3-2018

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DOI: https://doi.org/10.1111/1911-3846.12409

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January 2017

Contemporary Accounting Research, Forthcoming

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* Accepted by Sarah McVay. We thank the Editor, Sarah McVay, and two anonymous reviewers for their constructive comments. We also thank Chih-Ying Chen, Sunhwa Choi, Jimmy Lee, Yanju Liu, Dan Segal, Jean Seow, Katherine Yuen, An Ping Lin, Suay Peng Wong, workshop participants at CKGSB, Peking University, Singapore Management University, Tsinghua University, and conference participants at the 2015 CAAA annual conference, the 2015 European Accounting Association Annual Congress, and the 2015 American Accounting Association Annual Meeting for helpful comments. We also thank the School of Accountancy Research Center (SOAR) at Singapore Management University for financial support. Cheng and Goh also gratefully acknowledge funding from the Lee Kong Chian Fellowship. Please contact the authors at qcheng@smu.edu.sg (Qiang Cheng), bwgoh@smu.edu.sg (Beng Wee Goh), and jbkim@smu.edu.sg (Jae Bum Kim) for comments.

Internal Control and Operational Efficiency

Abstract: In this study, we examine whether internal control over financial reporting affects firm operational efficiency. We find that operational efficiency, derived from frontier analysis, is significantly lower among firms with material weaknesses in internal control relative to firms without such weaknesses. We also find that the remediation of material weaknesses leads to an improvement in operational efficiency. Additional analyses indicate that the negative effect of material weaknesses on operational efficiency is stronger for firms with a greater demand for higher quality information for decision making, for weaknesses that are deemed to be more severe, and to a certain extent, for smaller firms. Overall, our study extends the literature by presenting systematic evidence on the effect of effective internal control on operational efficiency and informs the debate over the costs and benefits of the internal control reporting requirements under the Sarbanes-Oxley Act of 2002.

Key words: Internal control, operational efficiency, internal information environment, Sarbanes-Oxley Act

JEL codes: G30, L20, M10, M41

1. Introduction

Section 404 (a) of the Sarbanes-Oxley Act of 2002 (SOX 404 (a)) requires management to report on the effectiveness of internal control over financial reporting (ICFR), and Section 404 (b) (SOX 404 (b)) requires the auditor to provide an independent opinion on the effectiveness of ICFR.[1] Since its effective date, SOX 404 has been subject to intense debate. Many critics argue that the expected benefits are not commensurate with the high compliance costs (Michaels 2003; DeFond and Francis 2005; Powell 2005; Romano 2005). While prior studies have documented the benefits of effective ICFR, such as better financial reporting quality and lower cost of capital,[2] the high compliance costs have led to the permanent exemption of SOX 404 (b) for non-accelerated filers under the Dodd-Frank Wall Street Reform and Consumer Protection Act in July 2010.[3] These later developments suggest that it is still important to examine the costs and benefits of maintaining effective internal control.

In this study, we examine the implications of ICFR on firm operational efficiency. We focus on operational efficiency because both anecdotal evidence and prior research (e.g., Feng, Li, and McVay 2009; Cheng, Dhaliwal, and Zhang 2013; Feng, Li, McVay, and Skaife 2015) suggest that effective internal control can enhance a firm's operations. The importance of effective internal control for operational efficiency is also highlighted by regulators. For example, in a 2012 interview related to the revised internal control framework, then COSO Chairman David Landsittel commented that: "some people, because of the implementation of our framework under SOX 404 and SOX, think of it as a financial reporting framework that really relates to published financial statements. But it's broader than that. We want to have the reader recognize more vividly the relevance and opportunities to adopt the framework as it relates to operations and compliance (Tysiac 2012)." Furthermore, the *Internal Control—Integrated Framework* issued by the Committee of Sponsoring Organizations of the Treadway Commission (COSO 2013) explicitly states that one of the objectives of internal control pertains to the "effectiveness and efficiency of the

[1] SOX 404 became effective for fiscal years ending after November 15, 2004 for accelerated filers – public firms with public float of at least $75 million. For non-accelerated filers, SOX 404 (a) was effective for years ending on or after December 15, 2007 but the implementation of SOX 404 (b) was delayed until the subsequent permanent exemption in July 2010.

[2] For examples, see Doyle, Ge, and McVay (2007a) and Ashbaugh-Skaife, Collins, Kinney, and LaFond (2008) on the effect of internal control on financial reporting quality, and Ogneva, Subramanyam, and Raghunandan (2007), Beneish, Billings, and Hodder (2008), Ashbaugh-Skaife, Collins, Kinney, and LaFond (2009), Dhaliwal, Hogan, Trezevant, and Wilkins (2011), and Kim, Song, and Zhang (2011) on the effect of internal control on the cost of capital.

[3] For example, CRA International's (2005) survey indicates that the total year-one Section 404 implementation cost is $1.5 million for a company with market capitalization between $75 and $700 million, or 0.46 percent of its revenue, and $7.3 million for a company with market capitalization above $700 million, or 0.09 percent of its revenue. Financial Executives International (2004) arrives at a similar conclusion from its survey. It estimated that the average year-one 404 compliance cost is over $8 million for companies with more than $5 billion in revenue and over $3 million for smaller ones. Eldridge and Kealey (2005) document that audit fees as a percentage of total assets more than doubled after the enactment of SOX, with smaller companies experiencing greater increases.

entity's operations, including operational and financial performance goals, and safeguarding assets against loss."[4] However, there is little empirical evidence on this issue, with the exception of a few studies on individual corporate decisions such as investments, tax planning, and inventory management (Cheng et al. 2013; Feng et al. 2015; Bauer 2016).[5] This study fills this void in the literature by examining the effect of ICFR on firms' overall operational efficiency, and the conditions under which this effect is stronger; such evidence can further inform the ongoing debate over the costs and benefits of SOX 404.

We hypothesize that ineffective internal control has a negative effect on firm operational efficiency. Ineffective internal control can result in erroneous *internal* management reports (Feng et al. 2009). While these erroneous reports can lead to errors in external financial reporting information, they can also lead to suboptimal operational decisions because managers rely on such reports to make operational decisions. For example, ineffective internal control can adversely affect a firm's ability to forecast sales, which can in turn adversely affect managers' production decisions for the next period. Over-forecasting of sales can result in overprovision of productive inputs and consequently increased costs in the form of inventory obsolescence, storage, and idle capacity. Under-forecasting of sales can result in under-provision of productive inputs and eventually increased costs in the form of last minute sourcing of potentially more expensive raw materials or rushed overtime work. In both cases, inefficiency arises because higher input costs are incurred for a given amount of outputs. Furthermore, ineffective internal control can cause misstatements in operating expenses, which in turn lead to inaccurate unit cost information, sub-optimal pricing decisions, poor control of costs, and ultimately lower operational efficiency. In sum, ineffective internal control can result in operational inefficiency by impairing the quality of internal reports, which in turn leads to poorer decision making.

Notwithstanding the above arguments, it is possible that we might not observe the hypothesized association

[4] This framework replaces the previous one issued in 1992, which defines internal control as "the process designed, implemented and maintained to provide reasonable assurance about the achievement of an entity's objectives with regard to (a) reliability of financial reporting, (b) *effectiveness and efficiency of operation*, (c) safeguarding of assets and (d) compliance with applicable laws and regulations (emphasis added)." Furthermore, Statement of Auditing Standards No. 115, Communicating Internal Control Related Matters Identified in an Audit, defines internal control as "a process—effected by those charged with governance, management, and other personnel—designed to provide reasonable assurance about the achievement of the entity's objectives with regard to the reliability of financial reporting, *effectiveness and efficiency of operations*, and compliance with applicable laws and regulations (emphasis added)."

[5] Cheng et al. (2013) find that internal control material weaknesses can lead to lower investment efficiency, and Bauer (2016) finds that firms with tax-related internal control material weaknesses are less effective in tax planning, as manifested in higher effective tax rates. More closely related to our study, Feng et al. (2015) find that inventory-related material weaknesses are associated with lower inventory turnover and higher inventory impairments. Unlike these studies on individual corporate decisions, our study is broader in nature and examines how ineffective internal control affects various operational decisions that managers make, thereby affecting firms' overall operational efficiency. We later discuss in detail how our study differs from Feng et al. (2015).

between internal control effectiveness and operational efficiency. Because the intended objective of SOX 404 is to improve the reliability of firms' external reports so as to enhance the decision making of external users (PCAOB 2004; Donaldson 2005), few, including managers, have envisaged the importance or the potential benefits of ICFR for internal users. Consistent with this notion, based on a survey of 2,901 corporate insiders, Alexander, Bauguess, Bernile, Lee, and Marietta-Westberg (2013) find that managers do not believe that SOX 404 can improve the efficiency of their firms' operations.

We test the association between internal control effectiveness and operational efficiency using a large sample of accelerated filers that reported internal control opinions under SOX 404 during the period 2004-13.[6] A firm is deemed to have ineffective internal control in a particular fiscal year if it reports at least one material weakness in internal control.[7] Following prior research, we use frontier analysis—Data Envelopment Analysis (DEA)—to measure operational efficiency.[8] Consistent with our prediction, we find that operational efficiency is significantly lower for firms with material weaknesses compared with firms without such weaknesses. This finding holds after controlling for factors associated with operational efficiency and determinants of material weaknesses. The finding is also robust to various sensitivity checks such as using the Fama-Macbeth (1973) approach to estimate our regression by industry, using the Heckman (1979) two-stage procedure, using alternative measures of operational efficiency, and excluding firms in industries that have a small number of observations. To triangulate the main results, we also examine the impact of the remediation of material weaknesses on the change in operational efficiency. Consistent with the main results, we find that the remediation of material weaknesses is associated with an increase in operational efficiency in the future.

Next, we conduct two sets of cross-sectional analyses to corroborate our inferences on the link between internal control and operational efficiency. First, we expect material weaknesses to have a more adverse effect on operational efficiency when there is a greater demand for higher quality internal reports for decision making. Consistent with this prediction, we find that the negative effect of material weaknesses on operational efficiency is

[6] Consistent with Feng et al. (2015), we exclude non-accelerated filers from our sample because they are not subject to Section 404 (b) and are only subject to Section 404 (a) since 2007. See Section 3.1 for more details.
[7] According to Auditing Standards No. 5 (PCAOB 2007), a material weakness is "a deficiency, or a combination of deficiencies, in internal control over financial reporting, such that there is a reasonable possibility that a material misstatement of the company's annual or interim financial statements will not be prevented or detected on a timely basis."
[8] The DEA methodology has been used extensively in operations research and management accounting research to evaluate organizations' efficiency (see Callen 1991 for a review). For example, Murthi, Srinivasan, and Kalyanaram (1996) use DEA to measure marketing efficiency, and Leverty and Grace (2012) use DEA to measure the relative efficiency of insurance companies. DEA provides a specific measure of the overall firm-level operational efficiency that is based on the relation between inputs and outputs. See Section 3.2 for more details.

exacerbated for firms with higher earnings volatility and lower trading volume, our proxies for greater business environment uncertainty and poorer information environments. Second, we examine whether the association between internal control quality and operational efficiency varies with the severity of material weaknesses. Given that internal control material weaknesses adversely affect operational efficiency because of their impact on the internal information environment, the more severe the material weaknesses, the more pronounced the effect should be. Consistent with our prediction, we find that the negative effect of ineffective internal control on firm operational efficiency is stronger for (i) material weaknesses that have a more pervasive effect on internal reporting, that is, those related to information technology or the lack of personnel with adequate expertise, and (ii) material weaknesses related to core accounts that are more likely to lead to errors in the internal reports managers rely on to make operational decisions (e.g., sales, cost of goods sold, fixed assets, and accounts receivable).

Because smaller firms experience a disproportionate amount of costs for implementing SOX 404, it is important to understand whether the benefit of effective internal control is also disproportionately larger for these firms. For this purpose, we investigate whether the effect of internal control effectiveness on operational efficiency varies with firm size. We find some evidence that smaller firms benefit more from effective internal control in terms of operational efficiency. One possible explanation for this finding is that smaller firms have poorer information environments and hence are more likely to benefit from effective internal control for operational decision making.

