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SOX, corporate transparency, and the cost of debt ☆

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ABSTRACT

We investigate the impact of the Sarbanes–Oxley (SOX) Act on the cost of debt through its effect on the reliability of financial reporting. Using Credit Default Swap (CDS) spreads and a structural CDS pricing model, we calibrate a firm-level corporate opacity parameter in the pre- and post-SOX periods. Our analysis shows that corporate opacity and the cost of debt decrease significantly after SOX. The median firm in our sample experiences an 18 bp reduction on its five-year CDS spread as a result of lower opacity following SOX, amounting to total annual savings of $ 844 million for the 252 firms in our sample. Furthermore, the reduction in opacity tends to be larger for firms that in the pre-SOX period have lower accrual quality, less conservative earnings, lower number of independent directors, lower S& P Transparency and Disclosure ratings, and are more likely to benefit from SOX-compliance according to Chhaochharia and Grinstein's (2007) criteria.

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1. Introduction

The enactment of the Sarbanes–Oxley (SOX) Act in July 2002 is arguably one of the most significant regulatory events in the recent history of US capital markets. Advocates of the Act claim that its main objective was to "rebuild public trust in US capital markets" after a series of accounting scandals (Cohen et al., 2008; Jorion et al., 2009; Healy and Palepu, 2003). To that end, the Act contains several mandates aiming to increase corporate transparency through more reliable corporate reporting. According to Coates (2007), the two core components of such mandates are the creation of a quasi-public institution to supervise auditors, and the enlisting of auditors to enforce new disclosure rules giving firms incentives to tighten financial controls.

The Sarbanes–Oxley Act imposes both direct and indirect costs on public firms. Direct out-of-pocket costs include internal compliance costs and increased audit fees (Iliev, 2007), while indirect costs arise from sub-optimal disclosure under tighter constraints compared to laxer ones (Verrecchia, 1983). The indirect costs of excessive disclosure may include competitive disadvantages in product markets; bargaining disadvantages with customers, suppliers, and employees; and increased risk exposure of top officers resulting in risk avoiding behavior (Hermalin and Weisbach, 2007; Bargeron et al., 2010; Kang and Liu, 2010). The benefits of the new legislation, if any, are still under debate.[1]

In this paper we focus on an aspect of SOX that has received little attention: the effect of the Act on the cost of debt capital due to presumably higher reliability of corporate reporting. Admittedly, we do not provide a full cost–benefit analysis of the Act. Instead we attempt to shed light on a particular effect of the legislation that is arguably hard to measure. Our results show a median decrease in the cost of debt of 17.7 basis points per year for our sample firms due to an increase in corporate transparency as perceived by investors. This effect is economically large considering that the risk-free rate and the median credit spread were respectively 330 and 111 basis points in the period immediately after the passage of the Act. In dollar terms, the perceived improvement in the quality of financial reporting translates into total savings of US$

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[1] See Akhigbe and Martin (2006, 2008), Bushee and Leuz (2005), Chhaochharia and Grinstein (2007), Zhang (2007), Leuz (2007), Iliev (2007), Hostak et al. (2013), and Ashbaugh-Skaife et al. (2008), for analyses of the economic consequences of SOX.

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843 million per year for the 252 firms in our sample. Consistent with previous studies, our evidence indicates that the effect of the Act depends on firms' predictable characteristics (Akhigbe and Martin, 2006; Chhaochharia and Grinstein, 2007; Zhang, 2008). Specifically, the reduction in opacity perceived by investors following SOX is larger for firms that are less transparent according to the 2002 S& P Transparency and Disclosure Index, have lower earnings quality in the pre-SOX period, have a lower number of independent directors, and are more likely to be affected by SOX according to the criteria used in Chhaochharia and Grinstein (2007).

Perhaps the large effect of SOX on credit spreads we document is not surprising: recent research underscores the importance of corporate transparency for the pricing of debt-related contracts. Duffie and Lando (2001) develop a model showing that corporations with less reliable financial reports have higher secondary market credit spreads due to the asymmetric nature of cash flows from debt contracts. This occurs even when investors are risk-neutral and symmetrically informed. The Duffie–Lando model is able to generate non-negligible short-term credit spreads for investment grade corporations, a robust empirical phenomenon that is hard to explain in a full information framework. Empirical research by Anderson et al. (2004), Ball et al. (2008), Duarte et al. (2008), Lu et al. (2010), Mansi et al. (2004), Sengupta (1998), Wittenberg-Moerman (2008), Yu (2005), and Zhang (2008) corroborates the importance of corporate transparency for debt pricing.

