The effect of the Sarbanes–Oxley Act on firm productivity

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Abstract

Purpose – This paper aims to examine the effect of the Sarbanes–Oxley Act (SOX), which was signed by President George W. Bush and came into effect on July 30, 2002, on firm productivity.

Design/methodology/approach – The authors use the total factor productivity (TFP) as our measure of firm productivity.

Findings – Analyzing annual firm-level data from the Compustat database for the period of 1991-2006, the authors find that firm productivity increases at a higher rate in the post-SOX period. The results indicate that, although firms incur significant costs in complying with the requirements of the SOX, they also benefit from these requirements as evidenced by the improved productivity over time post-SOX. There is also a shift in the output elasticities from capital toward labor. The SOX has a positive effect on the output elasticity of labor but a negative impact on that of capital.

Research limitations/implications – The results have the following important implications. The SOX is a value-enhancing regulation in that it not only strengthens a firm's corporate governance but also improves its productivity. However, compliance with the SOX can impose a long-term cost on firms: the decrease in the capital investment, leading to a decline in the output elasticity of capital. If this decline in the capital investment continues, it can have an adverse effect on firm productivity in the long term.

Originality/value – This paper extends the literature along the line of the actual operational effects of the SOX regulation by examining its effect on the productivity of firms.

Keywords Sarbanes-Oxley, Productivity, Capital, Labor, Output elasticity

Paper type Research paper

1. Introduction

This paper examines the impact of the Sarbanes–Oxley Act (SOX or Act hereafter) on firms' productivity. In the wake of corporate scandals and accounting irregularities that rattled the US capital markets, Congress passed and President George W. Bush signed the SOX into effect on July 30, 2002. The Act was enacted to enhance protection for investors by improving the accuracy and reliability of corporate disclosures made pursuant to the securities laws. The Act dictates improved corporate governance and increased accountability of officers and boards of directors of publicly traded companies. However, criticisms of the Act have intensified/increased[1] with some

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suggesting that it is "quack corporate governance and SOX's mandates were seriously misconceived because they are not likely to improve audit quality or otherwise enhance firm performance and thereby benefit investors as Congress intended (Romano, 2005). Romano argues that:

> [...] legislating in the immediate aftermath of a public scandal or crisis is a formula for poor public policy making. Legislation drafted in a perceived state of emergency can be difficult to undo. It took more than sixty years to repeal the Glass-Steagall Act, the New Deal financial market regulation that is now widely recognized as having greatly contributed to the banking debacle of the 1980s.

Similarly, April (2007) states that:

> SOX's governance provisions represent a misplaced and unwarranted federalization, upsetting the proper balance between state and federal regulation by intruding into matters of corporate governance that have been and should remain the province of the states.

Compliance with the SOX is also excessively expensive. For example, General Electric claimed that it spent $30 million in 2004 in complying with Section 404 requirement of the SOX.

A study of the impact of the SOX can be informative and beneficial to regulators, investors, corporate American and the general public. As Stigler (1964) points out that "it is possible to study the effects of public policies, and not merely assume that they exist and are beneficial". This is especially true for the SOX in that it actually mandates the structure of corporate governance, instead of promoting disclosure and transparency as in prior US Securities and Exchange Commission regulations (Romano, 2005; Smith, 2007). Hence, a study of the costs and benefits of the SOX is warranted. However, results of academic studies on the shareholder wealth effect of the SOX are mixed. While Zhang (2007) and Chhaochharia and Grinstein (2007) document a negative impact of the Act on the US stock market, Rezaee and Jain (2006) and Li *et al.* (2008) report a positive market effect of the Act. Regarding the positive market reaction, Rezaee and Jain (2006) find a positive abnormal stock return at the time of several legislative events that increased the likelihood of the passage of the Act and Li *et al.* (2008) also observe a negative relation between stock returns and the proportion of non-independent audit committee members and the extent of non-audit services performed by external auditors. These inconsistent results can be attributed to the ambiguities in the dating of the market's reaction to the SOX (Mulherin, 2007). Alternatively, Linck *et al.* (2009) look at the impact of the SOX on directors' compensation and document significant increases in directors' pay and total director costs, especially for small firms. Other studies have also examined the effect of the SOX on corporate risk behavior (Bargeron *et al.*, 2010), structure of compensation (Chang *et al.*, 2011), the role of audit committee (Zhang *et al.*, 2007), the productivity and efficiency of public accounting firms (Chang *et al.*, 2009a and 2009b) and CPA firms' returns to scale (Chang *et al.*, 2015). This paper extends the literature along the line of the actual operational effects of the SOX regulation by examining its effect on the productivity of firms. An empirical study of returns to scale of CPA firms in the post-SOX era complying with the various requirements of the SOX (in particular the compliance of Sections 302 and 404) could dampen firm productivity because it diverts significant amount of executives' energy and effort from value-enhancing activities of the firm. On the other hand, the strengthening of the independence and monitoring role of audit committee, the establishment of procedures for handling complaints about internal controls and accounting procedures and the resulting enhancement of internal control system (Sections 301, 302 and 404) can be beneficial to a firm's performance in the long run. For instance, the compliance effort and the evaluation of the control system provide firms with an opportunity to enhance their productivity by developing more effective processes and more efficient methods to operate their businesses, leading to productivity gains in the post-SOX period. Thus, the net effect of the SOX on firms' productivity remains an important empirical research issue.

The effect of the SOX on firm productivity is important given the fundamental role of productivity in firm performance to the US economy (Palia and Lichtenberg, 1999). In fact, since Solow (1957), various studies have documented that productivity growth contributed to about 90 per cent of the increase in real per capita output (Palia and Lichtenberg, 1999). Furthermore, given that the SOX is one of the most significant changes in securities law since the Securities Exchange Act of 1934, the impact of the SOX on firm productivity is of interest to policy setters, academics and the general public. Also, our study supplements the event study analysis of the SOX by looking beyond its impact on stock prices (Mulherin, 2007). Therefore, the objective of our paper is to empirically evaluate whether this congressional act has resulted in higher or lower productivity of publicly traded companies.

We use the total factor productivity (TFP) as our measure of firm productivity. There is a long list of prior studies that have investigated TFP in various industries and countries using parametric and non-parametric methods since the seminal work of Solow (1957). These include Griliches (1964), Jorgenson and Griliches (1967), Hayami and Ruttan (1970), Denny *et al.* (1981), Caves and Barton (1991), Bailey *et al.* (1992) and Palia and Lichtenberg (1999) just to name a few[2]. We evaluate whether firm productivity increased or decreased subsequent to the passage of the SOX. In addition, Bargeron *et al.* (2010) observe that there is a drop in the capital investment of US firms in the post-SOX period. While investment in new technology and production facility helps improve productivity, the decline in capital investment likely leads to a decline in the output elasticity of capital. On the other hand, an improvement in internal controls can help boost employee productivity by eliminating redundant activities and cutting the waste (or slack) in the consumption of human resources. As the output elasticities of both labor and capital can change in the post-SOX period, we also examine the change in output elasticities of labor and capital after the SOX.