Our study contributes to the literature in several important ways. While prior studies have shown that effective internal control mitigates information risk, our study extends this line of research by documenting that effective internal control can further improve firm operational efficiency. Our study hence adds to the emerging literature that examines the implications of internal control beyond financial reporting quality (e.g., Cheng et al. 2013; Feng et al. 2015; Bauer 2016). The evidence in this paper contributes to the ongoing debate on the costs and benefits of SOX 404 reporting. To the extent that greater operational efficiency leads to higher profitability (Greene and Segal 2004; Baik, Choi, and Farber 2013), the greater operational efficiency achieved through having effective internal control can help offset the compliance costs of SOX 404.

This study also contributes to the literature by examining the conditions under which effective internal control has a stronger effect on operational efficiency. We find that the effect is stronger when information is more important for managers' operational decisions, such as when business uncertainty is high or when the current information quality is poor. We also find that this effect is stronger for material weaknesses that have a more

pervasive effect on internal reporting, that is, those related to information technology or the lack of personnel with adequate expertise, and for material weaknesses in accounts that are more likely to impact the internal information managers use to make operational decisions (e.g., sales, cost of goods sold, fixed assets, and accounts receivable). These findings strengthen our argument that effective internal control leads to greater operational efficiency through its information effects and indicate that the effect of internal control on operational efficiency varies with the type of internal control material weaknesses. Lastly, our analysis of the differential effects of material weaknesses on operational efficiency by firm size sheds light on what types of firms potentially benefit more from effective internal control in terms of operational efficiency.

Our paper is closely related to, but extends Feng et al. (2015). Feng et al. document that firms with inventory-related material weaknesses have poorer inventory management (i.e., lower inventory turnover and higher inventory impairments). While they examine whether a specific type of material weaknesses in internal control adversely affects one aspect of firm operations, our study complements theirs by examining the link between all types of material weaknesses in internal control and an overall measure of operational efficiency.[9] Hence, our finding on the association between internal control and operational efficiency is more generalizable. Our study also extends Feng et al. by examining the types of weaknesses that have a greater impact on firm operational efficiency, that is, those that are deemed to be more pervasive and those related to core accounts. In addition, we provide a better understanding of which firms benefit more from having effective internal controls (e.g., smaller firms and those with poorer information environments).

The remainder of our paper proceeds as follows. The next section discusses the related literature and develops hypotheses. Section 3 describes the data and research methodology. Section 4 presents the primary and additional analyses. Section 5 concludes.

2. Related Literature and Hypothesis Development

The Sarbanes-Oxley Act of 2002 requires management to report, and auditors to certify, the effectiveness of

[9] In an untabulated analysis, we find that inventory-related material weaknesses are negatively, although insignificantly, associated with the overall operational efficiency, and that other types of material weaknesses are negatively and significantly associated with operational efficiency. In addition, we find that both the remediation of inventory-related material weaknesses and the remediation of other types of material weaknesses are positively and significantly associated with an increase in operational efficiency. These results suggest that the effect of material weaknesses on operational efficiency is not solely driven by inventory-related material weaknesses and that other types of material weaknesses are also important determinants of firm operational efficiency.

ICFR (SEC 2002, 2003). Regulators expect these requirements to enhance the reliability of financial reporting and improve firms' information environments. Consistent with the internal control requirements achieving these objectives, studies have documented that effective ICFR leads to better financial reporting quality (Doyle et al. 2007a; Ashbaugh-Skaife et al. 2008), a lower cost of equity (Beneish et al. 2008; Ashbaugh-Skaife et al. 2009), and a lower cost of debt (Dhaliwal et al. 2011; Kim et al. 2011). Studies have also examined the implications of internal control beyond financial reporting and find that effective ICFR results in greater management guidance accuracy (Feng et al. 2009).

Three recent studies document the impact of material weaknesses on individual corporate decisions. Cheng et al. (2013) find that material weaknesses lead to lower investment efficiency. Bauer (2016) finds that tax-related material weaknesses are associated with higher effective tax rates, suggesting that these material weaknesses reduce the effectiveness of firms' tax planning. Feng et al. (2015) investigate whether ineffective internal control over inventory affects inventory management. They argue that inventory-related material weaknesses in internal control can result in suboptimal order quantities, leading to higher inventory levels and higher holding costs. In addition, inaccurate inventory tracking and internal valuation processes can lead to inventory mismanagement and a diminution in value of obsolete inventory, resulting in greater inventory impairments. Consistent with their predictions, they find that firms with ineffective internal control over inventory experience lower inventory turnover and higher inventory impairments. Their study hence provides insights into how material weaknesses in internal control over inventory adversely affect inventory management.

In this study, we argue that ineffective internal control can have a negative effect on firm operational efficiency because it can result in erroneous internal management reports used for operational decisions. For example, material weaknesses related to information technology can impair a firm's ability to capture, process and record raw transactional data, resulting in errors in internal management reports. The lack of personnel with adequate expertise to generate timely information required by management can also result in incomplete or stale internal management reports (Feng et al. 2009).[10] Feng et al. (2009) argue that because the internal management

[10] To illustrate this point, Feng et al. (2009) provide the example of a material weakness disclosed by Dana Corp. in the 10-K for the fiscal year ending December 31, 2005. Dana Corp. disclosed that "Our financial and accounting organization was not adequate to support our financial accounting and reporting needs. Specifically, lines of communication between our operations and accounting and finance personnel were not adequate to raise issues to the appropriate level of accounting personnel and we did not maintain a sufficient complement of personnel with an appropriate level of accounting knowledge, experience and training in the application of GAAP commensurate with our financial reporting requirements. This control deficiency resulted in ineffective controls over the accurate and complete recording of certain customer contract pricing changes and asset sale

reports are critical to managers' day-to-day operational decisions, internal control effectiveness can affect not only management guidance but also other management decisions based on internal reports.

First of all, ineffective internal control can have negative implications for firm operational efficiency via its impact on sales forecast reports. Specifically, ineffective internal control over the recognition of revenue can adversely affect a firm's ability to forecast sales, which in turn can adversely affect managers' production decisions for the next period.[11] On the one hand, over-forecasting of sales can result in the overprovision of productive inputs and consequently increased costs in the form of inventory obsolescence, storage, idle capacity, redundant manpower, and wastage of resources. On the other hand, under-forecasting of sales can result in the under-provision of productive inputs that may eventually lead to increased costs in the form of last minute sourcing of potentially more expensive raw materials or rushed overtime work to produce the inventory. In both cases, inefficiency arises because higher input costs are incurred for a given amount of outputs.

Ineffective internal control can also adversely affect operational efficiency through the misstatement of operating expenses. To illustrate, companies assign direct material, direct labor, and manufacturing overhead to each unit of production to determine the unit cost. Managers then price each unit in a way that optimizes sales revenue. Ineffective internal control over the recognition of operating expenses (e.g., payroll, SG&A, depreciation expenses) can lead to inaccurate unit cost estimation and consequently sub-optimal pricing decisions. Specifically, if the unit cost is over-estimated, units may be priced too high and the firm can lose sales to its competitors. If the unit cost is under-estimated, units may be priced too low such that the firm has unnecessarily lower profit margin or even fails to cover the unit cost. In both cases, operational efficiency is reduced. For example, Foamex International Inc. disclosed in its 10-K filing for the fiscal year ending January 2, 2005 that "material weakness in our internal control over financial reporting related to our accounting for labor and overhead variances to our standard costs, which should be included in our work in process and finished goods inventories." This material weakness can lead to an under-estimation of the unit cost, resulting in sub-optimal pricing decisions and lower operational efficiency.

Besides affecting the estimation of the unit cost, inaccurate reporting of operating expenses can also adversely affect managers' ability to control operating costs, which ultimately leads to lower operational efficiency. For example, variance reports are regularly generated to identify instances where actual costs differ from the

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contracts (both within and outside of the Commercial Vehicle business unit) to ensure they were accounted for in accordance with GAAP."

[11] Consistent with this notion, Cassar and Gibson (2008) find that small privately held firms that have effective internal reporting and budgeting processes in place tend to make more accurate sales forecasts.

budgeted costs. When actual costs in direct material, direct labor, or manufacturing overhead exceed budgeted costs ("unfavorable variances"), managers can identify the cause of these variances and take corrective actions to reduce or eliminate them in a timely manner. However, under-reporting of operating costs, as in the case of the weaknesses disclosed by Foamex International Inc., could delay managers' actions to reduce or eliminate the unfavorable variances, resulting in poorer control of operating costs and lower operational efficiency.

In sum, ineffective internal control can result in lower operational efficiency by impairing the quality of internal reports and leading to suboptimal operational decisions. Thus, our first hypothesis (in alternative form) is as follows:

HYPOTHESIS 1. *There is a negative association between internal control material weaknesses and operational efficiency.*

Notwithstanding the above arguments, it is possible that we may not find results consistent with Hypothesis 1. Because the intended objective of SOX 404 is to improve the reliability of firms' *external* reports so as to enhance the decision making of external users (PCAOB 2004; Donaldson 2005), few, including managers, have envisaged the importance or potential benefits of ICFR for internal users. Consistent with this notion, based on a survey of 2,901 corporate insiders, Alexander et al. (2013) find that managers do not believe that SOX 404 can improve the efficiency of their firms' operations.

To investigate whether effective internal control leads to greater operational efficiency through its information effects, we exploit settings in which there is a greater demand for higher quality internal reports for decision making. We conjecture that for firms that operate in more uncertain business environments and/or in poorer information environments, managers can benefit more from accurate internal reports for budgeting, resource allocation, and capital investments. Consistent with this notion, Gallemore and Labro (2015) find that a higher quality internal information environment enhances tax decision making, resulting in greater tax avoidance. In addition, prior studies find that greater uncertainty creates a need for more information and hence the use of management accounting systems (e.g., Gordon and Narayanan 1984; Davila and Foster 2005). For example, Cassar and Gibson (2008) document a significant positive association between internal accounting report preparation and revenue forecast accuracy and this effect is driven mainly by firms with high information uncertainty. Our second hypothesis is thus as follows:

HYPOTHESIS 2. *The negative association between internal control material weaknesses and operational efficiency is stronger for firms with a greater demand for higher quality information for decision making than for other firms.*

Next, we examine whether the association between internal control quality and operational efficiency varies with the severity of material weaknesses. As discussed above, material weaknesses lead to a low quality internal information environment, which in turn reduces operational efficiency. It thus follows that the adverse effect of material weaknesses on operational efficiency should be stronger for the more severe type of weaknesses. Based on prior research, we argue that two types of material weaknesses are likely to have a more severe impact on operational efficiency: pervasive weaknesses and weaknesses in core accounts. First, as discussed earlier, material weaknesses related to information technology can impair a firm's ability to capture and process transactional data, and the lack of personnel with adequate expertise can lead to incomplete and untimely information needed by management. These weaknesses can result in systematic errors not only in external financial reports but also in the various internal reports that managers rely on to make operational decisions. Consequently, we expect that these types of material weaknesses (referred to as "pervasive weaknesses" for brevity) have a more adverse effect on operational efficiency.[12]

Second, material weaknesses affecting core accounts such as sales, cost of goods sold, accounts receivable, and inventory (referred to as "core accounts weaknesses" for brevity) are more likely to lead to errors in the internal reports that managers rely on to make operational decisions, compared with material weaknesses affecting other accounts such as shareholders' equity, financing, and stock-based compensation. For example, as discussed earlier, core accounts weaknesses in revenue recognition directly lead to erroneous sales forecasts and hence sub-optimal production decisions. Core accounts weaknesses in payroll, SG&A, depreciation, and other operating expenses not only affect the estimation of unit cost, which can lead to sub-optimal pricing decisions, but also impair managers' ability to detect unfavorable variances and control operating costs. Material weaknesses related to capital assets such as PPE can lead to inaccurate information about the firm's production capacity, and thus sub-optimal capital asset acquisition decisions. In sum, we expect core accounts weaknesses to have a more adverse effect on operational efficiency than non-core accounts weaknesses.

The above discussions lead to our third hypothesis:

[12] Consistent with the notion that material weaknesses related to information technology and the lack of accounting personnel with adequate expertise are indeed more pervasive than other types of material weaknesses, we find that firms with these material weaknesses have an average of 3.6 different account-specific material weaknesses. In contrast, other firms with internal control material weaknesses have an average of 2.2 different account-specific material weaknesses. The difference of 1.4 is statistically significant at the 1 percent level. This finding indicates that the information technology and accounting personnel related material weaknesses are indeed more pervasive. Note, however, that our classification of material weaknesses based on pervasiveness is not directly comparable to the company-level classification used in prior studies (e.g., Doyle et al. 2007a).