A contemporaneous and independent paper by DeFond et al. (2011) also studies the impact of SOX on debt prices. Using cumulative "abnormal" changes in corporate bond spreads over 13 short-term windows surrounding events leading up to the passage of SOX, they conclude that the Act increased the cost of debt by 20 basis points. Our work differs from theirs in at least three important ways. First, in the same spirit of Chhaochharia and Grinstein (2007), we use long pre- and post-SOX windows rather than price changes over a few days around selected pre-enactment events.[2] Second, our analysis relies on CDS spreads, not corporate bond prices. The secondary market for corporate bonds is less liquid, with larger bid–ask spreads than the CDS market, which may pose a challenge for event spreads study analyses, particularly those with short event windows such as DeFond et al. (2011).[3] Third, we rely on spread *levels* and a structural pricing model to calibrate firm-period specific opacity parameters, and use the latter to evaluate the effect of SOX on the cost of debt through its effect on the reliability of corporate reports.[4] In contrast, DeFond et al. use OLS regressions to detect "abnormal" *changes* in spreads. In the next section we argue that non-linearities, interaction terms, and endogeneity cast doubt on the use of OLS regressions to address the effect of SOX on credit spreads.

The effect of SOX on the cost of debt capital is related to additional areas of the literature. Several studies examine the cost of debt and how it relates to corporate governance. Studies that examine board characteristics, structures, and provisions include: Anderson et al. (2004), Bradley and Chen (2011), Chen (2012), and Flieds et al. (2012). Other studies that examine the impact of governance on debt prices include Klock et al. (2005) and Boubakri and Ghouma (2010).

It is difficult to capture every factor that drives credit spreads.[5] Therefore, we explore several alternative explanations that could impact our analysis. The two main factors that may impact our analysis and are not directly captured in the model are changes in systematic risk and changes in liquidity over time. Since prices of risk in the credit market may change over our sample period, we control for known systematic risk factors in our robustness check. We provide evidence that the reduction in opacity after SOX is not due to changes in risk premia. Perhaps a more important issue is the rapid expansion of the CDS market over time. The number of dealers and gross notional dollar volume expanded during our sample period. If a liquidity premium priced in the level of CDS spreads declined post-SOX, it could influence our measure of opacity. We provide evidence that the increase in dealer activity does not explain the reduction in opacity post-SOX.

The rest of the paper is organized as follows: in Section 2, we describe our methodology and data, and develop three hypotheses whose empirical tests are reported in Section 3. In this section, we also estimate the effect of SOX due to increased reliability of corporate financial reporting, the main goal of the paper. In Section 4, we show that our results are robust to plausible alternative explanations of our main findings and to sensible variations in our calibration procedure. Section 5 concludes the paper.

2. Methodology, data, and testable hypotheses

We measure the cost of debt using credit spreads from Credit Default Swap (CDS) contracts. A CDS is an over-the-counter insurance contract on debt. The buyer and seller of insurance agree on a reference corporate bond and on a notional value for the contract; for example, US$ 10 million. The buyer of insurance pays the quoted spread times $10 million to the seller of insurance, typically on a quarterly basis, and obtains the right to sell bonds with a face value of $10 million, at their face value, to the seller of insurance in the event of corporate default.

CDS and corporate bond spreads are closely related theoretically and empirically (Duffie, 1999; Blanco et al., 2005). However, there are several advantages in using CDS rather than bond spreads in our research. First, CDS spreads are quoted directly, as opposed to bond spreads that depend on the arbitrary choice of a default-free term structure of interest rates. Second, traded CDS spreads have a fixed maturity, so it is not necessary to control for changes in time to maturity. Third, the CDS market has become much more liquid than the secondary market for corporate bonds; therefore, CDS market prices are in principle more reliable (Hull et al., 2004; Blanco et al., 2005). Finally, in contrast to corporate bonds, there is no reason to believe that illiquidity in the CDS market affects the average level of a firm's CDS spread because a CDS is a derivative contract, not an asset (Longstaff et al., 2005).