Analyzing annual firm-level data from the Compustat database for the period of 1991-2006, we find that firm productivity increases at a higher rate in the post-SOX period. Our results indicate that, although firms incur significant costs in complying with the requirements of the SOX, they also benefit from these requirements as evidenced by the improved productivity over time post-SOX. There is also a shift in the output elasticities from capital toward labor. The SOX has a positive effect on the output elasticity of labor but a negative impact on that of capital.

In addition to the general effect of the SOX, we examine the effect of two specific sections of the SOX: Sections 302 and 404. These two sections have been cited as the most costly sections of the SOX. Companies spend millions of dollars to comply with these two sections. Supporters of these sections suggest that the documentation and certification requirements of Sections 302 and 404 help strengthen the internal control system, which contributes to organization effectiveness and productivity improvement. Anecdotal evidence such as:

> Suntron Corp., a $400 million electronics manufacturer, uses the process mapping and documentations required by Section 404 to support its Six Sigma activities and to drive continuous process improvement. Documenting a process can improve its efficiency up to 20 per cent by eliminating redundancy activities and identifying and fixing problems (Sammer, 2005).

supports this improvement argument. This evidence is also consistent with the findings of Abernethy and Brownell (1997), who observe that accounting controls have positive effects on performance[3].

In addition, an improvement in the control system can lead to a more efficient allocation of resources and hence an increase in productivity. For instance, an improvement in the accounting control process of budgeting and standard costing enables a better planning of raw material purchases and labor hiring. This helps to reduce unnecessary storage costs and idle time and minimizes sales lost due to backorder. Better planning also allows the firm to have more bargaining power in purchasing transactions than what they can have in a last-minute purchase. All these savings can lead to higher productivity. Similarly, a better variance monitoring system can help identify areas where the actual usage differs significantly from the standard. Managers can then focus their attention on investigating causes of these significant cost variances. This management by exception practice helps to enhance efficiency and productivity of the management team. Thus, an enhancement of internal control on accounting can help improve the productivity of a firm.

Further, the enhanced accountability for financial reporting and the increased penalties for fraud per the SOX also provide incentives for executives to "more truthfully" report the firm's performance. This helps executives to focus on actually improving the productivity of the firm, instead of spending time and effort on manipulating earnings.

Last but not least, compliance with Section 404 requirement encompasses both the control environment and the key process related to financial reporting (Deloitte, 2004). An evaluation of the control environment includes "the tone at the top, the assignment of authority and responsibility, consistent policies and procedures […]" (Doss and Jonas, 2004). A firm with control weaknesses at the firm level or related to its control environment "calls into question not only management's ability to prepare accurate financial reports but also its ability to control the business" (Doss and Jonas, 2004). Hence, an improvement in the overall control environment benefits not only the quality of financial reporting but also the control of business and, hence, likely to improve the firm's overall productivity. We, therefore, expect that firms reporting an improvement in their internal control systems are those that benefit the most from the SOX. An investigation of the change in productivity of these firms, compared with that of other firms, in the post-SOX period provides a direct test on the effect of the SOX, in particular, Sections 302 and 404.

Our empirical results do suggest that firms reporting an enhancement in their internal control system (i.e. from ineffective to effective) gain more, in terms of productivity, in the post-SOX period. The increase in productivity is particularly strong for manufacturing firms that report an improvement in their internal control systems. When we correlate the change in technical efficiency from pre- to post-SOX period with an improvement in internal controls, we observe a significantly positive correlation, indicating that the enhancement in technical efficiency is significantly higher for firms reporting an improvement in their control systems. This result provides further support that the SOX, in particular, Sections 302 and 404, helps to improve productivity.

Our results have the following important implications. The SOX is a value-enhancing regulation in that it not only strengthens a firm's corporate governance but also improves its productivity. However, compliance with the SOX can impose a long-term cost on firms: the decrease in the capital investment, leading to a decline in the output elasticity of capital. If this decline in the capital investment continues, it can have an adverse effect on firm productivity in the long term.

The rest of the paper is organized as follows. Section 2 develops our research hypotheses. Section 3 describes the measurement of firm productivity. Section 4 discusses the distribution of our sample and provides univariate analyses of our contextual variables. Section 5 presents results of our regression analyses and sensitivity checks. Section 6 concludes the paper.

2. Research hypotheses

The SOX aims to deter corporate frauds by improving corporate governance and making top executives accountable for their managerial activities. Specifically, it requires that audit committee members be fully independent and financially literate (Section 301). Section 407 further requires that at least one audit committee member has to be a financial expert. These requirements aim to strengthen the monitoring function of the audit committee. Section 301 also requires audit committee to set up procedures for employees to file complaints about accounting procedures and internal controls. This requirement provides an alternative venue for enhancing the internal control and minimizing the risk of fraud. Two sections specifically targeting the internal control of a firm are Sections 302 and 404. Per Section 302, top executives are required to endorse periodic financial reports and assess the internal control systems of their firms. Further, auditors have to evaluate the internal control systems and audit the management's internal control assessments, in addition to auditing the financial reports (Section 404).

Since the passage of the SOX, corporations have been complaining about the time and other resources "wasted" in compliance with the SOX. The requirements of the SOX (in particular Sections 302 and 404) have diverted significant management effort toward compliance with the rules instead of strategic planning and other business activities that are essential to value enhancing and creation. Hence, productivity as well as profitability is likely to suffer. According to a survey by Financial Executives International (2005), firms make an average estimated investment of 12,000 hours of internal work and 3,000 hours of external work in compliance work during the first year of compliance. For firms with revenues of $5 billion or higher, the cost of compliance is about $4.36 million on average[4]. In addition, a recent study of 29 smaller public companies (also known as non-accelerated filers) by Lord & Benoit, a consulting firm, reveals that the average first-year cost of compliance with Section 404 is $78,474 (Benoit, 2008). An average of $53,724 was spent on management assessment and the rest was caused by an increase in audit fees (Benoit, 2008). The House Committee on Small Business was also concerned about the potential for disproportionate costs associated with compliance of Section 404 (Benoit, 2008)[5]. Thus, detractors consider the Act an expensive government intrusion into the operations of the business world.

Benefits of the SOX include an improvement in the effectiveness of audit committee monitoring leading to the reliability of financial reporting, reduction in fraud and asset abuse. Rittenberg and Miller (2005) document in a 2004 survey of chief audit executives that over 60 per cent of the respondents agree that there were improvements in the control environment and anti-fraud awareness actions taken by their firms. Specifically, the survey respondents cited a more engaged control environment by the board, audit committee and management as a significant benefit of the SOX Section 202 implementation[6]. This improvement in the overall control environment can lead to not only better financial reporting but also a more effective and efficient control over the business operations, which can eventually lead to an enhancement in productivity. The Audit Analytics 2006 Audit Fee Briefing Paper further documents that the improvement in procedures resulted from compliance with Section 404 removes volatility in reporting and contributes to the recent decrease in security class action claims against companies. This drop in class action lawsuits can reduce management's time spent on defending the cases and refocus their efforts on strategic planning or day-to-day operations of the firm.