HYPOTHESIS 3. *The negative association between internal control material weaknesses and operational efficiency is stronger for firms with more severe material weaknesses than for other firms.*

3. Research design

Sample selection

Panel A of Table 1 summarizes the sample selection procedure. From *Audit Analytics*, we first identify a sample of 40,341 firm-year observations (6,936 unique firms) with a SOX 404 disclosure in the period 2004-13. Following Demerjian, Lev, and McVay (2012), we exclude firm-year observations that are from the financial and utilities industries because financial firms have unique asset structures and earnings generating processes, and utilities firms are subject to the regulation of the output price. We also exclude observations without data on operational efficiency. Next, we exclude observations with missing data on the other variables used in the analyses. Lastly, following Feng et al. (2015), we exclude non-accelerated filers from our sample. Non-accelerated firms – firms with public float below $75 million – likely under-report internal control material weaknesses because they are subject to less oversight (Ge, Koester, and McVay 2016). This under-reporting issue could potentially bias our results. The final sample consists of 24,462 firm-year observations from 4,300 unique firms.

[Insert Table 1 here]

Panel B of Table 1 shows the sample distribution of firm-year observations with ineffective ICFR over time. Over the period 2004 to 2013, 6.91 percent of the observations have ineffective ICFR. However, there is a declining trend in the proportion of firm-year observations with ineffective ICFR, dropping from 17.08 percent in 2004 to 4.52 percent in 2013.

Measuring operational efficiency

As mentioned earlier, we use DEA to construct a measure of firm operational efficiency (*EFFICIENCY*).[13] It measures operational efficiency by creating an efficient frontier of production based on an optimization program to maximize the ratio of outputs to inputs. This approach produces an ordinal ranking by measuring the relative efficiency of a firm compared to those firms located on the efficient frontier (i.e., the firms that produce the maximum level of outputs given the level of inputs or use the minimum level of inputs given the level of outputs). After solving an optimization program for each firm within an estimation group, the DEA analysis standardizes

[13] We obtain the DEA efficiency measure from Professor Peter Demerjian's website: http://faculty.washington.edu/pdemerj/data.html. We thank Prof. Demerjian for making this data available for research.

efficiency scores so that the most (least) efficient firms are assigned a value of one (zero).[14] The efficiency score for inefficient units can thus be interpreted as the distance from the frontier (Cooper, Seiford, and Tone 2000). The advantage of the DEA approach is that it is a nonparametric method and one does not need to impose a specific functional form for the relation between outputs and inputs or assign a priori factor weightings on inputs since the optimal weightings are derived from the data. See Cooper et al. (2000) for a more detailed discussion of the DEA approach and Demerjian et al. (2012) for the estimation process.

DEA has been widely used in operations and management accounting research to measure firm operational efficiency (e.g., Thore, Kozmetsky, and Phillips 1994; Barr and Siems 1997; Alam and Sickles 1998; Berk and Green 2004; Berk and Stanton 2007). For example, Thore et al. (1994) use the DEA measure to capture the intertemporal productive efficiency of U.S. computer manufacturers. Alam and Sickles (1998) use the DEA measure to examine how stock market returns are associated with the relative technical efficiency in the U.S. airline industry. Although these studies label the DEA efficiency measure somewhat differently (i.e., productive efficiency or technical efficiency), the underlying methodology to derive the efficiency score is the same.[15]

Because the efficiency measure is derived from the relation between inputs and outputs, the chosen inputs and outputs should adequately describe a firm's production function. Prior research uses sales revenue as the output variable because it is the primary source of earnings and cash flows generated from firms' operating activities (Verma 1993; Thore et al. 1994; Demerjian et al. 2012). Following Demerjian et al. (2012), we use seven input variables: (i) net property, plant and equipment (PP&E), (ii) cost of goods sold (COGS), and (iii) selling, general, and administrative costs (SG&A), (iv) capitalized operating leases, (v) capitalized research and development (R&D) costs, (vi) purchased goodwill, and (vii) other intangibles. These seven inputs largely capture managers' choices in the revenue generating process.

Panel A of Table 2 reports the mean *EFFICIENCY* and number of firms that are on the efficient frontier by

[14] Internal controls may be ineffective on an *absolute* basis, whereas our measure of operational efficiency based on the DEA approach is on a *relative* basis. However, if our argument that internal controls may be ineffective on an *absolute* basis is valid, there is no reason to believe that measuring operational efficiency on a *relative* basis would bias our results in favor of Hypothesis 1.

[15] Note that some prior studies use the DEA measure to capture managerial skills or talent (e.g., Murthi et al. 1996; Leverty and Grace 2012) because better managerial skills or talent can lead to higher firm operational efficiency. Our source data from Demerjian et al. (2012) provides a firm operational efficiency measure from which those authors parse a managerial ability measure. To the extent that the DEA measure proxies for something other than firm efficiency, our findings should be interpreted with caution.

year. The average efficiency score is 0.657.[16] While there is some year-to-year variation in the efficiency score over the sample period, the variation is relatively small.[17] We also examine the distribution of *EFFICIENCY* by industry (Fama and French (1997) industry classification).[18] As in previous studies (e.g., Demerjian et al. 2012), we observe a substantial variation in efficiency across industries (untabulated); the mean ranges from 0.301 to 0.948.[19] Hence, to control for the variation across industries, we use the standardized percentile rank of firm operational efficiency within industries.

[Insert Table 2 here]

Regression model

To test the relation between internal control effectiveness and firm operational efficiency, we estimate the following pooled Tobit regression:

$$EFFICIENCY_{it} = \alpha + \beta\ ICMW_{it} + \sigma\ EFFICIENCY\_CONTROLS_{it} + \theta\ LAG\_EFFICIENCY_{it} + Year\ Indicators + \varepsilon_{it} \quad (1)$$

where $EFFICIENCY_{it}$ refers to our measure of operational efficiency for firm *i* in year *t*, $ICMW_{it}$ is an indicator variable that equals one if firm *i* discloses internal control material weaknesses in year *t*, and zero otherwise. Hypothesis1 predicts that the coefficient on $ICMW_{it}$ is negative.

EFFICIENCY_CONTROLS refers to the determinants of operational efficiency. We follow Demerjian et al. (2012) in selecting the determinants of firm operational efficiency. First, larger firms and firms with higher market share are usually better in negotiating trade terms with their suppliers and customers. Hence, we control for the log of market value of equity (*LOG_MVE*) and the percentage of revenues earned by a firm within its Fama and French (1997) industry (*MKTSHARE*). Second, we control for free cash flow (*FCF*) because managers in firms with higher

[16] This average efficiency score is higher than that of 0.57 in Demerjian et al. (2012) because they use the data from a much longer period than our study, and hence are not directly comparable.

[17] The first-order autocorrelation of the DEA score is 0.87 (untabulated), comparable to that of 0.84 documented in Baik et al. (2013). To the extent that our DEA measure is sticky over time, it should bias against finding significant results. In Section 4.2, we conduct a remediation analysis to examine whether the remediation of material weaknesses is associated with the change in operational efficiency and obtain the same inferences.

[18] Demerjian et al. (2012) note that one limitation of using the Fama and French (1997) industries is that many firms operate in several different industries. Even within the same industry, the relation between accounting inputs and outputs can differ greatly depending on firms' asset and operation mix. We acknowledge that this estimation procedure does not allow us to control for differences in accounting policies among firms within the same industry. However, as argued in Demerjian et al. (2012), this limitation likely introduces noise to the operational efficiency measure, and we do not have a strong reason to believe that it will introduce systematic bias to our analyses.

[19] We also observe that the percentage of firms that are on or close to the efficient frontier varies across industries. For example, 17.6 percent (46.2 percent) of the firms have an efficiency score greater than or equal to 0.9 in 'Chemicals' ('Smoking') industry (untabulated). Prior studies suggest that such inter-industry variation could be due to the competitiveness of the industry and the number of observations available for the estimation of the efficiency frontier. In our sample, small industries generally have a higher concentration of firms on or close to the efficient frontier.

free cash flow are more effective in pursuing profitable projects. Third, we include firm age (*LOG_AGE*) because the life cycle of a firm can affect its opportunity set of possible projects and the required start-up costs of investments. Finally, operating in multiple industries and/or countries requires broader management skills and knowledge and limits managers' attention to any single industry, hence reducing their ability to efficiently allocate capital. We control for firm diversification using the Herfindahl index for business segment concentration (*CONCENTRATION*) and an indicator variable for foreign operations (*FOREIGN*). To mitigate the omitted correlated variable problem, we include the lagged efficiency variable *LAG_EFFICIENCY*, which is operational efficiency for firm *i* in year *t-1*. Appendix 1 presents detailed variable definitions. All *z*- and *t*-statistics are based on the standard errors adjusted for firm- and year-level clustering (Petersen 2009).

Descriptive statistics

Panel B of Table 2 presents the descriptive statistics on *EFFICIENCY* and firm characteristics for the full sample and Panel C reports descriptive statistics separately for firm-years with and without internal control material weaknesses. Note that we report the raw values of market value of equity and firm age in these panels but use the natural logarithm of these values in the correlation table and regression analyses. The mean *EFFICIENCY* is significantly lower for firm-years with internal control material weaknesses (0.572) than for those without material weaknesses (0.663). This result provides preliminary evidence on the negative association between internal control material weaknesses and operational efficiency. Among the determinants of operational efficiency, we find that firms with internal control material weaknesses are smaller, have lower market share, have lower free cash flow, and are younger.

Panel D of Table 2 presents correlations among firm operational efficiency, internal control material weaknesses, and control variables. As predicted, the correlation between *EFFICIENCY* and *ICMW* is significantly negative. Most of the control variables are significantly correlated with *EFFICIENCY*. An untabulated analysis of variance inflation factors suggests that our multivariate analyses are not subject to multicollinearity concerns.

4. Empirical results

Internal control material weaknesses and firm operational efficiency: Tests of Hypothesis 1 (H1)

Table 3 presents the pooled Tobit regression results on the association between internal control material weaknesses and firm operational efficiency. We find that the coefficient on *ICMW* is negative and significant (-

0.020 with *z*-statistic of -5.28). This result indicates that operational efficiency is lower for firm-years with ineffective internal control, consistent with H1. In terms of economic significance, the magnitude of the coefficient suggests that the operational efficiency of a firm with material weaknesses is on average about two percentile ranks lower than that of a firm without material weaknesses (e.g., 0.56 versus 0.58); note that the dependent variable is the standardized percentile rank of operational efficiency score within industries. The coefficients on control variables suggest that operational efficiency is higher for larger firms, firms with smaller market share, firms with more free cash flow, and younger firms.[20] The positive coefficient on *LAG_EFFICIENCY* suggests that operational efficiency in the current period predicts that in the following period.

[Insert Table 3 here]

To ensure the robustness of the results, we conduct a series of sensitivity tests and present the results in Table 4. The inferences based on these analyses remain the same. First, as an alternative approach to control for differences in operational efficiency across industries, we use the Fama and MacBeth (1973) approach to estimate our regression by industry. Column (1) presents the results based on the original, not the percentile ranks of, efficiency score.[21] Second, prior studies suggest that firms with material weaknesses systematically differ from those with effective internal control (e.g., Ashbaugh-Skaife, Collins, and Kinney 2007; Doyle, Ge, and McVay 2007b). Hence, we include the determinants of internal control effectiveness, measured in year t-1, to further control for their effect on operational efficiency and to address potential omitted correlated variable problems: (i) an indicator for losses, (ii) return on assets, (iii) the amount of inventory relative to total assets, (iv) firms involved in mergers and acquisitions or restructuring, (v) firms operating in a litigious industry, (vi) an indicator variable for rapid sales growth, and (vii) a Big 4 indicator. Column (2) reports the results. In untabulated analyses, we find that our results remain the same if we include these variables in the subsequent analyses. Third, it is possible that firms with lower operational efficiency have poorer financial performance (Baik et al. 2013), which in turn increases the likelihood of internal control material weaknesses (Ashbaugh-Skaife et al. 2007; Doyle et al. 2007b). To control for this reverse causality, we employ the Heckman (1979) two-stage procedure. In the first stage, we estimate a probit regression of

[20] Demerjian et al. (2012) document that operational efficiency is higher for older firms. When we replicate Table 2 of Demerjian et al. (2012) using their research design, we find that the signs of all the coefficients are consistent with those reported in Demerjian et al. (2012) and that the magnitudes of the coefficients are also comparable to those in Demerjian et al. (2012), except for firm age. The opposite results for firm age could arise from the difference in sample periods and/or the difference in the measurement of firm age. Nonetheless, when we exclude firm age from our regression models (untabulated), the inferences remain the same.

