition, firm-level factors, such as size and profitability, are also positively associated with ERP presence, although they are absorbed in our main analyses, which include firm-year fixed effects. In addition, industry-level IT budgets and the presence of ARPANET nodes are significantly associated with the presence of ERP systems at the facility level. Finally, we do not find evidence that prior facility-level violations or penalties, facility growth, or the number of facilities are significantly associated with the presence of an ERP system. Our finding that prior facility misconduct does not influence ERP presence reduces concerns that ERP rollout priority within a firm may be driven by compliance needs.

[33] Our results are similar if we exclude industry-level IT budget and use the full sample (untabulated).

These results have several important implications. First, they suggest that firm and facility size as well as firm profitability are important determinants of an ERP system. It is thus important that we control for these characteristics throughout our tests. The results also suggest that controlling for other operational aspects (e.g., the number of facilities) is less important.[34] Thus, we do not include these variables as controls in part because some factors reduce our sample size. Moreover, these results further alleviate concerns regarding violation pre-trends before adoption of the ERP system as prior misconduct is not associated with ERP presence. Finally, our results also suggest that the presence of ARPANET nodes as well as industry-level IT investments may be reasonable instruments as they are associated with local ERP adoption and are unlikely to be associated with facility-level violations. We discuss our instrumental variables tests next.

– Insert Table 7 here –

6.2. Instrumental Variables

One potential concern with our primary results is that the relationship between the adoption of ERP systems and facility-level misconduct could be driven by some correlated omitted factor. To a certain extent, the inclusion of finer fixed effects, such as firm-year and county-year fixed effects, helps to address this concern, as they control for any time-varying firm or county characteristic that may explain the documented associations. Nevertheless, we also address this concern more systematically by using two instruments for ERP adoption.

Our first instrument reflects the industry-level demand for ERP adoption, measured as the average IT budget across all firms in the same industry as the facility of interest. As

[34] Please note that our main results include firm-year fixed effects, which control for any time-varying firm-level changes, including the number of facilities belonging to a firm. We note that our results are unchanged when we remove firm-year fixed effects and control for time-varying firm factors specified in the determinants analysis (untabulated).

highlighted above, this proxy is associated with facility-level ERP adoption likely due to peer effects driving IT investments throughout a firm. However, industry-level ERP demand is less likely to directly drive an individual facility's misconduct. Conceptually, this latter link should be particularly weak in our setting, as we examine *facility*-level misconduct.

Table 8, Panel A presents the results from tests of our first instrumental variable analysis. Notably, the F-statistics from the first-stage regression passes the weak identification tests at the 1% level. In addition, the Kleinberg-Paap statistics pass the associated under-identification tests (e.g., Larcker and Rusticus, 2010). The results of the second stage IV regressions (see Table 8, Panel A, Columns (2) and (3)) are consistent with the main results reported in Table 4. Specifically, the results show that ERP adoption at the facility level results in fewer violations and lower penalties. We note that these tests are limited to the period 2010 to 2017, as data on IT budgets is only available as of 2010. Furthermore, we include facility and state-year fixed effects, but cannot include firm-year fixed effects, as those fixed effects would absorb the industry-level variation in IT budgets.

Our second instrument follows Forman et al. (2012) and utilizes the presence of historical ARPANET nodes per county. Forman et al. (2012) suggest that the presence of historical ARPANET nodes at the county level reflects local internet communication infrastructure and influences future IT investment (e.g., ERP adoption), which we demonstrate in our determinants analysis. At the same time, it is unlikely that the presence of historical ARPANET nodes per county directly affects local misconduct (i.e., the exclusion restriction).[35] Similar to Law and Shen (2020), we create an indicator set to one if the county has at least one ARPANET node in the year 2005 as a time-invariant proxy for the quality of the IT

[35] We note that it is not possible to statistically verify exclusion restrictions in instrumental variable models.

infrastructure in a county. Thus, we can use the full sample. As this measure is time-invariant, we run this test without facility fixed effects. Instead, we include firm-year and state-year fixed effects to control for firm-level and state-level changes over time.

Table 8, Panel B presents the results from the instrumental variable analysis. We find that the instrument is strongly associated with facilities' ERP adoption (see Table 8, Panel B, Column (1)). Again, the F-statistics from the first-stage regression passes the weak identification tests at the 1% level, and the Kleinberg-Paap statistics pass the associated under-identification tests. The results of the second stage IV regressions (see Table 8, Columns (2) and (3)) are consistent with the main results reported in Table 4. Specifically, the results show that ERP adoption at the facility level results in fewer violations and lower penalties. These findings establish a more robust link between ERP adoption and compliance.

– Insert Table 8 here –

6.3. Parallel Trends

We next plot the effects of ERP adoption on the number of violations and penalties in event time in Figure 2 and Figure 3, respectively. For these figures, we use the same regression as for our main results tabulated in Table 4 (including facility and year fixed effects) and focus on the subset of facilities for which we have data during a ten-year window around the ERP adoption. Figure 2 plots the coefficient on *ERP* (and the 90% confidence intervals) using the natural logarithm of the number violations as the dependent variable in the ten-year window around the ERP adoption. Figure 3 plots the coefficient on *ERP* (and the 90% confidence intervals) using the natural logarithm of the penalty amounts as the dependent variable in the ten-year window around the ERP adoption. Both graphs suggest that there were no pre-trends before the ERP adoption. Both figures also suggest that the effect of an ERP system on violations and penalties appears immediately after its adoption and persists for approximately five years.

– Insert Figure 2 and 3 here –

6.4. Entropy Balancing

Next, we examine the robustness of the results presented in Table 4 using entropy balancing. Entropy balancing re-weights control sample observations along moments of the control variable distributions (Hainmueller, 2012). In contrast to propensity-score matching, entropy balancing retains all observations (rather than discarding "unmatched" observations). In addition, entropy balancing does not require research-design choices, such as setting a certain caliber or radius, to achieve covariate balance, alleviating concerns that the results are sensitive to model specification.

Table 9, Panel A presents the results. Consistent with our main results, we find that, after an ERP rollout, treated facilities have fewer penalties and violations. The economic magnitudes are similar to those reported in Table 4.