In addition, internal control over financial reporting has two objectives: publishing reliable financial reports and safeguarding assets from unauthorized use (Louwers *et al.*, 2008, p. 159). An improvement in the safeguarding of assets can enhance a firm's productivity. For example, an improvement in internal control to prevent material misstatement caused by errors or fraud can also help to deter embezzlement of funds from the company. In their internal control report, Krispy Kreme's management noted that the lack of "effective process for monitoring the appropriateness of user access and segregation of duties" as a weakness of their internal control system. This weakness can compromise not only the quality of financial reporting but also the control over consumption of the firm's resources and assets (Louwers *et al.*, 2008). A lack of segregation of duties and control over user access allows embezzlement, theft and unauthorized purchase or disposal of a firm's assets to occur more easily. An improvement in the internal control can help to stop these embezzlement and thefts and, hence, raises a firm's productivity.

Furthermore, internal controls over financial reporting are not independent of the overall internal control of a firm. A firm's internal control mechanism can be divided into three categories: internal control over financial reporting, operations and compliance (Louwers *et al.*, 2008, p. 159). A firm with a strong overall internal control is more likely to have an effective internal control over financial reporting. Conversely, when a firm improves its internal control over financial reporting, it can have ripple effects over the firm's overall control system. When a firm improves its control system over financial reporting, it is also more likely to utilize its assets more effectively and efficiently. This is because management is more likely to devote their time to new product innovation or business strategy, rather than dealing with the risk of embezzlement. Therefore, an improvement in internal control over financial reporting can also help to enhance internal control over operations.

Finally, the assessment of internal control system "provides" firms with an opportunity to take a closer look at their internal control systems and the way they used to run businesses and, in the process, identify any redundant efforts and/or procedures and streamline their operating procedures to conserve resources. The assessment and the better control environment together help to curb wasteful consumption of resources and to enhance productivity.

Given that the start-up cost of complying with the SOX is high, firm productivity can suffer. However, firms can leverage the SOX provisions to improve productivity by streamlining operations and making better decisions through timelier and more accurate financial information (Quall, 2004). As the net effect of the SOX on firm productivity remains an empirical issue, we state our first hypothesis in null form as follows:

H1. The SOX has no impact on firm productivity.

An improvement in the overall corporate governance and control environment helps to reduce idle labor time and minimize the diversion of firms' resources toward personal benefits. Further, well-documented procedures/processes enable employees to quickly learn and implement them, leading to an increase in employee productivity. On the other hand, the diversion of management time and effort toward the examination and documentation of internal control systems can impede the strategic planning and other essential business operations, especially during the early years of the SOX. Therefore, we state our second hypothesis in null form:

H2. Firms' output elasticity of labor does not change in the post-SOX period.

Recently, Bargeron *et al.* (2010) document that firms reduce their capital expenditures in the post-SOX period. They argue that the SOX discourages directors to approve risky investments because these investments impose high monitoring costs on the directors. Further, to reduce the risk of ineffective internal controls, firms tend to reduce investment in risky projects to decrease the complexity of their operations (Bargeron *et al.*, 2010). With firms cutting their capital expenditures, the productivity of machinery and equipment likely declines, as their operation efficiency deteriorates over time. This can lower the output elasticity of capital investment in the long run. While the strengthening of internal controls can improve the safeguard of assets and improve their productivity, the reduction in capital expenditures points the other direction. As such, the direction of change in the output elasticity of capital is an empirical question, and we state our third hypothesis below in null form:

H3. Firms' output elasticity of capital does not change in the post-SOX period.

3. Measurement of productivity

In this section, we discuss how we construct our measures of productivity, output elasticity of labor and output elasticity of capital. In its simplest form, a production function $y = f(x_{1,} [\ldots][\ldots] x_n)$ relates an output measure y to input resources $x_1, [\ldots] .x_n$. If the output is homogeneous across different firms, the output measure y is the quantity of such output. In most other cases, the output measure y is structured to represent the monetary value of the output such as total sales[7]. Deriving from this production function, a firm's productivity measured by its total factor productivity (TFP, θ) can be defined as the output per unit of total input:

$$\theta = y/f(x_1, \ldots\ldots x_n) \tag{1}$$

TFP is considered superior to partial productivity measures, such as labor productivity and land productivity, which can provide a misleading indication of overall productivity in that they do not account for the contribution of all inputs (Coelli *et al.*, 2005, p. 3; Palia and Lichtenberg, 1999). TFP is also a better measure than profitability in capturing a firm's performance because it is less subject to management's manipulation[8]. Further, TFP allows the mix of inputs and outputs to vary cross-sectionally and over time (Banker *et al.*, 2005). Assuming a Cobb–Douglas production function, $f(L,K) = L^{\beta 1}K^{\beta 2}$, we can rearrange TFP in (1) as follows:

$$y = \theta f(L, K) = \theta L^{\beta 1}K^{\beta 2} \quad (2)$$

where y denotes output, θ denotes TFP, f(L,K) denotes the weighted sum of efficient total inputs, L denotes labor input and K denotes capital input. Although the translog functional form is more flexible and can provide a second-order approximation to the unknown production function with less restrictions on elasticities of substitution between any pairs of inputs, we use a Cobb–Douglas form for four reasons[9]. First, data limitations prevent us from estimating an appropriate translog production function. Second, the Cobb–Douglas type is relatively easy in interpretation (Hayami and Ruttan, 1970). Third, Maddala (1979) notes that within a limited class of production functions, such as Cobb–Douglas, generalized Leontief, homogeneous translog and homogeneous quadratic, differences in the functional form produce negligible differences in measures of TFP. Fourth, increased flexibility from other functional forms comes with econometric difficulties such as multicollinearity (Coelli *et al.*, 2005, p. 211). Note that the Cobb–Douglas specification of production function has also been used previously in economics literature including Griliches (1964), Aigner and Chu (1968), Hayami and Ruttan (1970) and Aigner *et al.* (1977) among others. Following Palia and Lichtenberg (1999), we measure output by the firm's net annual sales dollar amount, labor input by the number of employees and capital input by the net property, plant and equipment value at the beginning of the year. Taking logarithms on both sides of equation (2) yields:

$$\ln(y) = \ln(\theta) + \beta_1 \ln(L) + \beta_2 \ln(K) \quad (3)$$

To capture how productivity varies over time, we introduce a time trend term *TIME* which is computed as the difference between the year of observation and the year 1990. We also add interactions between *TIME* and factor inputs in equation (3) to analyze how *TIME* affects the output elasticity of each factor input. To evaluate how the SOX impacts productivity, we include *SOX* and interaction terms of *SOX**TIME*, *SOX**TIME**ln(*L*), and *SOX* * *TIME* * ln(*K*) in the equation, where *SOX* is a dichotomous variable whose value is 1 if the observation is in the post-SOX period and 0 otherwise. Thus, we express ln(θ) in equation (3) as a function of *TIME*, *TIME* * ln(*L*), *TIME* * ln(*K*), *SOX*, *SOX* * *TIME*, *SOX* * *TIME* * ln(*L*) and *SOX* * *TIME* * ln(*K*), a vector of other contextual variables z (such as firm size) hypothesized to affect productivity, and a random noise ε. More specifically, we expand equation (3) into the following model[10]:

$$\ln(y) = \beta_1 \ln(L) + \beta_2 \ln(K) + \gamma_1 TIME + \gamma_2 TIME * \ln(L) + \gamma_3 TIME * \ln(K) + \gamma_4 SOX + \gamma_5 SOX * TIME + \gamma_6 SOX * TIME * \ln(L) + \gamma_7 SOX * TIME * \ln(K) + \gamma_8 \ln(SIZE) + \varepsilon \quad (4)$$

where γ_1 captures the change in productivity over time, holding all else constant. γ_2 and γ_3 capture the change in output elasticity of labor and capital over time, respectively. The static effect of the SOX on y is captured by γ_4. The effect of the SOX on the change in firm productivity over time is captured by γ_5. A positive γ_5 indicates that firm productivity improves over time after the implementation of the SOX, whereas a negative coefficient of *SOX*TIME* indicates that firm productivity deteriorates in the post-SOX period. γ_6 and γ_7 capture the effect of the SOX on the change in output elasticity of labor and capital over time, respectively. A positive γ_6 (γ_7) suggests that the output elasticity of labor (capital) increased at an increasing rate or decreased at a slower rate in the post-SOX period, whereas a negative coefficient indicates an increase at a decreasing rate or a decrease at an increasing rate in the elasticity.

4. Data and sample

4.1 Sample selection

We collect financial data from the Compustat database for the period of 1991-2006. Because our main objective is to examine the impact of the SOX on firms' productivity, our sample period ends in 2006 to avoid the impact of subprime mortgage financial crisis that started in 2007. We exclude year 2002, the year when the SOX came into effect, from our sample to provide a more clear-cut classification of pre- and post-SOX periods and eliminate any effect the debate and anticipation of the passage of the SOX in July 2002 have on firms' strategic plans[11]. We include all firm-years with the necessary input and output data within the sample period in our analyses. We have 89,700 observations in our initial sample. Following other productivity studies, we also perform our analyses on a sub-sample of manufacturing firms only. The size of this sub-sample is 38,411 firm-year observations.

Table I presents the sample distribution by year and industry. Our sample is concentrated in the manufacturing sector: 42.8 per cent of our sample is in that sector, followed by 17.7 per cent in the service sector. Our sample industry distribution is very similar to that of the Compustat universe, with a slightly higher concentration in the manufacturing sector[12].

4.2 Descriptive statistics

Table II reports summary statistics of our output, inputs and other firm characteristics in the pre- and post-SOX periods. All dollar amounts are adjusted by the consumer price index to convert to year 2000 price level. Average sales of our full sample increased from \$1,587.78 millions in the pre-SOX period to \$2,456.66 millions in the post-SOX period. The median sales also increased from \$121.61 million to \$145.83 million. Statistical tests, both *t*-test and Wilcoxon z-statistic, show that the difference is significant at the 1 per cent level. The market capital of sample firms also increased in the post-SOX period.

The number of employees increased from a mean of 6.98 in the pre-SOX period to 9.14 in the post-SOX period. The mean value of capital input, measured by the net value of property, plant and equipment, also increased in the post-SOX period. Both changes are statistically significant at the 1 per cent level. These data show that on average firm size

Table I. Sample distribution by industries and years

Year	Agriculture, Forestry and Fisheries	Mineral	Construction	Manufacturing	Transportation, Communication and Utilities	Wholesale	Retail	Finance	Service	Other	Total
1991	19	266	67	2,126	492	194	307	525	675	61	4,732
1992	19	252	65	2,189	511	205	332	536	710	63	4,882
1993	21	252	70	2,298	519	210	383	517	773	47	5,090
1994	20	270	78	2,477	545	229	419	544	817	52	5,451
1995	19	275	80	2,603	563	247	430	524	892	57	5,690
1996	20	294	81	2,858	605	268	448	563	1,054	75	6,266
1997	21	283	88	3,038	629	277	470	541	1,234	77	6,658
1998	23	275	92	2,988	620	268	457	535	1,278	81	6,617
1999	21	263	84	2,866	607	266	455	1,013	1,279	65	6,919
2000	23	266	73	2,780	612	240	436	1,162	1,441	74	7,107
2001	24	255	70	2,800	603	219	394	1,120	1,475	67	7,027
2003	24	241	57	2,570	585	193	360	1,098	1,219	41	6,388
2004	21	246	54	2,513	572	181	332	1,060	1,141	27	6,147
2005	21	256	55	2,431	558	172	322	1,066	1,095	14	5,990
2006	14	223	48	1,874	424	130	252	956	806	9	4,736
Total	310	3,917	1,062	38,411	8,445	3,299	5,797	11,760	15,889	810	89,700
(%) of Sample	0.4	4.3	1.2	42.8	9.4	3.7	6.5	13.1	17.7	0.9	100.0
(%) of Compustat	0.4	5.0	1.1	37.0	10.2	3.3	5.5	18.5	17.4	1.6	100.0

Note: This sample includes all firms in the period of 1991-2006, excluding 2002, that have the financial data required for the analysis. We classify each firm into industry sectors based on their one-digit standard industry classification code

Table II. Descriptive statistics for firm characteristics

Firm characteristics	Pre-SOX (1) Mean	(2) Median	(3) SD	Post-SOX (4) Mean	(5) Median	(6) SD	(7) *t*-Test	(8) Wilcoxon *z*-statistic
Sale (in constant 2000 dollar; $M)	1,587.78	121.61	7,185	2,456.66	145.83	11,141	11.11***	9.35***
Market capitalization (in constant 2000 dollar; $M)	2,006.87	105.48	12,787	3,194.85	228.23	13,794	11.52***	35.52***
PP&E (net; in constant 2000 dollar; $M)	684.68	22.97	3,315	948.97	23.52	4,575	8.10***	−0.12
Employee	6.98	0.67	28.31	9.14	0.66	41.85	7.31***	1.68*
Capital expenditure (scaled by total assets, 49,837obs)	0.063	0.041	0.094	0.046	0.025	0.089	−20.69***	−38.07***
Improvement in internal controls	0.044	0.0	0.206	0.084	0.0	0.277	22.73***	22.66***
Number of observations	66,430			23,270				

Notes: This table reports descriptive statistics for the key financial variables for the sample of 89,700 firm-year observations during the period of 1991-2006, excluding 2002. Differences in the reported means and medians are tested with the *t*-tests and Wilcoxon *z*-statistics, respectively; *** Significant at the 1% level; ** significant at the 5% level; * significant at the 10% level (2-sided tests) increased in the post-SOX period. Consistent with the findings of Bargeron *et al.* (2010), our univariate results indicate a significant decline in the capital expenditure of firms in the post-SOX period.