[21] The coefficient on *ICMW* is -0.013, suggesting that the efficiency score of firm-years with material weaknesses is on average 0.013 lower than that of firm-years with no material weaknesses. This value translates into a relative drop of 1.98 percent based on a mean efficiency score of 0.657 for the full sample (Table 2 Panel B).

the likelihood of having an *ICMW* using the full set of internal control determinants.[22] From this regression, we calculate the inverse Mills ratio *LAMBDA* and include it in Equation (1). Column (3) reports the results.

Fourth, when a firm invests in R&D, the operational efficiency decreases in the current year but it increases in the future years because of the accounting treatment for R&D expenditures (i.e., expensing the current year's R&D). Hence, there could be a trade-off between the operational efficiency of the current year and the operational efficiency of the future years. To mitigate this concern, we re-estimate operational efficiency without the R&D input variable. Column (4) reports the results. Fifth, we use an alternative measure of operational efficiency derived from the Stochastic Frontier Analysis (SFA), which is a parametric approach to model the relation between outputs and inputs.[23] We use the same seven inputs as used in the DEA approach and estimate a SFA model for each industry group. See Coelli, Rao, O'Donnell, and Battese (2005) and Baik et al. (2013) for the details of the SFA approach. Column (5) presents the results. Sixth, to mitigate the concern that small industries have higher DEA scores on average, we present in Column (6) the results after excluding firms in the industries that have fewer than 100 firm-year observations. In sum, our results are robust to a battery of sensitivity analyses.

Overall, consistent with H1, we document a negative association between internal control material weaknesses and firm operational efficiency.

[Insert Table 4 here]

Remediation of internal control material weaknesses: Alternative tests of H1

As an alternative test of H1, we next conduct a remediation analysis to provide further evidence on the link between internal control effectiveness and operational efficiency. The advantage of such an analysis is that it uses the same firm as its own control and thus mitigates the omitted correlated variable concern by controlling for time-invariant firm characteristics. Specifically, we examine whether the remediation of material weaknesses is associated with the change in operational efficiency using the following OLS regressions:

[22] The untabulated first-stage probit regression includes the following explanatory variables: *LOG_MVE*, *MKTSHARE, Log_AGE*, *FOREIGN*, *CONCENTRATION*, *LAG_LOSS*, *LAG_INVENTORY*, *LAG_MERGER*, *LAG_RESTRUCTURE, LAG_LITIGATION*, *LAG_GROWTH*, and *LAG_BIG4*. We also include year and industry fixed effects. Please see the note to Table 4 for variable definitions. Note that the last seven variables are not included in the second-stage regression; among them, *LAG_RESTRUCTURE*, *LAG_GROWTH*, and *LAG_BIG4* are significant in the first-stage regression, but they are not significantly correlated with operational efficiency, as shown in Column (2) of Table 4. Hence, the exclusion restriction requirement is satisfied. The pseudo R^2 for the first-stage probit regression is 12.5%.

[23] The advantage of using a parametric method such as the SFA is to allow random shocks in the production process in measuring efficiency. However, unlike DEA, to use the SFA model, one has to specify a specific functional form for the relationship between inputs and outputs and make certain distributional assumption for the random error term, which could be arbitrary (e.g., Stone 2002).

$$\Delta EFFICIENCY_{it} = \alpha + \gamma\ REMEDIATION_{it} + \sigma\ \Delta EFFICIENCY\_CONTROLS_{it} + \theta\ \Delta LAG\_EFFICIENCY_{it} + \varepsilon_{it} \quad (2)$$

where *ΔEFFICIENCY* refers to the change in operational efficiency from year *t* to *t*+2,[24] *REMEDIATION* is an indicator variable that equals 1 if the firm reports material weaknesses in year *t* but reports no material weaknesses in year *t*+1 (i.e., the firm remediates its material weaknesses), *ΔEFFICIENCY_CONTROLS* refers to the change in the determinants of operational efficiency from year *t* to *t*+2, and *ΔLAG_EFFICIENCY* refers to the change in operational efficiency from year *t*-1 to *t*+1. A similar research design is used in Feng et al. (2015). Unlike the tests in the previous section, for the remediation tests, we restrict the sample to the 915 unique firms that report at least one material weakness in 2004-2013 (i.e., 4,472 firm-year observations). Including the firms that do not report any material weaknesses in the sample period likely leads to inflated *t*-statistics; however, we obtain the same inference if we include these firms (not tabulated).

Table 5 presents the regression results. We find that the coefficient on *REMEDIATION* is significantly positive (*t*-statistic = 3.48), indicating that the remediation of internal control material weaknesses is associated with an increase in operational efficiency.[25] The results on the control variables are largely consistent with those reported in Table 3.

[Insert Table 5 here]

In an untabulated analysis, we re-estimate Equations (2) by replacing *REMEDIATION* with *ΔICMW*, the change in the internal control material weakness indicator from year *t* to *t+1*. We find that the coefficient on *ΔICMW* is significantly negative (*t*-statistic = -3.91), implying that the change in the internal control material weaknesses indicator is negatively associated with the change in operational efficiency, further confirming the inferences based on Table 3.

Overall, the results from the remediation analysis are consistent with the main results, providing further support for H1 on the negative association between ineffective internal control and operational efficiency.

Cross-sectional analyses – the importance of internal information: Tests of Hypothesis 2 (H2)

We use the following two regression models to test whether the association between internal control effectiveness and operational efficiency is stronger when there is a greater demand for higher quality internal reports

[24] The results (untabulated) are qualitatively similar when we use a shorter interval, that is, the change in operational efficiency from year *t* to *t*+1.
[25] We also conduct similar sensitivity tests for the remediation analysis as those reported in Table 4, except for the Heckman two-stage procedure. The inferences are the same.

for decision making:

$$EFFICIENCY_{it} = \alpha + \beta\ ICMW_{it} + \lambda\ ICMW_{it} \times Information_{it} + \delta\ Information_{it} + \sigma\ EFFICIENCY\_CONTROLAS_{it} + \theta\ LAG\_EFFICIENCY_{it} + \varepsilon_{it}, \quad (3')$$

$$\Delta EFFICIENCY_{it} = \alpha + \gamma\ REMEDIATION_{it} + \lambda\ REMEDIATION_{it} \times Information_{it} + \delta\ Information_{it} + \sigma\ \Delta EFFICIENCY\_CONTROLAS_{it} + \theta\ \Delta LAG\_EFFICIENCY_{it} + \varepsilon_{it}, \quad (3'')$$

where *Information* refers to proxies for the demand for higher quality internal reports for decision making, and all other variables are defined as before. We use both the level regression and the remediation regression to ensure that the results are robust.

We use two proxies to capture the business environment uncertainty and the quality of the firm's information environment, and hence the demand for high quality internal reports for decision making. Firms that operate in a highly uncertain business environment likely face more uncertain business conditions, resulting in greater volatility in their earnings.[26] Hence, our first proxy is the return on asset volatility (*STDROA*), measured as the standard deviation of income before extraordinary items divided by total assets in the past five years. Our second proxy is trading volume, which has been used as a proxy for information uncertainty and asymmetry (Leuz and Verrecchia 2000; Lo, Mamaysky, and Wang 2004). Trading volume (*VOLUME*) is measured as the median daily dollar volume during the fiscal year. For ease of presentation, we construct two indicator variables based on these variables to capture the greater demand for high quality internal reports. For return on asset volatility (trading volume), we construct an indicator variable, *STDROA_H* (*VOLUME_L*), that equals one for firms belonging to the top (bottom) quartile of the sample distribution within the industry, and zero otherwise. H2 predicts that the coefficient on the interaction variable is negative in Equation (3'), but positive in Equation (3").

Panels A and B of Table 6 report the regression results from estimating Equations (3') and (3"), respectively. In Panel A, we find that the coefficients on *ICMW* × *STDROA_H* and *ICMW* × *VOLUME_L* are significantly negative (*z*-statistic = -2.74 and -1.63, respectively) when they are included in the regression separately. We obtain quantitatively similar results when we include them in the regression at the same time. In Panel B, we find that the coefficient on *REMEDIATION* × *VOLUME_L* is significantly positive (*t*-statistic = 2.58). The coefficient on

[26] In addition, material weaknesses can adversely affect firms' estimation of accruals and hence earnings. For example, inventory counting and pricing errors can lead to misreporting of inventory on hand and related cost of goods sold, the lack of specific policies (or employee discretion) for revenue recognition can lead to variation in revenue recognition, and an inadequate basis for accounting estimates can lead to inaccurate recording of allowance for inventory obsolescence (Doyle et al. 2007a; Ashbaugh et al. 2008). Hence, we use return on assets volatility instead of operating cash flow volatility, in the tests. We obtain qualitatively similar, albeit weaker, results when using operating cash flow volatility.

REMEDIATION × *STDROA_H* is positive but statistically insignificant. The results are the same when we include the two interaction terms in the same regression.[27]

[Insert Table 6 here]

Taken together, these results indicate that the negative effect of internal control material weaknesses on operational efficiency, or the positive effect of remediation of material weaknesses on the improvement in operational efficiency, is more pronounced for firms with higher earnings volatility and lower trading volume. To the extent that these proxies capture firms with more uncertain business environments and poorer information environments, these results are consistent with H2 that internal control material weaknesses have a more adverse impact on operational efficiency when managers have a greater demand for higher quality information for decision making.

Cross-sectional analyses – the severity of material weaknesses: Tests of Hypothesis 3 (H3)

To test H3, we classify firms as having severe material weaknesses based on the taxonomy list in Audit Analytics. Specifically, we classify the following as weaknesses with a pervasive effect on internal reporting: information technology, software, security & access issue (Audit Analytics Reason Key #22) and accounting personnel resources, competency/training issues (Reason Key #44).[28] We discuss above why these two types of weaknesses can have pervasive effects. We classify the following as core accounts weaknesses: revenue recognition issues (Reason Key #39), expense recording (payroll, SG&A) issues (Reason Key #29), liabilities, payables, reserves and accrual estimation failures (Reason Key #33), inventory, vendor and cost of sales issues (Reason Key #32), depreciation, depletion or amortization issues (Reason Key #28), PPE, intangible or fixed asset

[27] In an untabulated analysis, we also use analyst coverage as an alternative proxy because prior studies find that analyst coverage is positively associated with the quality of a firm's information environment (e.g., Lang and Lundholm 1996; Ayers and Freeman 2003; Frankel and Li 2004). The inferences are the same as those based on trading volume. We do not tabulate the results on analyst coverage because it is highly correlated with trading volume.

[28] We find that some of the material weaknesses related to accounting personnel resources, competency/training issues are confined to a specific area/account of the firm (e.g., tax, non-routine transactions such as derivatives, hedging, and merger and acquisition, and staff issues at a subsidiary company), which are unlikely to have a pervasive effect on internal reports. Hence, we read the disclosures of *all* the material weaknesses with Reason Key #44 and only include in our classification of pervasive weaknesses the cases that we deem pervasive. The following is an example of the accounting personnel material weaknesses that we consider to be pervasive and affect several accounts, as disclosed in Aspen Technology, Inc.'s annual report for the year ending 30 June 2005: "We did not have (a) a sufficient number of experienced personnel in our accounting and finance organization to provide reasonable assurance that transactions were being recorded as necessary to permit preparation of financial statements in accordance with generally accepted accounting principles and (b) training of and communication to employees regarding their duties and control responsibilities within the accounting and finance organization was inadequate to ensure that process and control activities were being carried out appropriately. These are considered to be deficiencies in the operation of entity-level controls and the ineffectiveness of such controls can have the effect of either increasing or decreasing assets, liabilities, revenue and expenses." In addition, Aspen Technology Inc. also disclosed material weaknesses related to revenue recognition, accounts receivable, capitalization of expenditures, tax, and bank accounts, which may indicate the pervasive nature of this accounting personnel material weakness.

(value/diminution) issues (Reason Key #16), capitalization of expenditure issues (Reason Key #14), lease, FAS 5, legal, contingency & commit issues (Reason Key #3), lease, leasehold & FAS 13 (98) issues (Reason Key #73), accounts/loans receivable, investments and cash issues (Reason Key #15), and tax issues (Reason Key #41). In Appendix 2, we discuss in detail how each type of core accounts weaknesses can lead to sub-optimal operational decisions, thereby resulting in lower operational efficiency.