6.5. Alternative ERP Measure

We next assess the sensitivity of our results to two alternative ERP measures. The first measure addresses potential concerns regarding how we backfill data on ERP rollouts. In our main analyses, we backfill years with missing ERP data (as facilities may not respond to the Aberdeen survey every year). We thus consider a raw measure of ERP adoption, as provided by Aberdeen to ensure that our research-design choice to backfill missing years does not drive the results.[36] The second measure considers an alternative treatment based on the number of modules included in the ERP implementation.

[36] As ERP adoption is missing for some years, this reduces our sample to 28,194 observations.

Table 9, Panel B reports the results. We present the results for *Penalties* in Columns (1) and (2) and the results for *Number_Violations* in Column (3) and (4). The raw Aberdeen sample is presented in Columns (1) and (3), and the continuous ERP treatment is presented in Columns (2) and (4). As shown in Panel B, we find consistent results using both treatments.

6.6. Alternative Dependent Variable and Estimation Models

We also consider the robustness of our primary results to an alternative dependent variable and alternative estimation techniques to better capture the underlying distribution of our dependent variables. In particular, we first rerun our results using *Misconduct*, an indicator set to one in years with a violation, as the dependent variable. As shown in Table 9, Panel C, Column (1) the results hold. We also report results from robust regressions. As shown in Table 9, Panel C, Columns (2) and (5) the results hold. Next, we also report robustness tests in Table 9, Panel C, Columns (3) and (6) using Poisson pseudo maximum likelihood regressions as an alternative estimation technique to alleviate the concern that estimating linear regressions of log(1+X) transformation can lead to biased estimates and standard errors (Cohn et al., 2022). Our inferences remain unchanged with this alternative specification.

Finally, we acknowledge that a potential concern with our primary research design is that our estimated effects could be biased due to the observations that form the control group. In our context, ERP rollout was staggered, creating the concern that, for late treatments, the control group consists not only of “not-yet-treated” facilities but also facilities that had ERP rollout in earlier periods. To alleviate this concern, we follow Baker et al. (2022) and adjust for the use of prior treated units as effective comparison units by running stacked regressions. In particular, we create a separate dataset for each ERP rollout year and only use not-yet-treated facilities as controls. We then stack these datasets to calculate average treatment effects across the events by including year-group and facility-group fixed effects. As shown in Table 9, Panel

C, Columns (4) and (7) our results hold using this alternative estimation technique. Overall, our results are robust to using alternative estimation techniques.

6.7. Alternative Fixed Effects

To further alleviate potential concerns that unobservable factors explain our results, we consider two alternative fixed-effects structures. First, we replace year fixed effects with industry-year fixed effects to control for changes at the industry level over time. Second, we replace year fixed effects with county-year fixed effects, exploiting the fact that facilities operating in the same county adopt ERP systems at different points in time. The sample for the latter test is slightly smaller; in some instances, only one facility operates in a county.

Table 9, Panel D provides the results from our alternative fixed-effects structure analyses. Columns (1) and (2) provide the results for *Penalties* and Columns (3) and (4) provide the results for *Number_Violations*. As shown in Columns (1) and (3), our results are robust to the inclusion of industry-year fixed effects. In Columns (2) and (4), we include county-year fixed effects and also find that our inferences continue to hold. Overall, the results from our alternative fixed effects analysis provide further evidence that our findings do not appear to be influenced by unobservable local or industry-level heterogeneity. It is also notable that the coefficients remain rather stable across our specifications and are comparable in magnitude to our main results.

6.8. Alternative Sample

Next, we examine the robustness of our main results to five research-design choices related to our sample (discussed above). First, we assign violations with ambiguous or unavailable location information to a firm's headquarters location. Second, we exclude facilities without violations, focusing only on those that experienced at least one violation. Third, we keep observations from facilities that do not experience a violation for a sustained period of time. Fourth, we exclude industry-specific violations. Fifth, we exclude facilities that do not have an ERP system by the end of the sample period, albeit they belong to a firm that rolled out an ERP system.

To examine the robustness of our main results to the first design choice, we set all violations with ambiguous or unavailable location information to zero. This reduces the number of violations to 7,769 and penalties to approximately $2.5 billion. As shown in Table 9, Panel E, Columns (1) and (6), the results continue to hold using this alternative sample.

To examine the robustness of our main results to the second design choice, we add facilities without violations from the Dun & Bradstreet Historical Duns Marketing Information (DMI) Files dataset. This dataset allows us to identify 51,307 additional non-violation facilities that reported positive sales at least once during our sample period. We estimate our primary model using the sample of violation and non-violation facilities, resulting in a much larger panel of 350,169 observations. Note that the average non-violation facility has sales of approximately $62,714, which is approximately 75 times smaller than the average facility in the violation sample (see Table 3). This adds justification to our previous research-design choice as violation and non-violation facilities are fundamentally different. We repeat our main analyses using penalties (Column (2)) and the number of violations (Column (7)) as the dependent variables. As shown in Table 9, Panel E, Columns (2) and (7), we find a negative and significant coefficient on *ERP* in both models. In terms of economic magnitude, the results indicate that ERP introduction decreases the dollar penalties and the number of violations in treated facilities by approximately 3% and 0.3%.

To examine the robustness of our main results to the third design choice, we exclude facility-year observations that had no violations in the last three years, reducing our sample size to 23,292 observations. As shown in Table 9, Panel E, Columns (3) and (8), the results hold, and the economic magnitudes are larger. In particular, after the introduction of an ERP system penalties reduce by almost 40% and the number of violations by almost 3%.

To examine the robustness of our main results to the fourth design choice, we exclude industry-specific violations (i.e., aviation safety, motor vehicle safety, and railroad safety violations). As shown in Table 9, Panel E, Columns (4) and (9), the results hold, and the economic magnitudes are larger. In particular, after the introduction of an ERP system penalties reduce by more than 36% and the number of violations by approximately 2.6%.

To examine the robustness of our main results to the fifth design choice, we exclude facilities that do not have an ERP system by the end of the sample period, albeit they belong to a firm that implemented an ERP system. As shown in Table 9, Panel E, Columns (5) and (10), the results hold, and the economic magnitudes are similar to our main results. Overall, our results hold using different sampling choices.