5. Regression analyses

5.1 Estimation model

In this study, we use a panel dataset for our analysis. To avoid the unobserved-heterogeneity problem, we follow Himmelberg *et al.* (1999) and use a fixed-firm-effect model to examine the relation between the SOX and firm productivity. We also use the Huber (1967) and White (1980, 1984) method to adjust standard errors. In addition, we control for the effect of firm size on productivity by including ln(*SIZE*) in our estimation models, where *SIZE* is the market capitalization of a firm at the beginning of the year[13]. That is, we use the following model specification derived from equation (4) to test for the effect of the SOX on firm productivity and output elasticities:

$$\begin{aligned} ln(y_{it}) = {} & \alpha_i + \beta_1 ln(L_{it}) + \beta_2 ln(K_{it}) + \gamma_1 TIME_t \\ & + \gamma_2 TIME_t{*}ln(L_{it}) + \gamma_3 TIME_t{*}ln(K_{it})) + \gamma_4 SOX_t \\ & + \gamma_5 SOX_t{*}TIME_{,t} + \gamma_6 SOX_t{*}TIME_t{*}ln(L_{it}) \\ & + \gamma_7 SOX_t{*}TIME_t{*}\, ln(K_{it}) + \gamma_8 ln(SIZE_{it}) + \varepsilon_{it} \end{aligned} \tag{5}$$

5.2 Regression results

5.2.1 Full sample. Column (1) of Table III shows the regression results for equation (5). All the reported standard errors are White-corrected for heteroscedasticity. Consistent with the estimates of Palia and Lichtenberg (1999), the input share of labor is 0.662 (0.696 in Palia and Lichtenberg, 1999) while that of capital is 0.150 (0.152 in Palia and Lichtenberg, 1999). The coefficient of *TIME* is positive, but not statistically significant. This suggests that there is little improvement in firm productivity over time prior to the SOX. The coefficient of *SOX* is significantly negative, indicating that firm productivity drops initially post SOX. This decrease can be caused by the initial investment of both capital and human resources to comply with the various requirements of the SOX. However, the coefficient estimate of *SOX*TIME* is significantly positive, indicating that subsequent to its initial drop, firm productivity increases over time in the post SOX period. This improvement in productivity over time post SOX can be the result of the compliance efforts that lead to a more effective and efficient use of resources. Taken together, our results show that while the SOX has an initial negative impact on productivity, there is an improvement in productivity over time in the post-SOX period. Therefore, our first hypothesis of no change in firm productivity in the post-SOX period is rejected in favor of an increase in productivity over time.

Our results suggest that the initial start-up resources involved in compliance with the requirements of the SOX are not "wasted" in that firms actually improve their productivity in the post-SOX period. This improvement can be attributed to the enhancement in corporate governance – the main focus of the SOX – and internal control systems and procedures. Strengthening of governance structure and internal control systems not only helps prevent fraud and improve financial reporting quality but also improves the overall control environment and the safeguarding of assets (including human resources) from unauthorized use.

Variables	Pred. signs	(1) Full sample Coefficient estimates (Robust SE)	(2) Manufacturing firms only Coefficient estimates (Robust SE)
$ln(L_{it})$	+	0.662*** (0.0108)	0.709*** (0.0196)
$ln(K_{it})$	+	0.150*** (0.0074)	0.145*** (0.0140)
$TIME_t$	+	0.0030 (0.0028)	0.0110* (0.0063)
$TIME_t \times ln(L_{it})$	?	−0.0059*** (0.0009)	−0.0063*** (0.0023)
$TIME_t \times ln(K_{it})$	?	0.0045*** (0.0007)	0.0020 (0.0018)
SOX_t	?	−0.431*** (0.0473)	−0.418*** (0.0825)
$SOX_t \times TIME_t$	?	0.0387*** (0.0039)	0.0362*** (0.0073)
$SOX_t \times TIME_t \times ln(L_{it})$	?	0.0019*** (0.0006)	0.0031** (0.0015)
$SOX_t \times TIME_t \times ln(K_{it})$	?	−0.0016*** (0.0005)	−0.0011 (0.0012)
$lnSIZE_{it}$	+	0.0784*** (0.0034)	0.0791*** (0.0051)
Intercept	?	3.995*** (0.0313)	3.958*** (0.0521)
N		89,700	38,411
Adjusted R^2		0.965	0.964

Notes: This table examines the change in firm productivity and the output elasticities of labor and capital in the post-SOX period. We use the following model to examine the effect of the SOX: $ln(y_{it}) = \alpha_i + \beta_1 ln(L_{it}) + \beta_2 ln(K_{it}) + \gamma_1 TIME_t + \gamma_2 TIME_t{*}ln(L_{it}) + \gamma_3 TIME_t{*}ln(K_{it}) + \gamma_4 SOX{*}TIME_t + \gamma_5 SOX{*}TIME_t{*}ln(L_{it}) + \gamma_6 SOX{*}TIME_t{*}\,ln(K_{it}) + \gamma_7 lnSIZE_{it} + \varepsilon_{i,t}$ where $ln(y_{it})$ is the logarithm of total sales for firm i in year t. $ln(L_{it})$ is the logarithm of the number of employees. $ln(K_{it})$ is the logarithm of the net value of property, plant and equipment measured at the beginning of the year. *TIME* is the difference between the observation year t and 1990. *SOX* is a dummy variable that takes on a value of 1 if the sample period is after 2002 and 0 otherwise. $\ln(SIZE_{it})$ is the logarithm of market capitalization of firm i at the beginning of year t. We use the fixed-firm-effect model in estimating the abovementioned specification and the standard errors are robust standard errors calculated using Huber (1967) and White (1980, 1982) method; ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level (2-sided tests)

Table III.
Empirical results of the SOX's impact on firm productivity

For the output elasticities, we observe a decrease in the elasticity of labor over time in the pre-SOX period. The coefficient of *TIME**ln(*L*) is -0.0059. That is for each year, this elasticity decreases by 0.0059 per cent. Considering our average elasticity of labor of 0.662 per cent, this means that elasticity of labor is dropping by 0.89 per cent of its mean value per year. This decrease in elasticity reverts in the post-SOX period. Coefficient of *SOX*TIME**ln(*L*) takes on a value of 0.0019, suggesting that the drop in the elasticity of labor slows down in the post-SOX period. That is, the elasticity of labor decreases by 0.004 per cent (= 0.0019 per cent −0.0059 per cent) per year in the post-SOX period. This rejects our second hypothesis and suggests an improvement in output elasticity of labor after the passage of the SOX.

Contrary to the declining trend of output elasticity of labor over time, we observe an increase in the output elasticity of capital over time in the pre-SOX period. Coefficient of *TIME**ln(*K*) is 0.0045. This implies that the elasticity of capital increases by 0.0045 per cent, about 3 per cent of the mean elasticity of capital, every year. Advances in technology help improve the output elasticity of capital and the overall productivity over time. This together with a decrease in the labor output elasticity over time suggests that there is a substitute of capital for labor over time. However, this increasing trend of output elasticity of capital slows down in the post-SOX period. Coefficient of

*SOX***TIME**ln(*K*) is −0.0016, implying that the output elasticity of capital increases only at 0.0029 per cent (=0.0045 per cent - 0.0016 per cent) in the post-SOX period. This rejects our third hypothesis. The slowdown in the drop of output elasticity of labor and in the growth rate of elasticity of capital imply that there is a shift in input contribution from capital to labor after the SOX.

One potential reason for the slowdown in the increase in output elasticity of capital in the post-SOX period is the decrease in firms' capital expenditures as documented by Bargeron *et al.* (2010). This drop in capital investment means that firms continue to use existing older machinery and technology in the production process, which leads to a decline in the technical parameter of capital – i.e. a drop in the output elasticity of capital. Overall, as evidenced by the increasing speed of progress in productivity after the SOX, the improvement introduced by an enhancement in the internal control system more than offsets the decline in the output elasticity of capital. These changes in productivity and elasticities are observed after controlling for the size effect. Large firms seem to be more productive and hence enjoy higher productivity.