Panel A of Table 7 provides the number of firm-year observations with each type of weaknesses. Specifically, 36.1 percent of the firm-years contain at least one pervasive weakness, 81.6 percent of the firm-years contain at least one core accounts weakness, and 30.2 percent of the firm-years contain both pervasive and core accounts weaknesses.

[Insert Table 7 here]

Based on the above classifications, we construct three indicator variables, *Pervasive*, *Core Accounts*, and *Both*, which are coded as one if the firm discloses at least one pervasive weakness, at least one core accounts weakness, and at least one pervasive *and* one core accounts weakness, respectively, during our sample period, and zero otherwise.

To test H3, we replace *ICMW* in Equation (1) with *ICMW_Severe* and *ICMW_Non Severe*, where *ICMW_Severe* is either *Pervasive*, *Core Accounts*, or *Both*, and *ICMW_Non Severe* is one when *ICMW* is one and *ICMW_Severe* is zero. *ICMW_Severe* and *ICMW_Non Severe* are coded as zero for firm-years without any internal control material weaknesses.

Panel B of Table 7 presents the results based on the level regression. Column (1) reports the results when *ICMW_Severe* is defined as *Pervasive*. We find that the coefficients on both *ICMW_Severe* and *ICMW_Non Severe* are significantly negative (*z*-statistic = -8.25 and -3.41, respectively). However, an F-test suggests that the coefficient on *ICMW_Severe* is significantly more negative than that on *ICMW_Non Severe* (Chi-square = 3.62), indicating that the negative effect of material weaknesses on operational efficiency is stronger for firms with pervasive weaknesses than for firm with other types of weaknesses. Column (2) reports the results when *ICMW_Severe* is defined as *Core Accounts*. We find that the coefficients on both *ICMW_Severe* and *ICMW_Non Severe* are significantly negative (*z*-statistic = -6.49 and -1.69, respectively). The F-test shows that the coefficient on *ICMW_Severe* is significantly more negative than that on *ICMW_Non Severe* (Chi-square = 1.92), indicating that the negative effect of material weaknesses on operational efficiency is stronger for firms with core accounts weaknesses

than for firm with other types of weaknesses. Finally, Column (3) reports the results when *ICMW_Severe* is defined as *Both*. We find that the coefficients on both *ICMW_Severe* and *ICMW_Non Severe* are significantly negative (*z*-statistic = -5.89 and -3.30, respectively), and the F-test indicates that the coefficient on *ICMW_Severe* is significantly more negative than that on *ICMW_Non Severe* (Chi-square = 1.86).

We then test H3 by replacing *REMEDIATION* in Equation (2) with *REMEDIATION-Severe,* which is an indicator variable that equals 1 if the firm reports a more severe type of material weaknesses in year *t* but reports no material weaknesses of that type in year *t*+1, and *Severe* is either *Pervasive*, *Core Accounts*, or *Both*. Panel C of Table 7 presents the results, which are qualitatively similar to those in Panel B except for the results for core accounts weaknesses. In Column (1), we find that while both the remediation of pervasive and non-pervasive material weaknesses results in improvement in operational efficiency, the effect of the remediation of pervasive material weaknesses is greater than that of non-pervasive material weaknesses. In Column (2), only the remediation of core accounts material weaknesses has a positive effect on operational efficiency, and the F-test indicates that the coefficients on *REMEDIATION-Severe* and *REMEDIATION-Non Severe* are not significantly different from each other. In Column (3), the effect of the remediation of both pervasive and core accounts material weaknesses on operational efficiency is significantly greater than that of the remediation of other weaknesses.

Taken together, these results are consistent with H3 that the negative effect of material weaknesses on operational efficiency is stronger for firms with the more severe type of weaknesses, that is, the more pervasive ones or the weaknesses related to core accounts that are more likely to affect internal reports used for operational decisions.

Analysis of the effect of internal control on operational efficiency by firm size

As mentioned in the introduction, smaller firms experience a disproportionate amount of costs for implementing SOX 404. However, there is limited research on whether these firms benefit from SOX 404 differently from other firms. Because small firms have poorer information environments (e.g., Lang and Lundholm 1993), they are likely to benefit more from effective internal control in the form of higher quality reports for decision making.[29] Hence, we examine whether smaller firms disproportionately benefit from having effective

[29] On the other hand, smaller firms have less complex product lines, and/or higher geographic concentrations in operations. The more centralized management oversight of the business and management's hands-on involvement in operations may reveal significant variances and inaccuracies in operating data (e.g., sales volume, the price of raw materials), reducing the need for more formal control procedures (COSO 2005). To the extent that smaller firms have lower demand for effective ICFR in terms of managerial decision making, they may not benefit more from effective internal control in terms of operational efficiency.

internal control in terms of operational efficiency.

For this purpose, we estimate Equation (1) after adding the interaction of *ICMW* with *R10_MVE*, which is the standardized inverse decile rank within the industry (i.e., observations in the bottom decile taking the value of one and observations in the top decile taking the value of zero) of the firm's market capitalization at the end of the second quarter in the year of SOX 404 disclosure (Gao, Wu, and Zimmerman 2009). We use the standardized decile ranks to facilitate result interpretation and to mitigate the effect of extreme values. To be consistent, we replace *LOG_MVE* in Equation (1) with *R10_MVE*. The coefficient on the interaction term, *ICMW* × *R10_MVE,* captures the variation of the effect of internal control material weaknesses by firm size. Table 8, Panel A reports the regression results. The coefficient on *ICMW* × *R10_MVE* is significantly negative (*z*-statistic = -1.91). This finding suggests that the adverse effect of material weakness on operational efficiency is particularly severe for small firms.

[Insert Table 8 here]

Next, we replicate the above results using a modified version of the remediation model in Equation (2) and present the results in Table 8, Panel B. We find that the coefficient on *Remediation* × *R10_MVE* is positive and statistically significant (*t*-statistic = 1.65). Hence, this result suggests that the remediation of material weaknesses is associated with a greater improvement in operational efficiency for smaller firms.

Overall, our findings provide some evidence that compared to other firms, smaller firms benefit more from effective internal control in terms of operational efficiency. The greater benefit for smaller firms likely arises because they are subject to more information problems. Our analysis of the differential effects of material weaknesses on operational efficiency by firm size sheds light on what types of firms potentially benefit more from effective internal control in terms of operational efficiency. Note that we are documenting the impact of effective internal control on operational efficiency and the evidence does not speak to its net benefit, which is also a function of other benefits of having effective internal control, such as higher financial reporting quality and lower cost of capital, and the cost of maintaining effective internal control.

5. Conclusion

In this paper, we examine whether internal control effectiveness affects firm operational efficiency. Using a sample of accelerated filers that reported internal control opinions under SOX 404 during the period 2004-2013 and frontier analysis to measure operational efficiency, we find that operational efficiency is significantly lower for the

firms that disclose material weaknesses in internal control than for other firms. This finding holds after controlling for factors associated with operational efficiency. The result is robust to a battery of sensitivity checks.

We conduct three sets of cross-sectional analyses to provide additional insights. First, we find that the negative effect of material weaknesses on operational efficiency is exacerbated for firms where managers' demand for high quality internal information for decision making is more salient, proxied for by high ROA volatility and low trading volume. Second, we find that the negative effect of internal control on firm operational efficiency is stronger for firms with more severe internal control material weaknesses: (1) material weaknesses related to information technology and accounting personnel with adequate expertise, and (ii) material weaknesses related to core accounts (e.g., sales, cost of goods sold, fixed assets), which are more likely to have a pervasive effect and lead to errors in the internal reports that managers rely on to make operational decisions. Finally, we find some evidence that the effect of internal control material weakness on firm operational efficiency varies with firm size, with smaller firms benefitting more from effective internal controls in terms of firm operational efficiency than other firms.

Overall, our study documents that effective internal control not only helps external market participants make more informed decision, as documented in prior research, but also enhances firms' internal operations. This finding extends the emerging literature that examines the implications of internal control beyond financial reporting (e.g., Cheng et al. 2013; Feng et al. 2015; Bauer 2016). It also informs the debate on the costs and benefits of SOX 404 reporting, which is relevant and timely given that regulators have recently granted non-accelerated filers permanent exemption from SOX 404 (b) under the Dodd-Frank Act on grounds of high compliance costs. One implication of our study is that the greater operational efficiency achieved from having effective internal control can partially offset the compliance costs of SOX 404.

Appendix 1

Variable definitions

Variable	Definition
EFFICIENCY	A continuous variable of firm efficiency, ranging from 0 to 1, for fiscal year t based on the Data Envelopment Analysis (DEA). We obtain the data on firm efficiency from Professor Peter Demerjian's website (http://faculty.washington.edu/pdemerj/data.html). Demerjian et al. (2012) estimate firm operational efficiency by using one output of revenue (SALE) and seven inputs: net PP&E (PPENT), cost of goods sold (COGS), selling, general, and administrative expenses (XSGA), capitalized operating leases (MRC1 – MRC5), capitalized research and development (R&D) costs (XRD), purchased goodwill (GDWL), and other intangibles (INTAN minus GDWL). For our regression analysis, we use the standardized percentile rank of firm operational efficiency within the industry to control for the variation across industries;
ICMW	An indicator variable for ineffective internal control that takes a value of one if a firm reports a material weakness in internal control over financial reporting for fiscal year t, and zero otherwise;
LOG_MVE	The natural logarithm of market value of equity (PRCC_F×CSHO);
MKTSHARE	The percentage of revenue (SALE) earned by a firm within its Fama and French (1997) industry for fiscal year t;
FCF	An indicator variable that equals one if a firm's free cash flow is not negative, and zero otherwise; free cash flow is measured as earnings before depreciation and amortization (OIBDP) minus the change in working capital (RECT + INVT + ACO – LCO – AP) and capital expenditure (CAPX);
LOG_AGE	The natural logarithm of one plus the number of years a firm has appeared in the Compustat database at the end of fiscal year t;
CONCENTRATION	The Herfindahl index for business segment concentration, measured as the square of the ratio of individual business segments sales to total sales, summed across all business segments for fiscal year t;
FOREIGN	An indicator variable that equals one if a firm reports a non-zero value for foreign currency adjustment (FCA) in fiscal year t, and zero otherwise;
LAG_EFFICIENCY	Lagged value of *EFFICIENCY*;
STDROA	Standard deviation of return on assets (ROA) in the last five years, where ROA is calculated as income before extraordinary items (IB) divided by average total assets (AT);
VOLUME	Trading volume for fiscal year t, measured as the median daily trading volume over the fiscal year t.

Appendix 2

Core accounts material weaknesses and sub-optimal operational decisions

Panel A: Internal information and key operational decisions

1. *Sales forecast and production decisions*. Managers rely on sales forecast reports to make production decisions such as the purchase of raw materials, scheduling of manpower, and processing of inventory. Inaccurate sales forecasts can lead to sub-optimal production decisions, which can then increase costs in the form of inventory obsolescence, extra storage, idle capacity, redundant manpower, and wastage of resources.

2. *Unit cost and pricing decisions*. In determining the unit cost, companies assign direct material, direct labor, and manufacturing overhead to each unit of production. Managers then price each unit in a way that maximizes revenue. Inaccurate unit cost information can lead to sub-optimal pricing decisions.

3. *Operating cost and cost control decisions*. Variance reports are generated to help managers identify instances where actual costs are above the planned costs ("unfavorable variance"). By detecting unfavorable variances promptly, managers are able to take corrective action to eliminate the unfavorable variances, resulting in more effective control of operating costs. Conversely, under-reporting of actual costs can lead to a delay in the detection of unfavorable variances and consequently poor control of operating costs.

4. *Asset value and asset acquisition/depletion decisions*. As a company depletes its capital assets (e.g., PPE, intangible assets), it must re-invest to sustain its ability to generate revenue. Accurate information of production capacity of capital assets allows managers to make optimal capital asset acquisition decisions. On the other hand, overinvestment in capital assets can lead to idle capacity, while underinvestment can hurt the company's production capacity and future sales.

5. *Customer credit worthiness and sales/pricing decisions*. Managers make decisions on whether to grant credit to customers after assessing the credit worthiness of customers. Overestimating the credit worthiness of customers can result in longer payment periods and higher bad debt expense. Underestimating the credit worthiness of customers may lead managers to forego selling to these customers or implementing overly strict credit terms and stifling sales. In both cases, the company fails to achieve the optimal sales level.