6.9. Alternative Clustering

In our primary tests, we cluster the standard errors by firm. We also re-examine our main tests clustering by facility, state, or state and year. As shown in Table 9, Panel F, we find consistent results using these alternative clustering approaches. Collectively, our results suggest that ERP adoptions have a robust effect on misconduct.

6.10. Firm-Level Analysis

Finally, we examine the effect of ERP rollouts at the firm level. For these tests, we aggregate total penalties and number of violations at the firm level (denoted *Penalties_Firm* and *Number_Violations_Firm*). We use two alternative definitions of *ERP*. First, *ERP* equals one after at least half of a firm's facilities introduced an ERP system. Second, *ERP* is measured as the percentage of a firm's facilities with an ERP system. As shown in Table 9, Panel G, the coefficient on *ERP* is negative and significant using both definitions of ERP. These results suggest that an ERP rollout is associated with a reduction in violations across the firm.

– Insert Table 9 here –

Overall, the results from our robustness analyses help document a stronger link between facility-level ERP adoption and compliance benefits. Our analyses suggest that unobservable heterogeneity at various levels is unlikely to explain our results and show that our results are robust to various alternative research-design choices.

7. Conclusion

Information technologies have the potential to reshape how firms adhere to regulations. Our study sheds light on this issue by examining the effects of IT investments on corporate misconduct. Using the staggered rollout of enterprise resource planning (ERP) systems across U.S. firms, we document marked decreases in both facility-level violations and penalties following ERP adoption.

In addition, we show that the compliance benefits of ERP systems depend on the system's ability to improve managerial monitoring and constrain employee choice. In particular, our findings suggest that ERP adoptions reduce misconduct only when such systems provide more decision-useful information relevant to compliance, thus enhancing managerial monitoring. In addition, ERP systems are more effective when facilities exhibit less resistance to new technologies, thus ensuring that employees' choices are constrained. These findings provide large-sample evidence validating arguments proposed by management accounting researchers regarding the mechanisms through which ERP systems influence organizational control.

More broadly, our study should also be informative to practitioners and regulators interested in the compliance-related benefits associated with IT investments. As regulation becomes increasingly complex, regulators have indicated that new technology may help firms better navigate compliance issues. Our results provide evidence to confirm this claim and suggest that firms experience compliance benefits from investing in IT systems.

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Appendix. Variable Definitions

The following variables are constructed using data from Violation Tracker's dataset of corporate misconduct [VT], data on facilities from Dun and Bradstreet DMI files [D&B], Compustat [C], data on a county's population age structure from the American Community Survey [ACS], data on STEM jobs from the Occupational Employment and Wage Statistics of the U.S. Bureau of Labor Statistics [STEM], and data on facilities' IT investments from Aberdeen's Computer Intelligence Technology Database [CiTDB].

A. Variables of Interest

Penalties	The natural logarithm of one plus total penalties for misconduct per facility and year winsorized at the 99^{th} percentile. [VT]
Number_Violations	The natural logarithm of one plus the number of violations per facility and year winsorized at the 99^{th} percentile. [VT]
ERP	Indicator variable that is set to 1 in the years following a facility's ERP adoption, and 0 in the years prior to the adoption. If facility-level information on ERP adoption for a *specific* year is missing (as the facility most likely did not respond to the Aberdeen survey), we use facility-level information from other years. [CiTDB]
ERP_with(without)_BI-DW_Software	Indicator variable that is set to 1 after a facility introduced an ERP system with (without) Business Intelligence and Data Warehouse Software, and 0 otherwise. [CiTDB]
High_Resistance	Indicator variable that is set to 1 if the facility is located in a county with below median number of STEM jobs and above median age, and 0 otherwise [ACS + STEM].
B. Controls	
Employees_Facility	The natural logarithm of one plus the number of employees per facility. [D&B]
Sales_Facility	The natural logarithm of one plus sales per facility (in thousands of dollars). [D&B]
Growth_Facility	The change in sales per facility. [D&B]
Number_Facilities	The natural logarithm of one plus the number of facilities per firm. [D&B]
Size	The natural logarithm of one the firm's asset size (in millions of dollars) at the beginning of the year. [C]
Leverage	The ratio of total liabilities to total equity. [C]
ROA	Net income scaled by total assets. [C]

Figure 1. Map of ERP Adoption in Sample Firms

This map shows the geographic distribution of ERP adoption within our sample of facilities of publicly listed firms across the United States during the period 2005-2017. The blue, green, and purple grids indicate counties in which at least 50% of the facilities in our sample adopted an ERP system as of 2005, 2010, and 2017, respectively.