Column (2) of Table III presents the results for firms in the manufacturing sector only[14]. Results in Column (2) are similar to those in Column (1) for the full sample, except that the time trend in the output elasticity of capital [coefficient of *TIME***ln(K*)] and the change in the output elasticity of capital in the post-SOX period [coefficient of *SOX***TIME***ln(K*)] are no longer statistically significant. This challenges the assumption in some prior studies that there is no cross-sectional variation in the technical parameters (Palia and Lichtenberg, 1999).

Overall, we observe that the SOX has a negative impact on productivity initially, but it is associated with improved productivity over time.

5.3 Sensitivity analyses

We first repeat our analyses after winsorizing our continuous variables at the 1 per cent level to minimize the effect of outliers. All the results (untabulated) are qualitatively the same as those reported above. In addition, we perform the following additional analyses to check the robustness of our results.

5.3.1 Improvement in internal control systems. As the most costly provisions of the Act are the documentation, certification and implementation of an internal control system (Sections 302 and 404), we examine in this section whether firms reporting an enhancement in their internal controls experience a more significant improvement in their productivity. If the SOX helps to improve the productivity of firms, its effect should be the strongest among this group of firms. We introduce a dummy variable, *Improve*, which takes on a value of 1 if a firm reported a weakness in its internal control systems and later fixed it (i.e. an improvement from an ineffective internal control system to an effective one), and 0 otherwise[15]. That is, we separate our sample firms into two groups based on whether they report an improvement in their internal control systems in the post-SOX period. As shown in Table II, about 8.4 per cent of our firm-year observations report an improvement in their internal control systems in the post-SOX period. A firm is classified as in the *Improve*=1 group if it reported an improvement and the *Improve*=0 group if it did not. If a firm is categorized into the *Improve*=1 group, all its observations (both in the pre- and post-SOX periods) will belong to the *Improve*=1 category.

We also include interaction terms between *Improve* and other variables in our analyses to capture the differential impact of these variables for firms with an improvement in their internal controls versus those without such a reported improvement. That is, we allow the productivity and output elasticities to differ between these two groups of firms. For instance, the coefficient of the interaction term *Improve**SOX*Time* captures whether there is any differential effect of the SOX on productivity over time between firms reporting an improvement in internal controls versus those without such a reported improvement. Coefficients of *Improve**SOX*Time*ln(L)* and *Improve**SOX*Time*ln (K)* capture the differential impact of the SOX on elasticities of labor and capital over time, respectively.

Column (1) of Table IV shows the results for firms without a reported improvement in internal controls while Column (2) presents those with such an improvement. As shown in these two columns, in the post-SOX period, both groups of firms experience: an increase in productivity, an increase in output elasticity of labor and a decrease in the output elasticity of capital over time. However, we cannot tell whether there is any statistically significant difference between these two groups of firms from the results in Columns (1) and (2). Column (3) pools all the observations together and compares whether there is any significant difference between the two sub-samples. By incorporating the interaction terms between *Improve* and other variables, we can test whether *Improve* has any significant moderating effect on the relation between the SOX and firm productivity. While both firms with and without a reported improvement in their internal control systems show progress in their productivity in the post-SOX period (as evidenced by the positive coefficient of *SOX*TIME*), such progress is more significant in firms with a reported improvement in their internal control systems as evidenced by the positive coefficient of *Improve*SOX*TIME* in Column (3).

When we limit our sample to manufacturing firms only (Column 4), the differential impact of the SOX on productivity between the two sub-samples becomes even more significant. For the manufacturing sector, the improvement in productivity for firms reporting an enhancement in their internal controls is incrementally larger than those without such a reported improvement. The coefficient of *Improve*SOX*TIME* is 0.0269, significant at the 1 per cent level. Furthermore, *Improve*SOX*TIME**ln(*L*) takes on a positive coefficient (coefficient = 0.0085), while *Improve*SOX*TIME**ln(*K*) takes on a negative value (coefficient = −0.0075). These results suggest that the output elasticity of labor improves, but the output elasticity of capital falls in the post-SOX period for firms with an enhancement in internal controls. Together, these results suggest that the effect of the SOX on firms' productivity and output elasticities is strongest among firms reporting an improvement in their internal control systems.

5.3.2 Stochastic frontier analysis. Economic theory defines the production function as the maximum output possible from a vector of inputs. In practice, however, firms may differ in their productivity in converting the inputs into the output due to changes in technical efficiency as well as variations in other factors such as contextual variables and random noises. To incorporate the effect of technical efficiency changes in productivity measurement, we use a stochastic frontier model with an exponential specification of time-varying firm effects that incorporate unbalanced panel data on a sample of N firms over T-year periods. Thus, we specify the error term ε_{it} in equation (5) as being composed of two independent components, u_{it} and v_{it}. That is, $\varepsilon_{it} = v_{it} - u_{it}$, where v_{it} is a symmetric two-sided error term which captures the effects of random

Table IV. Empirical results of the SOX's impact on firm productivity–internal control effectiveness

Variables	Pred. Sign	(1) Improve = 0 Coefficient estimates (Robust SE)	(2) Improve = 1 Coefficient estimates (Robust SE)	(3) Full Coefficient estimates (Robust SE)	(4) Manufacturing only Coefficient estimates (Robust SE)
$ln(L_{it})$	+	0.692*** (0.0084)	0.632*** (0.0080)	0.699*** (0.0083)	0.685*** (0.0293)
$Ln(K_{it})$	+	0.132*** (0.0064)	0.170*** (0.0063)	0.134*** (0.0064)	0.175*** (0.0219)
$TIME_t$	+	0.0033 (0.0027)	−0.0018 (0.0028)	0.0038 (0.0027)	0.0222** (0.0093)
$TIME_t \times ln(L_{it})$	?	−0.0065*** (0.0008)	−0.0055*** (0.0009)	−0.0064*** (0.0008)	−0.0005 (0.0033)
$TIME_t \times lnK_{it}$	?	0.0044*** (0.0007)	0.0055*** (0.0007)	0.0044*** (0.0007)	−0.0020 (0.0026)
SOX_t	?	−0.400*** (0.0515)	−0.462*** (0.100)	−0.433*** (0.0457)	−0.427*** (0.0855)
$SOX_t \times TIME_t$	?	0.0341*** (0.0040)	0.0431*** (0.0074)	0.0362*** (0.0036)	0.0263*** (0.0086)
$SOX_t \times TIME_t \times ln(L_{it})$	?	0.0015*** (0.0005)	0.0012* (0.0007)	0.0015*** (0.0005)	−0.0012 (0.0020)
$SOX_t \times TIME_t \times ln(K_{it})$	?	−0.0010** (0.0004)	−0.0019*** (0.0006)	−0.0010** (0.0004)	0.0021 (0.0016)
$Improve_{i,t} \times ln(L_{it})$	−			−0.0747*** (0.0114)	0.0474 (0.0384)
$Improve_{i,t} \times ln(K_{it})$	−			0.0332*** (0.0090)	−0.0563** (0.0276)
$Improve_{i,t} \times TIME_t$	?			−0.0057 (0.0039)	−0.0315*** (0.0122)
$Improve_{i,t} \times TIME_{,t} \times ln(L_{it})$	?			0.0009 (0.0012)	−0.0140*** (0.0044)
$Improve_{i,t} \times TIME_t \times ln(K_{it})$	?			0.0010 (0.0010)	0.0101*** (0.0034)
$Improve_{i,t} \times SOX_t \times TIME_{,t}$	+			0.0051* (0.0027)	0.0269*** (0.0088)
$Improve_{i,t} \times SOX_t \times TIME_t \times ln(L_{it})$	+			−0.0002 (0.0008)	0.0085*** (0.0032)
$Improve_{i,t} \times SOX_t \times TIME_t \times ln(K_{it})$	?			−0.0009 (0.0007)	−0.0075*** (0.0025)
$lnSIZE_{i,t}$	+	0.0932*** (0.0033)	0.0616*** (0.0035)	0.0781*** (0.0024)	0.0810*** (0.0054)
Intercept	?	4.011*** (0.0284)	3.983*** (0.0271)	4.000*** (0.0197)	3.942*** (0.0533)
>N		44,503	39,844	84,347	35,968
Adjusted R^2		0.968	0.961	0.966	0.965