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[2] Both Chhaochharia and Grinstein (2007) and Zhang (2007) study the effect of SOX on firm value. Using short-term event windows surrounding events leading up to the passage of SOX, Zhang (2007) concludes that, in value-weighted aggregation, SOX reduced firms' value. Chhaochharia and Grinstein (2007) use long term windows and reach the opposite conclusion.

[3] Ait-Sahalia et al. (2005) show that in markets whose prices are affected by microstructure noise, short-window price variations are more affected by noise than longer-window price variations.

[4] Ball et al. (2008) propose a measure of accounting quality based on the goodness-of-fit of a model of credit rating changes as a function of lagged earnings. In contrast, our opacity parameter is calibrated from the levels of CDS spreads and current market and accounting information.

[5] As one anonymous referee pointed out to us, the ideal experiment would be to compare the CDS of firms affected and not-affected by SOX around the passage of SOX. One candidate control sample for this difference-in-differences approach would be foreign firms. However, foreign firms cross-listed in the US are also subject to SOX. Therefore, the control sample would contain non-cross listed foreign firms only. Unfortunately, as of 2002, the overwhelming majority of non-US firms with CDS trading were in fact cross-listed in the US. For example, among the 311 European firms with 5-year CDS quotes available in the Markit database prior to SOX, we verified that 292 of them were cross-listed in the US. Of the 19 (311–292) non-cross-listed firms, 5 are financial firms, excluded from our analysis. Therefore, the potential control group of non-cross-listed, non-financial firms contains just 14 firms. This sample is too small for a meaningful difference-in-differences approach.

2.1. CDS pricing model

Corporate transparency is only one of several determinants of credit spreads. In order to measure the change in spreads due to a change in corporate reporting reliability, we need to control for changes in the other spread determinants. Controlling for other spread determinants using OLS regressions could lead to misspecification because of non-linearities and interaction terms, and because of an important endogeneity issue.

First, structural debt pricing models indicate that the derivative of credit spreads with respect to a given spread determinant depends crucially on the level of that factor and of other factors. In other words, the impact of credit spread determinants is highly non-linear and includes important interactions among the factors. Empirical research by Schaefer and Strebulaev (2008) confirms that non-linearities and interactions are economically significant. The authors show that the sensitivity of credit spreads to leverage is much higher at high spread levels than at low spread levels. Therefore, regressions of credit spreads would have to group firms by spread levels at the minimum. Ideally, the regression specification would include numerous powers and cross-products of the explanatory variables.

Second, firms with less reliable corporate reporting, recognizing that they are charged relatively high interest rates, may choose to take on less debt. Therefore, if corporate opacity is imperfectly measured with existing proxies, OLS regressions of credit spreads on leverage and other explanatory variables yield biased and inconsistent coefficient estimates because the residual is correlated with explanatory variables. Research by Molina (2005) indicates that the endogeneity of leverage is more than a mere technicality: accounting for it increases the effect of leverage on default probabilities by a factor of three.[6] Analogously, the endogeneity of leverage should matter for the relation between credit spreads and leverage.

We address these empirical difficulties by using a structural debt pricing model that explicitly incorporates the effect of accounting reliability, along with all the other credit spread determinants. We rely on the CreditGrades model, which delivers a simple, analytical debt pricing formula. The model was jointly developed by Goldman Sachs, JP Morgan, and Deutsche Bank and is a popular debt pricing tool among practitioners. According to Currie and Morries (2002), the CreditGrades model was the industry standard CDS pricing model as of 2002. Attesting to the popularity of the model, Yu (2006) and Duarte et al. (2007) use the CreditGrades model in recent research.