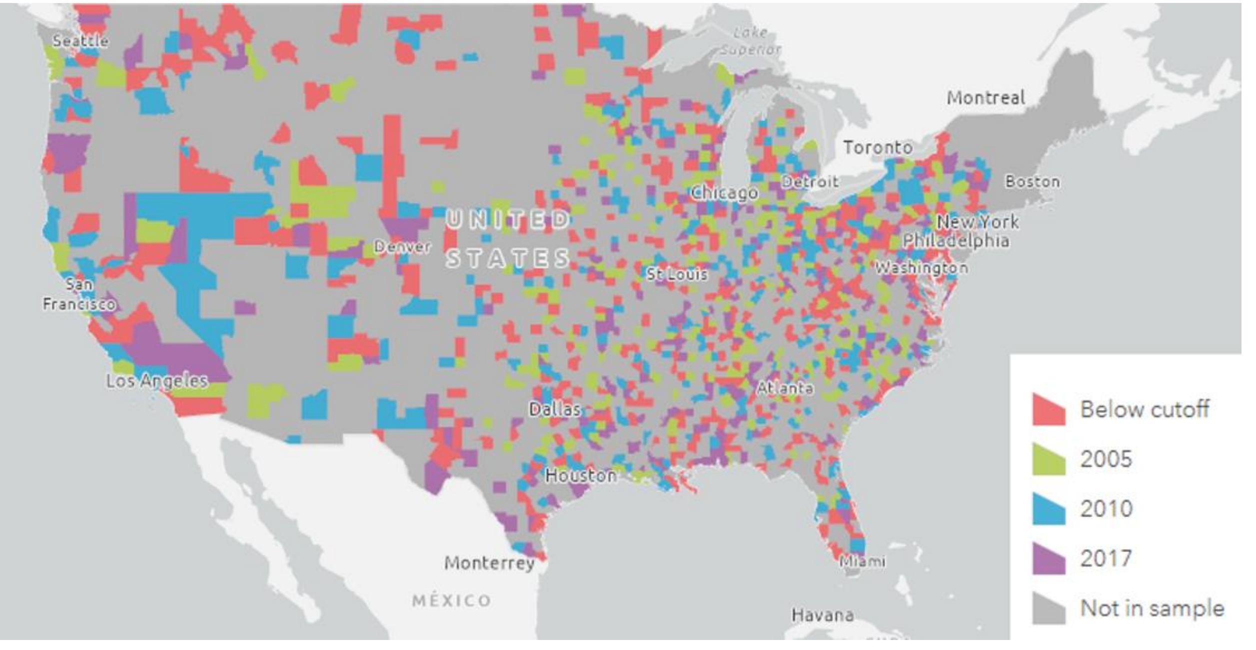

Figure 2. Parallel Trends - Violations

This graph plots the coefficient on *ERP*, which takes the value of 1 after a facility adopted an ERP system, (and the 90% confidence intervals) using the natural logarithm of one plus the number of violations as dependent variable around the ERP adoption. The coefficients are estimated using the same model as for Table 4 (including facility and year fixed effects), and focusing on the subset of facilities for which we have data during the ten-year window around the ERP adoption.

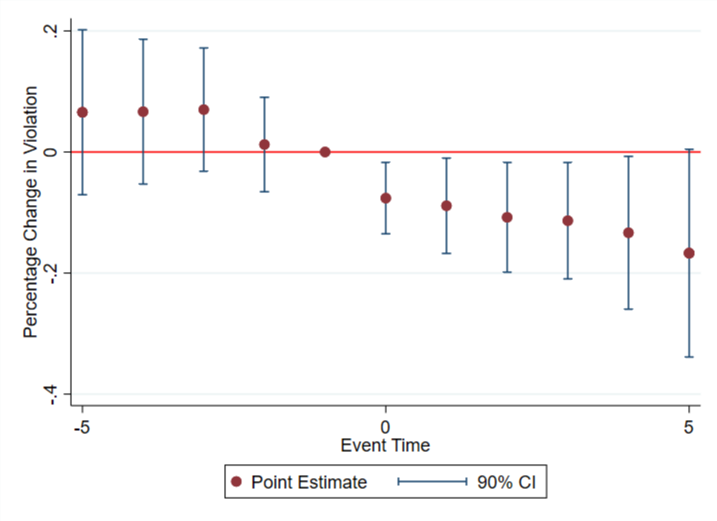

Figure 3. Parallel Trends - Penalties

This graph plots the coefficient on *ERP*, which takes the value of 1 after a facility adopted an ERP system, (and the 90% confidence intervals) using the natural logarithm of one plus the penalty amounts as dependent variable around the ERP adoption. The coefficients are estimated using the same model as for Table 4 (including facility and year fixed effects), and focusing on the subset of facilities for which we have data during the ten-year window around the ERP adoption.

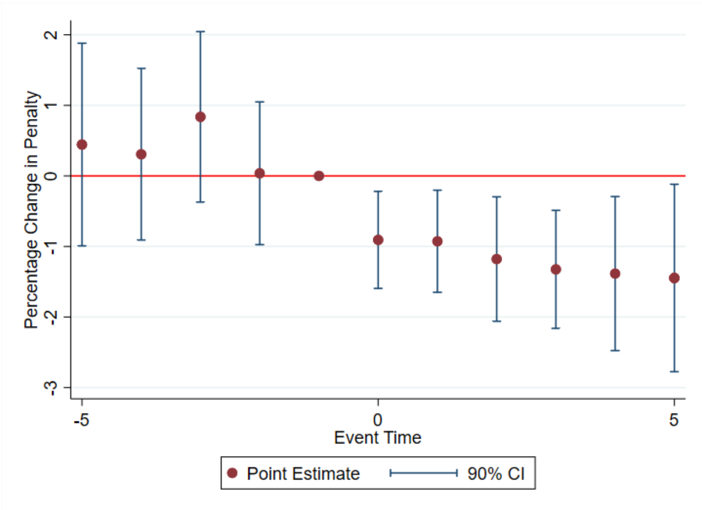

Table 1. Sample

Panel A. Sample Composition

This table presents the sample composition for the period 2005-2017.

	Number of Violations (1)	Number of Firms (2)	Number of Facilities (3)
Violation Tracker sample	67,000	2,875	
Less: Private companies	(23,637)	(1,362)	
Less: Financial industry	(5,231)	(130)	
Less: Violations before 2005	(24,360)	(347)	
Less: Firms not included in Aberdeen	(18)	(3)	
Less: Firms included in Aberdeen, but no facility included in Violation Tracker included in Aberdeen	(509)	(215)	
Less: Missing control variables	(1,174)	(96)	
Final sample	12,071	722	5,733

Panel B. Sample Composition by Year

This table presents the distribution of violations and penalties in our sample for the period 2005-2017 by year.

Year	Number of Violations	% of Total	Penalties ($m)	% of Total
2005	596	4.9%	3,442.4	15.1%
2006	710	5.9%	1,158.5	5.1%
2007	746	6.2%	935.4	4.1%
2008	654	5.4%	1,654.5	7.3%
2009	890	7.4%	1,371.0	6.0%
2010	1,380	11.4%	1,204.4	5.3%
2011	1,208	10.0%	1,946.8	8.5%
2012	1,084	9.0%	1,567.5	6.9%
2013	1,013	8.4%	4,050.7	17.8%
2014	879	7.3%	533.7	2.3%
2015	1,111	9.2%	1,806.7	7.9%
2016	999	8.3%	2,373.3	10.4%
2017	801	6.6%	753.2	3.3%
Total	12,071	100%	22,798.1	100%

Panel C. Sample Composition by Offense Type

This table presents the sample composition for the period 2005-2017 by offense type.