Notes: This table examines the change in firm productivity and the output elasticities of labor and capital in the post-SOX period. This table differs from Table III in that we examine whether the changes in productivity and elasticities differ between firms that have an improvement in their internal control as reported in their Section 302 reports and other firms. We expect that the impact of the SOX is most prevalent in firms that experience an improvement in their internal control systems because of the enhancement in reporting quality and monitoring mechanism introduced by the SOX. Ln(L_{it}) is the logarithm of the number of employees. Ln(K_{it}) is the logarithm of the net value of property, plant and equipment measured at the beginning of the year. *SOX is a dummy variable that takes on a value of 1 if the sample period is after 2002 and 0 otherwise. TIME* is the difference between the observation year and 1990. *Improve* is a dummy variable that takes on a value of 1 if the firm reported an improvement in its internal control system per requirement of SOX (i.e. from an ineffective internal control to an effective one). *Ln(SIZE)* is the natural logarithm of market capitalization of a firm at the beginning of a year. We use the fixed-firm-effect model in estimating the abovementioned specification and the standard errors are robust standard errors calculated using Huber (1967) and White (1980, 1982) method; ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level (2-sided tests) noises and u_{it} is a one-sided error term that measures the production inefficiency (Aigner *et al.*, 1977). We follow Battese and Coelli (1992) and assume that v_{it} is distributed as N $(0, \sigma_v^2)$ and $u_{it} = u_i e^{-\eta(t-T)}$ with u_i distributed independently of v_{it} and derived from non-negative truncations of the N (μ, σ_u^2) distribution, where η is an unknown scalar parameter[16]. Then, as shown by Battese and Coelli (1992), the density function of the composed error term $\varepsilon_{it} = v_{it} - u_{it}$ derived jointly from that of u_{it} and v_{it} by convolution is given as follows:

$$f(\varepsilon_{it}) = \frac{[1 - F(-\mu_i^*/\sigma_i^*)]\exp -\frac{1}{2}\{(\varepsilon_{it}/\sigma_v^2) + (\mu/\sigma_u)^2 - (\mu_i^*/\sigma_i^*)^2\}}{(2\pi)^{T_i/2}\sigma_v^{T_i-1}[\sigma_v^2 + \eta^2\sigma_u^2]^{1/2}[1 - F(-\mu/\sigma_u)]} \tag{6}$$

where F(.) is the standard normal distribution function, $\mu_i^* = \mu\sigma_v^2 - \eta\varepsilon_{it}\sigma_u^2/\sigma_v^2 + \eta^2\sigma_u^2$ and $\sigma_i^{*2} = \sigma_v^2\sigma_u^2/\sigma_v^2 + \eta^2\sigma_u^2$. The estimated technical efficiency, TE_{it}, of the *i*th firm at the *t*th time period can be calculated as follows (Battese and Coelli, 1992; Kumbhakar and Lovell, 2000, p. 113):

$$TE_{it} = E[e^{-u_{it}}|e_{it}] = \left\{\frac{1 - F(\eta_{it}\sigma_i^* - (\mu_i^*/\sigma_i^*))}{1 - F(-\mu_i^*/\sigma_i^*)}\right\} e^{-\eta_{it}\mu_i^* + \frac{1}{2}\eta_{it}^2\sigma_i^{*2}} \tag{7}$$

We estimate the stochastic frontier model using the maximum likelihood estimation (MLE). The results are reported in Panel A of Table V. As we can observe from Table V Panel A, coefficients of all SOX terms are qualitatively similar to those reported in Table III. Specifically, we observe a significant improvement both in productivity and the output elasticity of labor, while the output elasticity of capital drops after the SOX. We also evaluate the null hypothesis that all the SOX and its interaction terms have coefficients of zero (i.e. a test of the coefficient of $SOX_t = SOX_t{*}TIME_t = SOX_t{*}TIME_t{*}ln(L_{it}) = SOX_t{*}TIME_t * ln(K_{it}) = 0$) based on the likelihood ratio, distributed asymptotically as chi-squared with degrees of freedom equal to the number of restrictions being imposed (Greene 2000, p. 152; Callen *et al.*, 2005). Our untabulated likelihood ratio test results using chi-squared statistics indicate that the restricted model with all the SOX terms having identically zero coefficients is rejected at the 1 per cent significance level for the full sample as well as for the manufacturing firms. Thus, we use the unrestricted frontier model to estimate technical efficiency.

Note that the estimate of σ_u is statistically significant, indicating the existence of technical inefficiency among the firms[17]. The estimate of σ_u (2.167 for the full sample and 2.166 for the manufacturing firms) is significantly greater than that of σ_v (0.325 for the full sample and 0.304 for the manufacturing firms). This suggests that the variation in productivity across firms can be attributed mainly to changes in technical inefficiency rather than random noises.

The estimate of η is significantly different from zero, suggesting that the stochastic frontier model we use with time-varying technical efficiencies of firms is a proper specification (Battese and Coelli, 1992).