6. *Tax expenses and tax planning.* Taxes make up a substantial part of a firm's operating expenses. Hence, managers make important tax decisions to reduce tax expenses or taxes paid to the authorities. Ineffective tax planning can result in higher operating expenses.

Panel B: Core accounts material weaknesses and suboptimal operational decisions

Core accounts material weaknesses	**Example of material weaknesses from companies' disclosures**	**Impact on operational decisions** (The number in parentheses refers to the operational decisions in Panel A.)
Revenue recognition issues (Reason Key #39)	The Company did not maintain appropriate internal controls related to the recognition of revenue for the sale of games, systems and parts. The Company's controls were not adequate to capture and analyze the terms and conditions of all contracts and agreements to ensure the proper recording of revenue related to game and system sales. The internal controls include those related to the systematic tracking of contract terms and amendments. …The review process is manual and the resources dedicated to the process are not adequate to address all of the accounting considerations on a timely basis given the increased volume of business. (Bally Technologies, Inc. 10-K, 30 June, 2007)	The material weaknesses can lead to erroneous sales forecasts and consequently sub-optimal production decisions (#1). Erroneous sales forecasts can also lead to the wrong planning decisions for capital asset acquisitions (#4).
Expense recording (payroll, SG&A) issues (Reason Key #29)	In the course of preparing its consolidated financial statements, the Company employed numerous spreadsheets and database programs ("User Developed Applications"). The User Developed Applications are utilized in calculating estimates, reconciling payroll hours, tracking inventory costs and making cost allocations, among other things. …. The Company determined that deficiencies surrounding their payroll process, in particular, adequacy of personnel involved in the process, lack of proper documentation concerning hours worked or rate changes coupled with deficiencies with reconciliations where payroll data was a major component constituted a material weakness in their system of internal controls. (Key Energy Services, Inc.,10-K, 31 December, 2007)	The material weaknesses can result in the mis-statement of operating costs such as direct materials, labor, or manufacturing overhead. This can lead to the wrong estimation of unit cost, and consequently sub-optimal pricing decisions (#2). The under-recording of the operating costs can also result in the under-reporting of unfavorable variances, preventing managers from taking prompt actions to cut operating costs (#3).
Liabilities, payables, reserves and accrual estimation failures (Reason Key #33)	The Company's lack of effective controls did not prevent or detect the inappropriate override of established procedures to adjust workers' compensation liabilities to amounts determined by independent actuaries. Errors in timing of incentive compensation accruals resulted from inadvertent misapplication of GAAP as well as lack of effective controls which permitted override of established procedures. In addition, the Company identified improper and unsupported journal entries to the general ledger that resulted in the misstatement of certain accrued expense accounts and related operating and administrative expenses. This material weakness resulted in errors in certain accrued expenses and related operating and administrative expenses, including workers' compensation liabilities and incentive compensation costs (CSK Auto Corporation, 10-K, 29 January, 2006)	The material weaknesses can result in a misstatement of operating costs and hence unit cost, leading to sub-optimal pricing decisions (#2). In addition, the under-recording of the operating costs can result in the under-reporting of unfavorable variances (#3).
Inventory, vendor and	The Company did not maintain effective controls over the completeness,	Material weaknesses in inventory purchase, tracking,

cost of sales issues (Reason Key #32)	accuracy, valuation and existence of its inventory and related cost of sales accounts. Specifically, the Company's controls with respect to the accuracy of product costing, job order closeout, accounting for cost accumulation on long-term contracts and certain inventory management processes, including obsolete and slow-moving inventory identification, lower-of-cost-or-market and LIFO inventory valuation were not effective. Also, the Company did not maintain effective controls over the accurate and timely recording of inventory receipts and shipments. Furthermore, the Company did not maintain effective controls over the accuracy and completeness of periodic physical counts of inventory quantities. (Flowserve Corporation, 10-K, 31 December, 2004)	and valuation can increase the likelihood of a mismatch between inventory supply and demand, leading to sub-optimal production decisions (#1, Feng et al. 2015). In addition, the material weaknesses can lead to the In addition, the material weaknesses can lead to the misstatement of unit cost and hence sub-optimal pricing decisions (#2).
Depreciation, depletion or amortization issues (Reason Key #28)	The Company did not maintain effective controls over the completeness and accuracy of depreciation expense and accumulated depreciation. Specifically, the Company lacked effective controls to ensure the: (i) application of the appropriate useful lives for certain asset groups when calculating depreciation expense and (ii) timely preparation and review of account reconciliations and analyses, and manual journal entries related to the determination of depreciation expense and accumulated depreciation for the paging infrastructure assets. (USA Mobility, Inc., 10-K, 31 December, 2004)	The incorrect recording of depreciation expenses of the capital assets used for production can lead to wrong estimation of overhead expenses and hence unit cost, resulting in sub-optimal pricing decisions (#2). In addition, to the extent that the material weakness results in the under-recording of depreciation expenses of capital assets used for production, unfavorable overhead variances could be under-reported (#3).
PPE, intangible or fixed asset (value/diminution) issues (Reason Key #16)	The Company did not maintain effective controls over the valuation and accuracy of long lived assets and goodwill. Specifically, the Company did not maintain effective controls to identify the deterioration in fourth quarter operating results as a condition that triggered a requirement to assess long-lived assets for impairment. Also, certain plants did not maintain effective controls to identify impairment of idle assets in a timely manner (Dana Corporation, 10-K, 31 December, 2005).	Failure to recognize the impairment/write-off can lead to the wrong assessment of the productive capacity of the capital assets, resulting in sub-optimal capital assets acquisition decisions (#4). Incorrect recognition of the impairment/write-down of capital assets can also misstate depreciation expense and hence unit cost, leading to sub-optimal pricing decisions (#2).
Capitalization of expenditure issues (Reason Key #14)	The Company did not have internally developed software capitalization guidelines consistent with U.S. GAAP; lacked personnel with sufficient expertise in software capitalization rules pursuant to U.S. GAAP; did not adequately train employees, such as financial analysts and project managers, who performed these accounting functions; failed to document sufficient support for the historical capitalization of certain software development costs and for the commencement of amortization related to such costs; and	R&D expenditures that are capitalized (expensed off) are treated as product costs (period costs) and are (are not) allocated to unit costs. Hence, when the company erroneously capitalizes R&D expenditure, amortization expenses will be allocated to unit cost, resulting in the overstatement of unit cost and sub-optimal pricing decisions (#2).

	preventive and detective controls related to the capitalization of internally developed software were insufficient (Ceridian Corp. 10-K, 31 December, 2004)	
Lease, FAS 5, legal, contingency & commit issues (Reason Key #3) Lease, leasehold & FAS 13 (98) issues (Reason Key #73)	The Company did not maintain effective controls over the complete and accurate recording of leases. Specifically, effective controls were not designed and in place to evaluate and accurately record lease expense on a straight line basis for leases with rent escalation clauses and rent holidays, and the amortization expense over the remaining lease term for leasehold improvements, in conformity with generally accepted accounting principles affecting the following accounts: property, plant and equipment, deferred liabilities, rent expense, depreciation expense and related disclosures. This control deficiency resulted in the restatement of the Company's interim and annual consolidated financial statements for 2002 and 2003, the first, second and third quarter financial statements for 2004 as well as audit adjustments to the 2004 financial statements. (Sirva, Inc. 10-K, 31, December, 2014)	The erroneous accounting for rent escalation clauses and rent holidays can lead to incorrect recording of rent expenses, resulting in a wrong estimation of unit cost and sub-optimal pricing decision (#2). The under-recording of rent expenses in the early part of the lease period can also lead to the under-reporting of unfavorable variances (#3). In addition, the erroneous accounting for the amortization expense over the remaining lease term for leasehold improvements (e.g., by expensing the cost of leasehold improvements over the longer estimated useful lives of the properties) can lead to the misreporting of depreciation expenses and hence unit cost (#2).
Accounts/loans receivable, investments and cash issues (Reason Key #15)	The Company's controls over the procedures for consideration of creditworthiness or the assessment as to whether billings are collectible were not designed effectively to meet the Company's revenue recognition policy in accordance with generally accepted accounting principles…Effective controls were not designed to ensure that an appropriate analysis of receivables from customers was conducted, reviewed, approved and documented in order to reasonably estimate the allowance for doubtful accounts (On2 Technologies, Inc.10-K, 31 December, 2007)	Inaccurate assessment of customers' creditworthiness can lead to sub-optimal sales decisions (#5).
Tax issues (Reason Key #41)	The Company identified a material weakness related to the design effectiveness of internal controls over income taxes. The CFO does not review journal entries to record income tax expense and related liabilities, as well as supporting schedules prepared by the Company's outside tax firm which include an analysis of current and deferred taxes and significant transactions or events that may have an impact on income taxes. Additionally, the CFO does not approve disbursements related to tax payments and does not review the calculations of the effective tax rates (Home Solutions of America, Inc. 10-K, 31 December, 2006).	Tax-related material weaknesses can impair the firm's ability in tax planning, resulting in higher tax expense (Bauer 2016) (#6).

This appendix details how each type of core accounts weaknesses can lead to sub-optimal operational decisions. Panel A describes the type of internal

information that is used in key operational decisions. Panel B discusses how each type of core accounts weaknesses leads to erroneous information and adversely affect operational decisions.

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TABLE 1
Sample selection and internal control effectiveness over time

Panel A: Sample selection

Description	Firm-years	Firms
Firms on Audit Analytics with an internal control disclosure for years 2004-2013	40,341	6,936
Less: firms in the financial industries or utilities and observations with missing value on firm operational efficiency	14,162	2,418
Less: observations with missing value on firm characteristics	918	157
Less: observations with market value of equity below $75 million	799	61
Final Sample	24,462	4,300

Panel B: Internal control effectiveness over time

Year	Total number of firms	Number of firms with ineffective internal control	Percentage of firms with ineffective internal control (%)
2004	1,657	283	17.08
2005	2,453	341	13.90
2006	2,644	267	10.10
2007	2,773	232	8.37
2008	2,709	134	4.95
2009	2,499	74	2.96
2010	2,542	70	2.75
2011	2,580	93	3.61
2012	2,461	100	4.06
2013	2,144	97	4.52
Total	24,462	1,691	6.91

This table presents the sample selection process and the number and percentage of firm-years with ineffective internal control over the period from 2004 to 2013 as reported in Audit Analytics.

TABLE 2
Descriptive statistics

Panel A: Firm efficiency over time

Year	Total number of firm-years	Mean *EFFICIENCY*	# of firms with *EFFICIENCY*= 1	Percentage of firms with *EFFICIENCY*= 1 (%)
2004	1,657	0.613	69	4.16
2005	2,453	0.642	132	5.38
2006	2,644	0.658	179	6.77
2007	2,773	0.648	182	6.56
2008	2,709	0.658	184	6.79
2009	2,499	0.638	100	4.00
2010	2,542	0.671	175	6.88
2011	2,580	0.680	253	9.81
2012	2,461	0.683	225	9.14
2013	2,144	0.667	240	11.19
Total	24,462	0.657	1,739	7.11

Panel B: Descriptive statistics for the full sample

	Mean	Std. Dev.	Q1	Median	Q3
EFFICIENCY	0.657	0.261	0.465	0.707	0.875
MVE (in million$)	5,652	15,986	305	896	3,163
MKTSHARE	0.011	0.028	0.000	0.002	0.007
FCF	0.725	0.447	0.000	1.000	1.000
AGE (in years)	21.78	15.39	10.00	16.00	28.00
CONCENTRATION	0.797	0.319	0.519	0.967	1.000
FOREIGN	0.388	0.487	0.000	0.000	1.000
LAG_ EFFICIENCY	0.654	0.262	0.460	0.705	0.871

Panel C: Firm efficiency and control variables by internal control effectiveness

	Firm-years with ineffective internal control (N = 1,691)		Firm-years with effective internal control (N = 22,771)		*p*-value for the tests of the difference between the two groups	
Variable	Mean	Median	Mean	Median	*t*-test	Wilcoxon
EFFICIENCY	0.572	0.570	0.663	0.717	<.01	<.01
MVE (in million$)	1,749	377	5,942	965	<.01	<.01
MKTSHARE	0.005	0.001	0.012	0.002	<.01	<.01
FCF	0.598	1.000	0.734	1.000	<.01	<.01
AGE (in years)	18.20	14.00	22.05	17.00	<.01	<.01
CONCENTRATION	0.809	0.985	0.796	0.966	0.11	0.06
FOREIGN	0.399	0.000	0.388	0.000	0.35	0.35
LAG_ EFFICIENCY	0.579	0.589	0.660	0.714	<.01	<.01