In contrast to models of debt pricing under full information, the CreditGrades model explicitly incorporates a parameter representing uncertainty about the true level of a firm's liabilities. The logic underlying this extension is that the level of liabilities reported on the firm's balance sheet is potentially different from the level of liabilities that will drive a corporation to default. We refer to this uncertainty parameter as "corporate opacity." Our research strategy is to calibrate this parameter for each firm in the pre- and post-SOX periods by minimizing the sum of squared differences between market and model-implied prices. By using firm-level changes in calibrated corporate opacity in the pre- and post-SOX periods, we control for all of the other credit spread determinants in the model, taking into account interactions between them and non-linear effects.[7]

Table 1
Sample mean and standard deviation of inputs of the CDS Spread Pricing model. This table reports the cross-sectional means and standard deviations of time-series averages of inputs required by the CreditGrades CDS pricing model. The sample has 252 firms. *Pre-SOX Period* is January/2001 to July/2002, *Post-SOX Period is* August/2002 to December/2003. *CDS Spread* is the 5-year spread expressed in basis points, for contracts with the Modified Restructuring clause. *Equity Volatility* is the annualized 5-year equity volatility forecast at a point in time from a GARCH (1, 1) model fitted using daily stock returns in January/2001–September/2007. *Risk-free rate* is the 5-year swap rate minus 10 basis points. *Recovery Rate* is the recovery rate in case of default reported by Markit. *(1 Minus Leverage)* is equal to stock price divided by the stock price plus liabilities per share. *Number of Time-Series Obs.* is the number time-series observations used to perform the calibration.

	Pre-SOX Period		*Post-SOX Period*	
	Mean	Std. dev.	Mean	Std. dev.
CDS spread (bp)	120.2	112.8	112.7	119.3
Equity volatility	0.330	0.120	0.331	0.118
Risk-free rate	0.049		0.033	
Recovery rate	0.428	0.037	0.411	0.019
One minus leverage	0.604	0.192	0.574	0.190
Number of time-series obs.	261	125	350	58

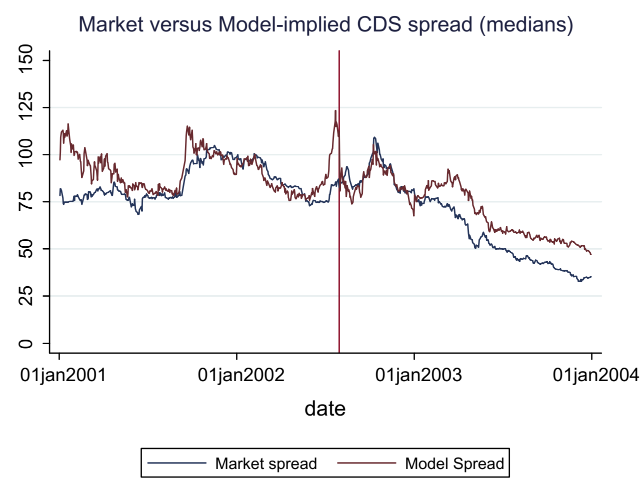

Fig. 1. Market spreads versus model spreads (medians).

2.2. CDS pricing formula

The CreditGrades CDS pricing model requires eight inputs: time to expiration T, stock price S, equity volatility σ_S, recovery rate R, risk-free rate r, reported liabilities per equity share D, expected location of the default boundary as a fraction of liabilities $\bar{L}$, and a parameter λ representing uncertainty about the location of the default boundary. Formally, λ is the standard deviation of the log of the default boundary as a fraction of liabilities. We interpret λ as a measure of corporate opacity because when reported liabilities are less reliable there is more uncertainty about the true level of liabilities that will drive the firm to default. The CreditGrades

[6] Molina (2005) attributes the leverage endogeneity problem to imperfect measurement of fundamental risk: equity or asset volatility would be imperfect proxies of fundamental business risk, therefore OLS regressions that attempt to control for fundamental risk by adding volatility as an explanatory variable (along with leverage) would yield biased and inconsistent coefficients. Our point about the imperfect measurement of corporate transparency provides *additional* motivation for the leverage endogeneity problem. Molina (2005) uses IV estimation to circumvent the leverage endogeneity problem, using the history of firms' past market valuations and firms' marginal tax rates as instruments for the effect of leverage on default probabilities.

[7] A similar approach to account for non-linearity and interactions among credit spread determinants is used by Davydenko and Strebulaev (2007). To study the effect of strategic interactions between shareholders and debtholders on credit spreads, while taking account of other spread determinants, the authors compute the difference between actual spreads and spreads implied by a structural debt pricing model without such strategic interactions. Then they regress these residuals onto theoretically motivated variables that might explain strategic interactions.

Table 2
Definition of variables. This table describes the variables used in the analysis. Accruals Quality, Discretionary Accruals, and Earnings Conservativism are calculated with up to 10 years of yearly data ending in 2001, as in Francis et al. (2004).