Offense Type	Number of Violations	% of Total	Penalties ($m)	% of Total
Workplace safety or health violation	5,517	45.7%	123.5	0.5%
Environmental violation	2,477	20.5%	7,296.0	32.0%
Railroad safety violation	1,875	15.5%	22.0	0.1%
Wage and hour violation	731	6.1%	3,139.2	13.8%
Labor relations violation	472	3.9%	92.4	0.4%
Aviation safety violation	405	3.4%	94.2	0.4%
Employment discrimination	212	1.8%	422.1	1.9%
Motor vehicle safety violation	96	0.8%	998.4	4.4%
False Claims Act violation	83	0.7%	3,691.1	16.2%
Benefit Plan Administrator violation	63	0.5%	1,490.5	6.5%
Securities violation	35	0.3%	1,184.9	5.2%
Other	105	0.9%	4,243.8	18.6%
Total	12,071	100%	22,798.1	100%

Table 2. Descriptives on ERP Systems

Panel A. ERP Vendor Distribution

This table presents the ERP vendor distribution for our sample.

ERP Vendor	Count of Facilities Using ERP Vendor	% of Total
SAP	1,111	32.2%
Oracle	590	17.1%
Microsoft	359	10.4%
Longview	149	4.3%
IBM	143	4.2%
QAD	120	3.5%
Infor	118	3.4%
NavexGlobal	101	2.9%
Peoplesoft	99	2.9%
Sage	82	2.4%
EMC	73	2.1%
Other Vendor	500	14.5%
Total	3,445	100%

Panel B. ERP Vendor Top 10 Ranking by Industry

This table presents the Top 10 ranking of ERP vendors by two-digit-SIC-code industry (industries that represent more than 5% of the sample observations are listed separately; all other industries are grouped into “Other”).

Ranking	Manufacturing (46%)	Transportation & Public Utilities (16%)	Retail Trade (9%)	Services (8%)	Mining (6%)	Other (15%)
1	SAP	SAP	SAP	Oracle	SAP	SAP
2	Oracle	Microsoft	Oracle	SAP	IBM	Oracle
3	Microsoft	Longview	Longview	Microsoft	Microsoft	Microsoft
4	QAD	Oracle	Microsoft	Sage	Oracle	IBM
5	Infor	TIBCO	IBM	IBM	NavexGlobal	Syspro
6	NavexGlobal	EMC	Infor	Lawson	Peoplesoft	JD-Edwards
7	SYSPRO	IBM	Peoplesoft	Peoplesoft	JD-Edwards	Sage
8	Longview	Peoplesoft	TIBCO	Deltek	Longview	Infor
9	Peoplesoft	NavexGlobal	Concur	Concur	SAI Global	TIBCO
10	Sage	Sage	JD-Edwards	EMC	Infor	Concur

Panel C. ERP Vendor Top 10 Ranking by Size Quartile

This table presents the Top 10 ranking of ERP vendors by facility revenue size quartiles.

Ranking	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
1	SAP	SAP	SAP	SAP
2	Oracle	Microsoft	Oracle	Oracle
3	Microsoft	Oracle	Microsoft	Microsoft
4	IBM	Longview	QAD	Concur
5	Longview	IBM	IBM	Peoplesoft
6	EMC	Infor	Longview	QAD
7	QAD	QAD	Infor	Infor
8	Sage	NavexGlobal	Peoplesoft	NavexGlobal
9	Infor	Sage	NavexGlobal	IBM
10	TIBCO	Peoplesoft	Sage	Longview

Table 3. Summary Statistics Facilities

This table reports the summary statistics on an annual basis of the variables used in our analyses. All variables are defined in the Appendix.

	Facility-Years Sample (N = 53,790)				
Variable	Mean	Std.	Min.	Median	Max.
ERP	0.583	0.493	0	1	1
Number of Violations	0.225	2.433	0	0	224
Penalties (in $)	317,821	1,481,672	0	0	700,000,000
Employees_Facility	807	4,732	1	185	58,507
Sales_Facility (in thousands)	4,731	20,379	0.11	67.3	273,005
Size (in millions)	43,975	99,815	286	11,556	656,560
Leverage	0.363	0.480	0	0.271	3.884
ROA	0.044	0.062	–0.225	0.047	0.206

Table 4. ERP Systems and Facility-Level Misconduct

This table reports the estimation results from linear regressions of the following form:

$$Y_{i,j,l,t} = \alpha_0 + \alpha_1\ ERP_{l,t} + \phi\ Controls + \gamma_i + \delta_{s,t} + \varepsilon_{i,j,l,t}$$

Y is either the natural logarithm of one plus the dollar amount of penalties per facility and year (Columns 1-4) or the natural logarithm of one plus the number of violations per facility and year (Columns 5-8). Columns 1 and 5 report results with facility and year fixed effects. Columns 2 and 6 report results with facility and state-year fixed effects. Columns 3 and 7 report results with facility and firm-year fixed effects. Columns 4 and 8 report results with facility, state-year, and firm-year fixed effects. Our main explanatory variable is *ERP*, which takes the value of 1 after the introduction of an ERP system, and 0 in the years prior to the introduction of an ERP system. Please note that firm-level *Controls* are not included in Columns 3-4 and 7-8 due to the inclusion of firm-year fixed effects. All variables are defined in the Appendix, and the sample spans the period 2005-2017. Standard errors are clustered by firm. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Dependent Variable		Penalties				Number_Violations			
Variables	Pred.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ERP	–	–0.139**	–0.120**	–0.158**	–0.170**	–0.010**	–0.009*	–0.010*	–0.011**
		(0.060)	(0.061)	(0.071)	(0.071)	(0.005)	(0.005)	(0.006)	(0.005)
Employees_Facility		0.048***	0.047***	0.052***	0.052***	0.004***	0.004***	0.004***	0.004***
		(0.010)	(0.010)	(0.011)	(0.011)	(0.001)	(0.001)	(0.001)	(0.001)
Sales_Facility		–0.009	–0.008	–0.013	–0.014*	–0.001	–0.001	–0.001*	–0.001*
		(0.008)	(0.008)	(0.008)	(0.008)	(0.001)	(0.001)	(0.001)	(0.001)
Size		0.227***	0.211***			0.018***	0.016***		
		(0.078)	(0.075)			(0.006)	(0.006)		
Leverage		0.062	0.075			0.002	0.002		
		(0.079)	(0.079)			(0.005)	(0.006)		
ROA		0.385	0.306			0.035	0.028		
		(0.315)	(0.316)			(0.024)	(0.024)		
Facility FE		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	No	No	No	Yes	No	No	No
Year x State FE		No	Yes	No	Yes	No	Yes	No	Yes
Year x Firm FE		No	No	Yes	Yes	No	No	Yes	Yes
Adj. R-squared		0.113	0.114	0.137	0.137	0.149	0.150	0.168	0.168
Observations		58,509	58,496	53,812	53,790	58,509	58,496	53,812	53,790