TABLE 2 (Cont'd)

Panel D: Pairwise correlations

		1	2	3	4	5	6	7	8	9
1	*EFFICIENCY*		**-0.12**	**0.56**	**0.27**	**0.41**	**0.18**	**-0.14**	**0.11**	**0.87**
2	*ICMW*	**-0.12**		**-0.14**	**-0.06**	**-0.08**	**-0.07**	0.01	0.01	**-0.10**
3	*LOG_MVE*	**0.60**	**-0.14**		**0.49**	**0.30**	**0.31**	**-0.24**	**0.17**	**0.53**
4	*MKTSHARE*	**0.52**	**-0.09**	**0.65**		**0.16**	**0.27**	**-0.25**	**0.08**	**0.26**
5	*FCF*	**0.37**	**-0.08**	**0.31**	**0.39**		**0.22**	**-0.16**	**0.08**	**0.36**
6	*LOG_AGE*	**0.18**	**-0.07**	**0.29**	**0.40**	**0.22**		**-0.27**	**0.04**	**0.17**
7	*CONCENTRATION*	**-0.15**	0.01	**-0.25**	**-0.36**	**-0.18**	**-0.29**		**-0.11**	**-0.14**
8	*FOREIGN*	**0.11**	0.01	**0.16**	**0.14**	**0.08**	**0.04**	**-0.11**		**0.11**
9	*LAG_ EFFICIENCY*	**0.88**	**-0.10**	**0.56**	**0.51**	**0.33**	**0.17**	**-0.15**	**0.11**	

This table reports descriptive statistics and pair-wise correlation coefficients for variables used in the analyses. See Appendix 1 for variable definitions. All continuous variables are winsorized at the 1% and 99% levels. Panel A reports the mean firm efficiency, and the number and percentage of firms on the efficient frontier by year. Panel B and C present descriptive statistics on firm efficiency and control variables for the full sample and separately for firm-years with and without internal control material weaknesses, and the *p*-values for the tests of the difference between the two groups using a *t*-test and Wilcoxon rank-sum test. Panel D presents Pearson (Spearman) correlations above (below) the diagonal. The correlation coefficients significant at the 5% level are presented in boldface.

TABLE 3
Internal control effectiveness and firm operational efficiency

	Pred. Sign	Coeff.	*z*-stat.
ICMW	**-**	**-0.020*****	**-5.28**
LOG_MVE	+	0.020***	61.59
MKTSHARE	+	-0.145***	-2.86
FCF	+	0.053***	10.17
LOG_AGE	+	-0.004*	-1.84
CONCENTRATION	+	0.002	0.62
FOREIGN	-	-0.002	-0.71
LAG_EFFICIENCY	+	0.783***	65.41
YEAR FIXED EFFECTS		Yes	
N		24,462	
Likelihood Ratio Chi-Square		38,269	
Probability > Chi-Square		<0.001	

This table reports the results from pooled Tobit regressions of firm operational efficiency on *ICMW* and control variables. The dependent variable is the standardized percentile rank of firm operational efficiency within industries. See Appendix 1 for variable definitions. All continuous variables are winsorized at the 1% and 99% levels. All *z*-statistics are computed using the standard errors adjusted for firm- and year-level clustering, and are based on two-tailed tests except for *ICMW*, which is based on one-tailed tests.

*, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

TABLE 4
Sensitivity Analyses

	Pred. Sign	Industry-level regressions (1)		Controlling for determinants of *ICMW* (2)		Controlling for reverse causality (3)	
		Coeff.	*z*-stat.	Coeff.	*z*-stat.	Coeff.	*z*-stat.
ICMW	**-**	**-0.013*** **	**-2.74**	**-0.021*** **	**-5.44**	**-0.019*** **	**-4.89**
LOG_MVE	+	0.019***	12.74	0.021***	64.27	0.019***	51.73
MKTSHARE	+	0.049	0.99	-0.166***	-2.67	-0.137***	-2.61
FCF	+	0.034***	6.44	0.062***	47.15	0.054***	9.88
LOG_AGE	+	-0.004*	-1.86	-0.004***	-9.51	-0.004***	-8.24
CONCENTRATION	+	0.005	1.58	-0.001	-0.16	0.001	0.40
FOREIGN	-	-0.002	-0.60	-0.001***	-3.26	0.000	0.00
LAG_EFFICIENCY	+	0.676***	29.45	0.798***	30.55	0.781***	65.31
LAG_LOSS	?			0.022***	3.09		
LAG_ROA	?			-0.023	-1.25		
LAG_INVENTORY	?			0.040	1.56		
LAG_MERGER	?			-0.007***	-16.72		
LAG_RESTRUCTURE	?			-0.002	-0.96		
LAG_LITIGATION	?			0.003***	7.14		
LAG_GROWTH	?			-0.003	-1.19		
LAG_BIG4	?			0.001	0.27		
LAMBDA						0.028	0.95
YEAR FIXED EFFECTS		Yes		Yes		Yes	
N		43		24,205		24,205	
Likelihood Ratio Chi-Square		954		38,187		37,951	
Probability > Chi-Square		<0.001		<0.001		<0.001	

TABLE 4 (Cont'd)

	Pred. Sign	Dropping R&D from *EFFICIENCY* estimation (4)		Using SFA to estimate *EFFICIENCY* (5)		Excluding firms in small industries (6)	
		Coeff.	*z*-stat.	Coeff.	*z*-stat.	Coeff.	*z*-stat.
ICMW	-	**-0.026*** **	**-5.67**	**-0.010*** **	**-5.56**	**-0.019*** **	**-4.86**
LOG_MVE	+	0.010***	36.08	0.006***	6.61	0.020***	62.86
MKTSHARE	+	-0.316***	-4.77	-0.271***	-6.40	-0.126**	-2.53
FCF	+	0.053***	11.94	0.027***	4.76	0.054***	10.20
LOG_AGE	+	-0.008***	-3.72	-0.003*	-1.77	-0.004*	-1.67
CONCENTRATION	+	0.012***	2.97	0.025***	7.78	0.004	1.35
FOREIGN	-	-0.001	-0.32	-0.002	-0.61	-0.002	-0.98
LAG_EFFICIENCY	+	0.831***	85.17	0.876***	101.44	0.781***	64.34
YEAR FIXED EFFECTS		Yes		Yes		Yes	
N		24,457		24,404		23,785	
Likelihood Ratio Chi-Square		35,407		37,230		37,465	
Probability > Chi-Square		<0.001		<0.001		<0.001	

This table reports the results from the sensitivity tests of the relation between internal control effectiveness and operational efficiency based on the pooled Tobit regression except for Column (1). Column (1) presents the result from the Fama and MacBeth (1973) approach by estimating the Tobit regression by industry where the dependent variable is the raw efficiency score. Column (2) presents the result after including the determinants of material weaknesses identified in prior studies: (i) an indicator variable for loss firm (*LAG_LOSS*), (ii) return on assets (*LAG_ROA*), (iii) the amount of inventory relative to total assets (*LAG_INVENTORY*), (iv) an indicator variable for firms involved in mergers and acquisitions (*LAG_MERGER*) or restructuring (*LAG_RESTRUCTURE*), (v) an indicator variable for firms operating in a litigious industry (*LAG_LITIGATION*), (vi) an indicator variable for rapid sales growth (*LAG_GROWTH*), and (vii) an indicator variable for firms audited by a Big 4 auditor (*LAG_BIG4*). Column (3) presents the result after including the inverse Mills ratio, *LAMBDA*, which is calculated from a probit estimation of the likelihood of having an *ICMW* on its determinants. Column (4) reports the regression results where the operational efficiency measure is estimated using only six input variables after excluding R&D. Column (5) reports the results based on an alternative measure of operational efficiency derived from the Stochastic Frontier Analysis (SFA). Column (6) presents the regression results after excluding those industries that have fewer than 100 firm-year observations. See Appendix 1 for variable definitions. The additional variables used in this table are defined as follows:

LAG_LOSS = An indicator variable that takes a value of one if a firm reported a net loss (NI) for fiscal year t-1, and zero otherwise;

LAG_ROA	=	Return on assets, calculated as income before extraordinary items (IB) divided by average total assets (AT) for fiscal year t-1;
LAG_INVENTORY	=	The ratio of inventory (INVT) to total assets (AT) in fiscal year t-1;
LAG_MERGER	=	An indicator variable that equals one if a firm reports sales from merger and acquisition (AQC) for fiscal year t-1, and zero otherwise;
LAG_RESTRUCTURE	=	An indicator variable that equals one if a firm was involved in a restructuring in fiscal year t-1, and zero otherwise; this variable is set to one if any of the following Compustat data items (RCP, RCA, RCEPS, and RCD) is non-zero;
LAG_LITIGATION	=	An indicator variable that equals one if a firm is in a litigious industry (SIC codes 2833-2836, 3570 -3577, 3600–3674, 5200-5961, and 7370), and zero otherwise;
LAG_GROWTH	=	An indicator variable that equals one if a firm's industry adjusted sales growth (SALE) belongs to the top quintile for fiscal year t-1, and zero otherwise;
LAG_BIG4	=	An indicator variable that equals one if a firm's auditor in fiscal year t-1 is one of the Big 4 accounting firms, and zero otherwise.

All continuous variables are winsorized at the 1% and 99% levels. All *z*-statistics are computed using the standard errors adjusted for firm- and year-level clustering, and are based on two-tailed tests except for *ICMW*, which is based on one-tailed tests.

*, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

TABLE 5
Internal control effectiveness and firm operational efficiency: Remediation analysis

	Pred. Sign	Coeff.	*t*-stat.
REMEDIATION	**+**	**0.018*** **	**3.48**
Δ*LOG_MVE*	+	0.067***	13.27
Δ*MKTSHARE*	+	0.827	1.31
Δ*FCF*	+	0.055***	9.93
Δ*LOG_AGE*	+	-0.117**	-2.52
Δ*CONCENTRATION*	+	-0.004	-0.43
Δ*FOREIGN*	-	-0.006	-0.79
Δ*LAG_EFFICIENCY*	+	0.261***	11.90
YEAR FIXED EFFECTS		Yes	
N		4,472	
Adjusted R^2		0.240	

This table reports the OLS regression results of the changes in firm operational efficiency on the remediation of ineffective internal control. The dependent variable *ΔEFFICIENCY* refers to the changes in operational efficiency from year t to t+2. *REMEDIATION* is an indicator variable that equals one if the firm reports material weakness in year t but reports no material weaknesses in year t+1, and zero otherwise. The changes in control variables and *LAG_EFFICIENCY* are measured from year t to t+2 and from year t-1 to t+1, respectively. See Appendix 1 for variable definitions. All continuous variables are winsorized at the 1% and 99% levels. All *t*-statistics are computed using the standard errors adjusted for firm- and year-level clustering, and are based on two-tailed tests except for *REMEDIATION*, which is based on one-tailed tests.

*, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

TABLE 6
Cross-sectional analyses of the relation between internal control effectiveness and firm operational efficiency: Demand for higher quality internal reports for decision making

Panel A: Level Analysis

	Pred. Sign	(1)		(2)		(3)	
		Coeff.	*z*-stat.	Coeff.	*z*-stat.	Coeff.	*z*-stat.
ICMW	-	-0.013***	-4.61	-0.016***	-3.14	-0.010**	-2.49
ICMW × STDROA_H	-	**-0.018*****	**-2.74**			**-0.017*****	**-2.47**
ICMW × VOLUME_L	-			**-0.010***	**-1.63**	**-0.009***	**-1.51**
STDROA_H		-0.001	-0.20			-0.002	-0.27
VOLUME_L				-0.005***	-9.08	-0.005***	-9.67
LOG_MVE	+	0.019***	61.76	0.019***	64.89	0.018***	65.02
MKTSHARE	+	-0.138***	-2.58	-0.137***	-2.83	-0.131**	-2.59
FCF	+	0.052***	47.39	0.052***	9.96	0.051***	45.73
LOG_AGE	+	-0.004***	-9.32	-0.004***	-9.09	-0.004***	-10.51
CONCENTRATION	+	0.002	0.76	0.001	0.41	0.001	1.43
FOREIGN	-	-0.002	-0.83	-0.002	-0.71	-0.002	-0.82
LAG_ EFFICIENCY	+	0.783***	68.90	0.783***	64.84	0.784***	68.99
YEAR FIXED EFFECTS		Yes		Yes		Yes	
N		24,285		23,990		23,841	
Likelihood Ratio Chi-Square		38,237		37,588		37,576	
Probability > Chi-Square		<0.001		<0.001		<0.001	

TABLE 6 (Cont'd)

Panel B: Remediation Analysis

	Pred. Sign	(1)		(2)		(3)	
		Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
REMEDIATION	+	0.017***	4.50	0.010*	1.74	0.009**	2.18
REMEDIATION × STDROA_H	**+**	**0.006**	**0.38**			**0.003**	**0.17**
REMEDIATION × VOLUME_L	**+**			**0.031*****	**2.58**	**0.030*** **	**2.39**
STDROA_H		-0.003	-0.40			-0.003	-0.43
VOLUME_L				0.005	0.61	0.005	0.60
Δ*LOG_MVE*	+	0.067***	13.69	0.071***	11.98	0.071***	12.15
Δ*MKTSHARE*	+	0.829	1.31	0.816	1.30	0.817	1.30
Δ*FCF*	+	0.055***	9.94	0.054***	9.09	0.054***	9.12
Δ*LOG_AGE*	+	-0.116**	-2.37	-0.110**	-2.35	-0.109**	-2.20
Δ*CONCENTRATION*	+	-0.004	-0.43	-0.004	-0.48	-0.004	-0.48
Δ*FOREIGN*	-	-0.006	-0.78	-0.005	-0.74	-0.005	-0.73
Δ*LAG_ EFFICIENCY*	+	0.261***	11.99	0.263***	11.36	0.263***	11.43
YEAR FIXED EFFECTS		Yes		Yes		Yes	
N		4,472		4,406		4,406	
Adjusted R^2		0.240		0.244		0.243	

This table reports the regression results from cross-sectional analyses of the relation between internal control effectiveness and operational efficiency. Panel A reports the results from the Tobit regression using the level of operational efficiency as the dependent variable and Panel B reports the results from the OLS regression using the change in operational efficiency as the dependent variable. See Appendix 1 for variable definitions. All continuous variables are winsorized at the 1% and 99% levels. For return on asset volatility (trading volume), we construct an indicator variable, *STDROA_H* (*VOLUME_L*), that equals one for firms belonging to the top (bottom) quartile of the sample distribution within the industry, and zero otherwise. All *z*-statistics and *t*-statistics are computed using the standard errors adjusted for firm- and year-level clustering, and are based on two-tailed tests except for the interaction terms, which are based on one-tailed tests.

*, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

TABLE 7
Internal control effectiveness and firm operational efficiency: Severity of material weaknesses

Panel A: Frequency Table for Severe Material Weaknesses

Reason Key	Reason Phrase	Number of firm-years	Percentage of full sample
1. Pervasive Weaknesses		**610**	**36.1**
# 22	Information technology, software, security & access issues	401	23.7
# 44	Accounting personnel resources, competency/training	337	19.9
2. Core Accounts Weaknesses		**1,380**	**81.6**
# 39	Revenue recognition issues	531	31.4
# 29	Expense recording (payroll, SG&A) issues	158	9.3
# 33	Liabilities, payables, reserves and accrual estimate failures	412	24.4
# 32	Inventory, vendor and cost of sales issues	463	27.4
# 28	Depreciation, depletion or amortization issues	127	7.5
# 16	PPE , intangible or fixed asset (value/diminution) issues	319	18.9
# 14	Capitalization of expenditures issues	114	6.7
# 3	Lease, FAS 5, legal, contingency & commit issues	182	10.8
# 73	Lease, leasehold & FAS 13 (98) (subcategory) issues	122	7.2
# 15	Accounts/loans receivable, investments & cash issues	349	20.6
# 41	Tax expense/benefit/deferral/other (FAS 109) issues	569	33.6
3. Both Types (i.e., both Pervasive and Core Accounts)		**511**	**30.2**

TABLE 7 (Cont'd)

Panel B: Level Analysis

	Pred. Sign	*ICMW_Severe = Pervasive* (1)		*ICMW_Severe = Core Accounts* (2)		*ICMW_Severe = Both* (3)	
		Coeff.	*z*-stat.	Coeff.	*z*-stat.	Coeff.	*z*-stat.
ICMW_Severe (a)	-	**-0.026*****	**-8.25**	**-0.022*****	**-6.49**	**-0.027*****	**-5.89**
ICMW_Non Severe (b)	-	**-0.017*****	**-3.41**	**-0.013****	**-1.69**	**-0.017*****	**-3.30**
LOG_MVE	+	0.020***	61.55	0.020***	61.57	0.020***	61.52
MKTSHARE	+	-0.145***	-2.86	-0.146***	-2.88	-0.145***	-2.87
FCF	+	0.053***	10.16	0.053***	10.17	0.053***	10.17
LOG_AGE	+	-0.004*	-1.84	-0.004***	-7.78	-0.004***	-7.83
CONCENTRATION	+	0.002	0.62	0.002	0.60	0.002	0.61
FOREIGN	-	-0.002***	-4.13	-0.002	-0.70	-0.002	-0.68
LAG_ EFFICIENCY	+	0.783***	65.39	0.783***	65.39	0.783***	65.40
YEAR FIXED EFFECTS		Yes		Yes		Yes	
N		24,462		24,462		24,462	
Likelihood Ratio Chi-Square		38,271		38,270		38,271	
Probability > Chi-Square		<0.001		<0.001		<0.001	
F-tests: severe versus non-severe type							
(a) – (b)		-0.009**	3.62	-0.009*	1.92	-0.010*	1.86

TABLE 7 (Cont'd)

Panel C: Remediation Analysis

	Pred. Sign	*REMEDIATION – Severe = Pervasive* (1)		*REMEDIATION – Severe = Core Accounts* (2)		*REMEDIATION – Severe = Both* (3)	
		Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
REMEDIATION – Severe (a)	**+**	**0.030*** **	**3.80**	**0.021*** **	**3.87**	**0.034*** **	**3.32**
REMEDIATION – Non Severe (b)	**+**	**0.014*** **	**2.72**	**0.007**	**0.46**	**0.014*** **	**2.71**
Δ*LOG_MVE*	+	0.067***	13.30	0.067***	13.33	0.067***	13.31
Δ*MKTSHARE*	+	0.831	1.31	0.829	1.31	0.834	1.31
Δ*FCF*	+	0.055***	9.84	0.055***	9.97	0.055***	9.81
Δ*LOG_AGE*	+	-0.118**	-2.51	-0.115**	-2.49	-0.117**	-2.48
Δ*CONCENTRATION*	+	-0.004	-0.41	-0.004	-0.44	-0.004	-0.42
Δ*FOREIGN*	-	-0.006	-0.77	-0.006	-0.78	-0.006	-0.77
Δ*LAG_ EFFICIENCY*	+	0.261***	11.87	0.261***	11.92	0.260***	11.89
YEAR FIXED EFFECTS		Yes		Yes		Yes	
N		4,472		4,472		4,472	
Adjusted R^2		0.240		0.240		0.240	
F-tests: severe versus non-severe type							
(a) – (b)		0.016***	6.34	0.014	0.77	0.020**	4.88

This table reports the regression results from the cross-sectional analyses of the relation between internal control effectiveness and operational efficiency, where *ICMW* is classified into severe and non-severe type. Panel A presents the frequency table for each type of weaknesses based on the classification using the taxonomy list in Audit Analytics. We classify the following as pervasive weaknesses: information technology, software, security & access issue (Audit Analytics Reason Key #22) and accounting personnel resources, competency/training (Reason Key #44). We classify the following as core accounts weaknesses: revenue recognition issues (Reason Key #39), expense recording (payroll, SG&A) issues (Reason Key #29), liabilities, payables, reserves and accrual estimation failures (Reason Key #33), inventory, vendor and cost of sales issues (Reason Key #32), depreciation, depletion or amortization issues (Reason Key #28), PPE, intangible or fixed asset (value/diminution) issues (Reason Key #16), capitalization of expenditure issues (Reason Key #14), lease, FAS 5, legal, contingency & commit issues (Reason Key #3), lease, leasehold & FAS 13 (98) issues (Reason Key #73), accounts/loans receivable, investments and cash issues (Reason Key #15), and tax issues (Reason Key #41).

Panel B presents the results from the Tobit regression using the level of operational efficiency as the dependent variable. *Pervasive*, *Core Accounts*, and *Both* are indicator variables coded as one if a firm discloses at least one pervasive material weakness, at least one core accounts material weakness, and at least one pervasive and one core accounts material weakness, respectively, during our sample period, and zero otherwise. *ICMW_Severe* is either *Pervasive*, *Core Accounts*, or *Both*. *ICMW_Non_Severe* is one when *ICMW* is one and *ICMW_Severe* is zero, and zero otherwise. *ICMW_Severe* and *ICMW_Non Severe* are coded as zero for firm-years without any material weaknesses. Columns (1), (2), and (3) present the results based on pervasive, core accounts, and both types of weaknesses, respectively.

Panel C presents results from the OLS regression using the change in operational efficiency as the dependent variable. *REMEDIATION-Severe*, is an indicator variable that equals one if a firm reports a more severe type of material weaknesses in year t but reports no material weaknesses of that type in year t+1, and *Severe* is either *Pervasive*, *Core Accounts*, or *Both*. *REMEDIATION-Non Severe* is an indicator variable that equals one if a firm reports at least one material weakness other than the severe type of material weaknesses in year t and reports no material weaknesses of that type in year t+1. Columns (1), (2), and (3) present the results based on pervasive, core accounts, and both types of weaknesses, respectively.

See Appendix 1 for other variable definitions. All continuous variables are winsorized at the 1% and 99% levels. All *z*-statistics and *t*-statistics are computed using the standard errors adjusted for firm- and year-level clustering, and are based on two-tailed tests except for *ICMW-Severe, ICMW-Non Severe, Remediation-Severe,* and *Remediation-Non Severe*, which are based on one-tailed tests. Chi-square statistics for the test of difference in coefficients between severe and non-severe type of weakness are based on one-tailed tests.

*, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

TABLE 8
Internal control effectiveness and firm operational efficiency: Firm size

Panel A: Level Analysis

	Pred. Sign	Coeff.	*z*-stat.
ICMW	-	-0.004	-0.42
ICMW × R10_MVE	**-**	**-0.026****	**-1.91**
R10_MVE	?	-0.091***	-14.68
MKTSHARE	+	-0.013	-0.35
FCF	+	0.054***	47.51
LOG_AGE	+	-0.002***	-4.64
CONCENTRATION	+	-0.001	-0.11
FOREIGN	-	-0.001	-0.40
LAG_ EFFICIENCY	+	0.782***	57.91
YEAR FIXED EFFECTS		Yes	
N		24,462	
Likelihood Ratio Chi-Square		38,148	
Probability > Chi-Square		<0.001	

Panel B: Remediation Analysis

	Pred. Sign	Coeff.	*z*-stat.
REMEDIATION	+	-0.001	-0.08
REMEDIATION × R10_MVE	**+**	**0.032****	**1.65**
R10_MVE	?	0.003	-0.67
Δ*LOG_MVE*	+	0.067***	13.32
Δ*MKTSHARE*	+	0.836	1.32
Δ*FCF*	+	0.055***	9.98
Δ*LOG_AGE*	+	-0.118**	-2.55
Δ*CONCENTRATION*	+	-0.004	-0.44
Δ*FOREIGN*	-	-0.006	-0.76
Δ*LAG_ EFFICIENCY*	+	0.261***	11.92
YEAR FIXED EFFECTS		Yes	
N		4,472	
Adjusted R^2		0.240	

This table reports the cross-sectional results on the effect of internal control effectiveness on operational efficiency by firm size. Panel A reports the results from the Tobit regression using the level of operational efficiency as the dependent variable, and Panel B reports the results from the OLS regression using the change in operational efficiency as the dependent variable. In each panel, *R10_MVE* is the standardized inverse decile ranks (i.e., observations in the bottom decile taking the value of one and observations in the top decile taking the value of zero) of the market value of equity at the end of second quarter of fiscal year *t* within the industry. See Appendix 1 for the

definition of other variables. All continuous variables are winsorized at the 1% and 99% levels. All *z*-statistics and *t*-statistics are computed using the standard errors adjusted for firm- and year-level clustering and are based on two-tailed tests except for the interaction terms, which are based on one-tailed tests.

*, **, *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.