To examine whether firms reporting an improvement in their control systems experience a larger increase in their technical efficiency, we perform a correlation analysis as in Callen *et al.* (2005) between the change in estimated technical efficiency (from the pre-SOX to the post-SOX period) and the dummy variable *Improve* defined

Table V. Empirical results of the SOX's impact on firm productivity–stochastic frontier estimation

Variables	Pred. signs	(1) Full coefficient estimates (SE)	(2) Manufacturing only coefficient estimates (SE)
Panel A: MLE estimation			
$ln(L_{i,t})$	+	0.704*** (0.002)	0.786*** (0.005)
$ln(K_{i,t})$	+	0.177*** (0.002)	0.218*** (0.004)
$TIME_t$	+	−0.017*** (0.001)	0.003* (0.002)
$TIME_t \times ln(L_{it})$	?	−0.005*** (0.0003)	0.001* (0.001)
$TIME_t \times ln(K_{it})$	?	0.005*** (0.0003)	−0.0001 (0.001)
SOX_t	?	−0.340*** (0.0287)	−0.458*** (0.0429)
$SOX_t \times TIME_t$	?	0.035*** (0.002)	0.042*** (0.003)
$SOX_t \times TIME_t \times ln(L_{it})$	?	0.003*** (0.0002)	0.004*** (0.0005)
$SOX_t \times TIME_t \times ln(K_{it})$	?	−0.002*** (0.0002)	−0.002*** (0.0004)
$lnSIZE_t$	+ ?	0.157*** (0.001)	0.052*** (0.001)
Intercept		3.797*** (0.008)	4.140*** (0.015)
σ_u		2.167*** (0.009)	2.166*** (0.015)
σ_v		0.325*** (0.001)	0.304*** (0.001)
μ		−1.740*** (0.022)	−1.740*** (0.038)
η		0.134*** (0.000)	0.136*** (0.000)
N		89,700	38,411
Log-likelihood		27,932.46	24,330.27
Panel B: Correlation between change in technical efficiency and improvement in internal controls			
		Coefficient (significance level)	Coefficient (significance level)
Pearson		0.0331 (0.001)	0.0267 (0.001)
Spearman		0.0501 (0.001)	0.0339 (0.001)

Notes: This table examines the change in firm productivity and the output elasticities of labor and capital in the post-SOX period using stochastic frontier estimation method. The analyses in this table are the same as in Table III except that we use MLE instead of OLS in estimating the model. To compare the change in technical efficiency of firms reporting an improvement in their internal control systems versus those without such a reported improvement, we regress the estimated change in technical efficiency, computed as the difference between average technical efficiency in the post-SOX period and that in the pre-SOX period, on a dummy variable, *Improve*, that takes on a value of 1 if the firm reported an improvement in its internal control system per requirement of SOX (i.e. from an ineffective internal control to an effective one) and 0 otherwise. We estimate the model by MLE; ***Significant at the 1% level; **significant at the 5% level; *significant at the 10% level

earlier. We present Pearson and Spearman correlation coefficients in Panel B of Table V. Evidently, the change in technical efficiency is positively and significantly correlated with *Improve* at the 1 per cent level (i.e. Pearson correlation coefficient = 0.0331 for the full sample and 0.0267 for the manufacturing firms; Spearman correlation coefficient = 0.0501 for the full sample and 0.0339 for the manufacturing firms). Thus, we do observe that the improvement in technical efficiency in the post-SOX period is statistically more significant for firms reporting an improvement in their internal control systems. Alternatively, we exclude our control for firm size from the stochastic frontier model in the first-stage analysis, and then include firm size in our second stage as a separate regressor in an ordinary least squares (OLS) regression analysis of technical efficiency changes on *Improve*. The untabulated results are similar to those reported in Panel B of Table V.

6. Conclusion

The SOX was enacted to protect investors by improving the accuracy and reliability of corporate financial reporting. However, opponents of the SOX criticize that the Act diverts management's effort from the important strategic planning and day-to-day operations of the firm toward mere compliance work, leading to a decrease in firm value and performance. In this paper, we directly test this claim by examining the impact of the SOX on firm productivity initially. Contrary to the criticism, we observe that, although the SOX has a negative impact on firm productivity, it is associated with improved productivity over time. The SOX also has a positive effect on the output elasticity of labor but a negative impact on the output elasticity of capital. In other words, there is a shift in the contribution from capital toward labor in the post-SOX period. While compliance with the SOX can be costly, "it is not without corresponding benefits". In this regard, we find an improvement in firm productivity over time post-SOX, possibly due to the enhancement in overall corporate governance and the internal control system. In fact, we find that firms with an improvement in their internal control systems experience significantly larger improvement in their productivity.

In conclusion, our results indicate that the overall benefits of the SOX seem to outweigh its costs as evidenced by the improved firm productivity. This productivity improvement in the post-SOX period was attributable to the efficient utilization of human resources. However, the decreased output elasticity of capital may serve as a warning of potential future productivity decline. Furthermore, since the financial crisis started in 2007, our observed productivity gain of SOX might be lost from 2007 onward. Therefore, it will be interesting for future study to extend the sample period beyond 2006 to evaluate whether the productivity gain of SOX sustained after 2007.

Notes

1. Please see Prentice (2007) and Prentice and Spence (2007) for a survey of the criticisms on the Act.
2. Please see Hulten (2000) for a literature review of TFP. Also, please see Kumbhakar and Lovell (2000) and Coelli *et al.* (2005) for detailed discussion on various approaches to estimating productivity.
3. Even though they do not look at the internal control over financial reporting directly, their results suggest that improvement in controls systems can contribute to better performance.
4. A survey by Charles River Associates (2005) on a sample of 90 of the Fortune 1000 firms (with an average gross revenue of $8.1 billion) shows that the firms spent an average of $7.8 million to comply with Section 404.
5. The Dodd-Frank Wall Street Reform and Consumer Protection Act enacted in 2010 allows smaller public companies (under $75 million in market cap) to be permanently exempt from having independent auditor test and report on the effectiveness of their internal controls over financial reporting.
6. Section 202 of SOX requires a firm's audit committee to comprise entirely of independent directors. It further requires that all auditing and permitted non-auditing services be pre-approved by this audit committee.
7. We do not control for prices of outputs because pricing data are unavailable to us. As a result, our productivity measure could mix up technical and allocative efficiencies. We acknowledge the reviewer for this comment.

8 While management can manipulate profits via both accrual management and real earnings management, the manipulation of sales via accrual management is difficult. Management can still use such real earnings management activities as offering price discounts or offering more

lenient credit terms (Roychowdhury, 2006) to increase sales (our measure of outputs). In addition, management can use channel stuffing to inflate sales. These earnings management tactics, however, are more costly than accrual management. Thus, using sales as a measure of outputs is less likely to suffer from accrual management, but it is not free from real earnings management.

9. The Cobb–Douglas production function that we adopt in this study will lead to biased estimates if labor and capital shares of total output were not constant over time; there is a positive decreasing marginal product of inputs; and the underlying production technology indeed varies across firms.
10. Our model specification can suffer from potential endogeneity problem given that output and inputs are determined simultaneously.
11. When we include year 2002 as part of the post-SOX period, we find similar but somewhat weaker results than those without including year 2002, suggesting that firms were anticipating the effect of SOX to some extent.
12. Our sample distribution across industries differs from that of Compustat because of missing data for some firm-years in the Compustat database. We include only firms with all the required financial data for our analyses in the sample.
13. This size variable helps to control for scale efficiency.
14. The interpretation of this result must be cautious because our assumption that all manufacturing firms operate under the same technology and market structure may not hold. We thank the reviewer for pointing out this limitation.
15. The standalone term of *Improve* is dropped from the final sample estimation because we use the fixed-firm-effect model for our estimation and there is perfect collinearity between *Improve* and the firm dummies.
16. This specification of one-sided error term implicitly assumes that SOX does not affect technical efficiency directly. That is, SOX improves technical efficiency indirectly through the improvement in internal controls.
17. This could be indicative of a skewed residual arising from model misspecification. We thank the reviewer for pointing out this possibility.

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