Variable	Definition
Pre-SOX opacity	Corporate opacity parameter λ calibrated using the CreditGrades CDS pricing model and daily CDS spreads in the period of January/2001–July/2002
Post-SOX opacity	Same as above, in the period of August/2002–December/2003
2004 and 2005 ppacity	Same as above, in the periods of January/2004–December/2004 and January/2005–December/2005
Accruals quality	Based on Dechow and Dichev's (2002) regression relating a firm's current accruals to lagged, current, and future operating cash flows: $\left(\frac{TCA}{Assets}\right)_t = \phi_0 + \phi_1 \frac{CFO_{t-1}}{Assets_t} + \phi_2 \frac{CFO_t}{Assets_t} + \phi_3 \frac{CFO_{t+1}}{Assets_t} + \upsilon_t.$ Accruals quality is (minus) the standard deviation of residuals from the regression above.
Discretionary accruals	Industry and performance-matched absolute abnormal accruals calculated from the cash flow statement and using the Jones (1991) model (Kothari et al., 2005). Averages of 1999, 2000 and 2001 values
Earnings conservativism	Based on Basu's (1997) regression relating a firm's earnings to its stock returns: $Earn_t = \alpha_0 + \alpha_1 NEG_t + \beta_1 RET_t + \beta_2 NEG_t \times RET + \epsilon_t,$ where $NEG_t = 1$ if $RET_t < 0$ and 0 otherwise. Conservatism is $(\beta_1 + \beta_2)/\beta_1$, normalized to have zero mean and unit variance
Number of independent directors	Number of independent directors in the Board according to the IRRC database. IRRC defines an independent director as director who is neither affiliated nor currently an employee of the company. An affiliated director is: a former employee of the company or a majority-owned subsidiary, a provider of professional services to the company or its executives, a costumer or supplier of the company, a significant shareholder, a director who controls more than 50% of the voting power, a family member of an employee, or an employee of an institution that receives charitable gifts from the company
Firm age	Number of decades a firm's common equity appears in the CRSP database
S& P transparency and disclosure rating	Transparency and disclosure rating of Patel and Dallas (2002), based on all corporate reports
Chhaochharia and Grinstein's (2007) dummy	1 If until November/2001 the firm has: restated earnings, or related party transactions, or instances of illegal insider trading. 0 otherwise.
Market factor loading	Slope of regression of excess stock returns onto CRSP value weighted market excess returns. Daily data in January/2001–July/2002 or August/2002–December/2003
TERM factor loading	Slope of regression of CDS-implied excess bond returns onto excess returns of portfolio long in Merrill Lynch 10-year US Treasury Bond Index and short in 30-day Treasury bond index. Daily data in January/2001–July/2002 or August/2002–December/2003
DEF factor loading	Slope of regression of CDS-implied excess returns onto excess returns of portfolio long in Merrill Lynch BBB Corporate Bond Index and short in AAA Corporate Bond Index. Daily data in January/2001–July/2002 or August/2002–December/2003
Ratio of short-term to total liabilities	The time-series average of the ratio of current liabilities to total adjusted liabilities, defined as total liabilities minus minority interest and deferred taxes. Period is January/2001–July/2002
Credit rating	Time-series median of S& P numerical credit rating (AAA is 10 and D is 1) in January/2001–July/2002
Number of quoting dealers	Time-series median of the number of CDS dealers quoting the 5-year CDS spread to Markit for the periods: January/2001–July/2002, August/2002–December/2003, January/2004–December/2004, January/2005–December/2005
Time in TRACE	Fraction of the August/2002–December/2003 period in which firm has bonds included in the TRACE reporting system
Market capitalization	Number of shares outstanding times price of share from the CRSP data as of 12/31/2001. In billions of dollars
Stock return volatility	Average annualized stock return volatility calculated from daily data in the period of January/2001–July/2002