Table 5. Advanced ERP System

This table analyzes cross-sectional variation in the results of Table 4. *ERP_with_BI-DW_Software* equals 1 after a facility introduced an ERP system with Business Intelligence and Data Warehouse Software, and 0 otherwise. *ERP_without_BI-DW_Software* equals 1 after a facility introduced an ERP system without additional Business Intelligence and Data Warehouse Software, and 0 otherwise. The dependent variable is either the natural logarithm of one plus the dollar amount of penalties per facility and year (i.e., Column 1) or the natural logarithm of one plus the number of violations (i.e., Column 2). *ERP* takes the value of 1 after the introduction of an ERP system, and 0 in the years prior to the introduction of an ERP system. All variables are defined in the Appendix, and the sample spans the period 2005-2017. Standard errors are clustered by firm. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Dependent Variables		Penalties	Number_Violations
Variables		(1)	(2)
ERP_with_BI-DW_Software	β_2	–0.153**	–0.011*
		(0.071)	(0.006)
ERP_without_BI-DW_Software	β_1	–0.013	0.000
		(0.066)	(0.005)
Employees_Facility		0.052***	0.004***
		(0.012)	(0.001)
Sales_Facility		–0.015*	–0.001***
		(0.008)	(0.001)
F-Test: $\beta_2 < \beta_1$		–0.140*	–0.011*
		[0.089]	[0.095]
Facility FE		Yes	Yes
Year x State FE		Yes	Yes
Year x Firm FE		Yes	Yes
Adj. R-squared		0.137	0.168
Observations		53,790	53,790

Table 6. Resistance to Technology

This table analyzes cross-sectional variation in the results of Table 4. *High_Resistance* equals 1 if the facility is located in a county with below median number of STEM jobs and above median age, and 0 otherwise. The dependent variable is either the natural logarithm of one plus the dollar amount of penalties per facility and year (i.e., Column 1) or the natural logarithm of one plus the number of violations (i.e., Column 2). *ERP* takes the value of 1 after the introduction of an ERP system, and 0 in the years prior to the introduction of an ERP system. All variables are defined in the Appendix, and the sample spans the period 2005-2017. Standard errors are clustered by firm. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Dependent Variables	Penalties	Number_Violations
Variables	(1)	(2)
ERP x High_Resistance	0.258**	0.015*
	(0.117)	(0.009)
ERP	–0.246***	–0.015***
	(0.076)	(0.006)
High_Resistance	0.648	0.050
	(0.427)	(0.035)
Employees_Facility	0.052***	0.004***
	(0.011)	(0.001)
Sales_Facility	–0.014*	–0.001***
	(0.008)	(0.001)
Facility FE	Yes	Yes
Year x State FE	Yes	Yes
Year x Firm FE	Yes	Yes
Adj. R-squared	0.137	0.168
Observations	53,790	53,790

Table 7. Determinants of ERP Rollout

This table examines the determinants of facility-level ERP systems. In Column 1, the dependent variable *ERP* takes the value of 1 after the introduction of an ERP system, and 0 in the years prior to the introduction of an ERP system. All variables are defined in Appendix A and the sample spans the period 2010-2017, as data on IT budgets is only available as of 2010. Standard errors are clustered by firm. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Dependent Variables	ERP
Variables	(1)
Penalties_{t-1}	0.028
	(0.036)
$\text{Number\_Violations}_{t-1}$	–0.300
	(0.566)
Employees_Facility	–0.002
	(0.015)
Sales_Facility	0.030***
	(0.012)
Growth_Facility	0.001
	(0.001)
Number_Facilities	–0.005
	(0.019)
Size	0.118***
	(0.028)
Leverage	0.104
	(0.066)
ROA	1.668*
	(0.889)
ARPANET	0.462***
	(0.113)
Industry_IT_Budget	0.083***
	(0.031)
Year FE	Yes
Observations	41,631
Pseudo R-squared	0.024

Table 8. Instrumental Variables

Panel A. Industry-Level IT Investments as Instrumental Variables

This table examines the robustness to our primary results tabulated in Table 3 using instrumental variables. Column 1 reports the results from the first stage of the instrumental variable. In Column 1, the dependent variable *ERP* takes the value of 1 after the introduction of an ERP system, and 0 in the years prior to the introduction of an ERP system. *Industry_IT_Budget* is the average IT budget per publicly listed firm in the same two-digit SIC code industry at the beginning of the year. Columns 2 and 3 report results from the second stage of the instrumental variable. In Columns 2 and 3, *ERP* is instrumented by *Industry_IT_Budget*. The dependent variable is either the natural logarithm of one plus the dollar amount of penalties per facility and year (i.e., Column 2) or the natural logarithm of one plus the number of violations (i.e., Column 3). *Controls* includes *Employees_Facility*, *Sales_Facility*, *Size*, *Leverage*, and *ROA*. All variables are defined in Appendix A, and the sample spans the period 2010-2017, as data on IT budgets is only available as of 2010. Standard errors are clustered by firm. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

	1st stage	2nd stage	2nd stage
Dependent Variables	ERP	Penalties	Number Violations
Variables	(1)	(2)	(3)
ERP		–7.912**	–0.672***
		(3.369)	(0.253)
Industry_IT_Budget	0.014***		
	(0.003)		
Controls	Yes	Yes	Yes
Facility FE	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes
First-Stage F-Test	140.47		
p-value	<0.01		
Kleibergen-Paap LM Statistic	16.14		
p-value	<0.01		
Observations	35,669	35,669	35,669
(Pseudo) R-squared	0.920	0.050	0.027

Panel B. ARPANET Nodes as Instrumental Variables

This table examines the robustness to our primary results tabulated in Table 4 using ARPANET nodes as an instrumental variable. Column 1 reports the results from the first stage of the instrumental variable. In Column 1, the dependent variable *ERP* takes the value of 1 after the introduction of an ERP system, and 0 in the years prior to the introduction of an ERP system. *ARPANET* is set to one if the county has at least one ARPANET node in 2005, and zero otherwise. Columns 2 and 3 report results from the second stage of the instrumental variable. In Columns 2 and 3, *ERP* is instrumented by *ARPANET*. The dependent variable is either the natural logarithm of one plus the dollar amount of penalties per facility and year (i.e., Column 2) or the natural logarithm of one plus the number of violations (i.e., Column 3). *Controls* includes *Employees_Facility* and *Sales_Facility*. All variables are defined in Appendix A. Standard errors are clustered by firm. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

	1st stage	2nd stage	2nd stage
Dependent Variables	ERP	Penalties	Number Violations
Variables	(1)	(2)	(3)
ERP		–1.484**	–0.124***
		(0.612)	(0.047)
ARPANET	0.082***		
	(0.021)		
Controls	Yes	Yes	Yes
Firm-Year FE	Yes	Yes	Yes
State-Year FE	Yes	Yes	Yes
First-Stage F-Test	138.22		
p-value	<0.01		
Kleibergen-Paap LM Statistic	14.28		
p-value	<0.01		
Observations	40,459	40,459	40,459
(Pseudo) R-squared	0.258	0.054	0.065

Table 9. Additional Tests

Panel A. Entropy Balancing

This table examines the robustness of the results presented in Table 4 using an entropy balancing. In Column 1, the dependent variable, *Penalties*, is the natural logarithm of one plus the dollar amount of penalties per facility and year. In Column 2, the dependent variable, *Number_Violations*, is the natural logarithm of one plus the number of violations per facility and year. Our main explanatory variable is *ERP*, which takes the value of 1 after the introduction of an ERP system, and 0 in the years prior to the introduction of an ERP system. *Controls* include *Employees_Facility* and *Sales_Facility*. All variables are defined in the Appendix, and the sample spans the period 2005-2017. Standard errors are clustered by firm. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Dependent Variables	Penalties	Number_Violations
Variables	(1)	(2)
ERP	–0.188***	–0.012**
	(0.071)	(0.005)
Controls	Yes	Yes
Facility FE	Yes	Yes
Year x State FE	Yes	Yes
Year x Firm FE	Yes	Yes
Adj. R^2	0.145	0.177
Observations	53,790	53,790

Panel B. Alternative ERP Measures

This table examines the robustness to our primary results tabulated in Table 4 using two alternative ERP measures. Columns 1 and 3 use the unadjusted information of ERP adoption as reported in Aberdeen (labeled "Non-Backfill"). Columns 2 and 4 use the natural logarithm of one plus the number of ERP modules (labeled "Log Modules"). The dependent variable is either the natural logarithm of one plus the dollar amount of penalties per facility and year (Columns 1 and 2) or the natural logarithm of one plus the number of violations per facility and year (Columns 3 and 4). *Controls* includes *Employees_Facility* and *Sales_Facility*. All variables are defined in the Appendix, and the sample spans the period 2005-2017. The sample in Columns 1 and 3 is smaller as ERP adoption information is missing in a number of facility years. The sample in Columns 2 and 4 is smaller as information on ERP modules is only available as of 2010. Standard errors are clustered by firm. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Dependent Variable	Penalties		Number_Violations	
ERP Measure	Non-Backfill	Log Modules	Non-Backfill	Log Modules
Variables	(1)	(2)	(3)	(4)
ERP	–0.139*	–0.152**	–0.010*	–0.011**
	(0.075)	(0.074)	(0.006)	(0.006)
Controls	Yes	Yes	Yes	Yes
Facility FE	Yes	Yes	Yes	Yes
Year x State FE	Yes	Yes	Yes	Yes
Year x Firm FE	Yes	Yes	Yes	Yes
Adj. R-squared	0.043	0.130	0.075	0.163
Observations	28,194	39,087	28,194	39,087

Panel C. Alternative Dependent Variable and Estimation Models

This table examines the robustness to our primary results tabulated in Table 4 using an alternative dependent variable and alternative estimation models. In Column 1, the dependent variable *Misconduct* is an indicator set to 1 in years with a violation, as the dependent variable. In Columns 2-7, the dependent variable is either the natural logarithm of one plus the dollar amount of penalties per facility and year (Columns 2-4) or the natural logarithm of one plus the number of violations per facility and year (Column 5-7). In Column 1, results are from an OLS regression and the adjusted R-squared is reported. In Columns 2 and 5, results are from a robust regression and the Pseudo R-squared is reported. In Columns 3 and 6, results are from a Poisson Pseudo Maximum Likelihood regression (and hence the dependent variables are not log transformed) and the Pseudo R-squared is reported. In Columns 4 and 7, results are from a stacked regression and the adjusted R-squared is reported. *ERP* takes the value of 1 after the introduction of an ERP system, and 0 in the years prior to the introduction of an ERP system. In Column 1, *Controls* includes *Employees_Facility* and *Sales_Facility*. In Columns 2-7, *Controls* also include *Size*, *Leverage*, and *ROA*. *Group* marks each subsample for each ERP rollout year, which includes only not-yet-treated facilities as controls. All variables are defined in the Appendix, and the sample spans the period 2005-2017. Standard errors are clustered by firm. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Dependent Variable	Misconduct	Penalties			Number_Violations		
Estimation Models	OLS	Robust Regression	Poisson Pseudo Maximum Likelihood Regression	Stacked Regression	Robust Regression	Poisson Pseudo Maximum Likelihood Regression	Stacked Regression
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ERP	–0.016**	–0.034**	–0.115*	–0.131*	–0.003**	–0.212**	–0.010*
	(0.007)	(0.014)	(0.069)	(0.076)	(0.001)	(0.103)	(0.006)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Facility FE	Yes	Yes	Yes	No	Yes	Yes	No
Year x State FE	Yes	Yes	Yes	No	Yes	Yes	No
Year x Firm FE	Yes	No	No	No	No	No	No
Facility x Group FE	No	No	No	Yes	No	No	Yes
Year x Group FE	No	No	No	Yes	No	No	Yes
Adj. / Pseudo R-squared	0.096	0.004	0.284	0.293	0.004	0.554	0.291
Observations	53,790	53,790	37,973	79,757	53,790	37,973	79,757

Panel D. Alternative Fixed Effects

This table examines the robustness to our primary results tabulated in Table 4 to different fixed effects. Columns 1 and 3 report results with industry-year fixed effects. Columns 2 and 4 report results with county-year fixed effects. *ERP* takes the value of 1 after the introduction of an ERP system, and 0 in the years prior to the introduction of an ERP system. The dependent variable is either the natural logarithm of one plus the dollar amount of penalties per facility and year (i.e., Columns 1-3) or the natural logarithm of one plus the number of violations (i.e., Columns 4-6). *Controls* includes *Employees_Facility*, *Sales_Facility*, *Size*, *Leverage*, and *ROA*. All variables are defined in the Appendix, and the sample spans the period 2005-2017. Standard errors are clustered by firm. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Dependent Variable	Penalties		Number_Violations	
Variables	(1)	(2)	(3)	(4)
ERP	−0.157***	−0.124*	−0.011**	−0.009*
	(0.057)	(0.071)	(0.004)	(0.005)
Controls	Yes	Yes	Yes	Yes
Facility FE	Yes	Yes	Yes	Yes
Year FE	No	No	No	No
Year x Industry FE	Yes	No	Yes	No
Year x County FE	No	Yes	No	Yes
Adj. R-squared	0.043	0.095	0.076	0.139
Observations	53,097	51,326	53,097	51,326

Panel E. Alternative Sample

This table examines the robustness to our primary results tabulated in Table 4 to different samples. Columns 1 and 6 report results excluding violations and penalties that cannot be unambiguously assigned to a facility. Columns 2 and 7 report results including facilities without violations. Columns 3 and 8 exclude facility-year observations that had no violations in the last three years. Columns 4 and 9 exclude hard-to-monitor violations (i.e., aviation safety violations, employment discrimination violations, and railroad safety violations). Columns 5 and 10 exclude facilities that do not have an ERP system by 2017 (albeit they belong to a firm that rolled out an ERP system). *ERP* takes the value of 1 after the introduction of an ERP system, and 0 in the years prior to the introduction of an ERP system. The dependent variable is either the natural logarithm of one plus the dollar amount of penalties per facility and year (i.e., Columns 1-5) or the natural logarithm of one plus the number of violations (i.e., Columns 6-10). *Controls* includes *Employees_Facility* and *Sales_Facility*. All variables are defined in the Appendix, and the sample spans the period 2005-2017. Standard errors are clustered by firm. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Dependent Variable	Penalties					Number_Violations				
Sample	No Ambiguous Violations	With No Violation Facilities	Fewer Non-Violation Years	No Hard-To-Monitor Violations	No Facilities without ERP	No Ambiguous Violations	With No Violation Facilities	Fewer Non-Violation Years	No Hard-To-Monitor Violations	No Facilities without ERP
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ERP	–0.141**	–0.029**	–0.439***	–0.142*	–0.160**	–0.011*	–0.003***	–0.031***	–0.012*	–0.010*
	(0.063)	(0.011)	(0.135)	(0.076)	(0.074)	(0.006)	(0.001)	(0.011)	(0.007)	(0.006)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Facility FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.048	0.191	0.217	0.134	0.137	0.241	0.359	0.257	0.315	0.165
Observations	53,790	350,169	23,292	48,174	43,614	53,790	350,169	23,292	48,174	43,614

Panel F. Alternative Clustering

This table examines the robustness to our primary results tabulated in Table 4 to different clustering of standard errors. Columns 1 and 4 report results with standard errors clustered by facility. Columns 2 and 5 report results with standard errors clustered by state. Columns 3 and 6 report results with standard errors two-way clustered by state and year. *ERP* takes the value of 1 after the introduction of an ERP system, and 0 in the years prior to the introduction of an ERP system. The dependent variable is either the natural logarithm of one plus the dollar amount of penalties per facility and year (i.e., Columns 1-3) or the natural logarithm of one plus the number of violations (i.e., Columns 4-6). *Controls* includes *Employees_Facility* and *Sales_Facility*. All variables are defined in the Appendix, and the sample spans the period 2005-2017. Standard errors are reported below the coefficients. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Dependent Variable	Penalties			Number_Violations		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
ERP	–0.170**	–0.170**	–0.170**	–0.011**	–0.011*	–0.011**
	(0.067)	(0.073)	(0.067)	(0.005)	(0.006)	(0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Facility FE	Yes	Yes	Yes	Yes	Yes	Yes
Year x State FE	Yes	Yes	Yes	Yes	Yes	Yes
Year x Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Clustered by	Facility	State	State and Year	Facility	State	State and Year
Adj. R-squared	0.137	0.137	0.137	0.169	0.169	0.169
Observations	53,790	53,790	53,790	53,790	53,790	53,790

Panel G. Firm-Level Analysis

This table examines the robustness to our primary results tabulated in Table 4 to a firm-level analysis. In Columns 1 and 3, *ERP* takes the value of 1 in the year after at least half of a firm's facilities introduced an ERP system, and 0 in the years prior to that. In Columns 2 and 4, *ERP* is the percentage of a firm's facilities that introduced an ERP system in a given year. The dependent variable is either the natural logarithm of one plus the dollar amount of penalties per firm and year (i.e., Columns 1-2) or the natural logarithm of one plus the number of violations (i.e., Columns 3-4). All variables are defined in the Appendix, and the sample spans the period 2005-2017. Standard errors are reported below the coefficients and are clustered by firm. *, **, *** indicate significance at the two-tailed 10%, 5%, and 1% levels, respectively.

Dependent Variable	Penalties_Firm		Number_Violations_Firm	
Variables	(1)	(2)	(3)	(4)
ERP	–0.162*	–0.193*	–0.021**	–0.028***
	(0.100)	(0.113)	(0.010)	(0.011)
Size	0.112***	0.113***	0.010***	0.010***
	(0.021)	(0.021)	(0.002)	(0.002)
Leverage	–0.052	–0.052	–0.008*	–0.008*
	(0.044)	(0.044)	(0.004)	(0.004)
ROA	–0.221	–0.220	–0.048	–0.048
	(0.604)	(0.604)	(0.063)	(0.063)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adj. R-squared	0.272	0.272	0.431	0.431
Observations	14,585	14,585	14,585	14,585