Technical Document, 2002CreditGrades manual (2002) shows that the CDS spread can be well approximated by:

$$c(T) = r(1-R)\frac{1 - q(0) + H(T)}{q(0) - q(T)e^{-rT} - H(T)} \tag{1}$$

The function $q(\cdot)$ is defined as

$$q(t) = \Phi\left(-\frac{A(t)}{2} + \frac{\ln(d)}{2}\right) - d\Phi\left(-\frac{A(t)}{2} - \frac{\ln(d)}{A(t)}\right), \tag{2}$$

where $\Phi(\cdot)$ is the standard normal c.d.f. and

$$d = \frac{S + \bar{L}D}{\bar{L}D}e^{\lambda^2}; \quad A(t) = \sqrt{\sigma^2 t + \lambda^2}; \quad \sigma = \sigma_S \frac{S}{S + \bar{L}D}.$$

Finally,

$$H(T) = e^{r\xi}(G(T+\xi) - G(\xi)), \tag{3}$$

where

$$G(t) = d^{z+\frac{1}{2}}\Phi\left(-\frac{\ln(d)}{\sigma\sqrt{t}} - z\sigma\sqrt{t}\right) + d^{-z+\frac{1}{2}}\Phi\left(-\frac{\ln(d)}{\sigma\sqrt{t}} + z\sigma\sqrt{t}\right), \tag{4}$$

and

$$\xi = \frac{\lambda^2}{\sigma^2} \tag{5}$$

$$z = \frac{1}{4} + \frac{2r}{\sigma^2}. \tag{6}$$

2.3. Data sources and sample selection

Using daily CDS quotes, we calibrate a corporate opacity parameter λ for each firm by minimizing the sum of squared differences between market CDS spreads and model-implied CDS spreads. We calibrate separate parameters before and after the enactment of SOX for each firm in the sample. We define the pre-SOX period as January 1, 2001 to July 31, 2002, and the post-SOX period as August 1, 2002 to December 31, 2003. To perform the calibrations, we require each firm in the sample to have at least 30 CDS quotes in the pre-SOX period and 30 CDS quotes in the post-SOX period. We restrict the sample to non-financial firms and main entities, as opposed to subsidiaries.

Markit Partners provided us with the CDS data.[8] Markit collects OTC dealer quotes on different CDS tenors on a daily basis. Until recently, volume in the CDS market was concentrated in 5-year

[8] The Markit database starts in January 2001, which limits our flexibility to define the pre-SOX period.

Table 3
Is the calibrated corporate opacity parameter associated with firm characteristics related to corporate reporting reliability? This table reports mean and medians of Pre-SOX Opacity parameters. Firms are grouped by characteristics related to corporate reporting reliability. The row labeled *Difference* reports the difference between the mean and median of the corporate opacity parameter across firm groups. The figures in *italics* are two-sided *p*-values for tests of the null hypothesis of no difference in means or medians. *p*-Values are calculated using *t*-tests with unequal variances for difference of means and Fisher exact *p*-values for difference of medians.

Pre-SOX opacity		
	Mean [std. error]	Median
(A) Accruals quality		
Low	0.865	0.695
($N = 115$)	[0.057]	
High	0.521	0.460
($N = 115$)	[0.041]	
Diff.	−0.344	−0.235
p-Val.	<0.000	<0.000
(B) Discretionary accruals		
Low	0.633	0.497
($N = 120$)	[0.051]	
High	0.687	0.528
($N = 120$)	[0.052]	
Diff.	0.054	0.031
p-Val.	0.462	0.699
(C) Earnings conservativism		
Low	0.730	0.535
($N = 103$)	[0.058]	
High	0.590	0.462
($N = 104$)	[0.051]	
Diff.	−0.140	−0.073
p-Val.	0.070	0.267
(D) Firm age		
Young	0.778	0.660
($N = 125$)	[0.054]	
Old	0.533	0.464
($N = 125$)	[0.042]	
Diff.	−0.245	−0.196
p-Val.	0.001	0.011
(E) Number of independent directors		
Low	0.742	0.640
($N = 80$)	[0.067]	
High	0.589	0.472
($N = 111$)	[0.048]	
Diff.	−0.153	−0.168
p-Val.	0.065	0.028
(F) S& P transp. & discl. 2002 ratings		
Low	0.713	0.535
($N = 65$)	[0.053]	
High	0.581	0.491
($N = 124$)	[0.062]	
Diff.	−0.132	−0.044
p-val.	0.110	0.286

contracts. Since we want liquid market quotes in our model calibration, we focus on the 5-year contract, as do other researchers. Also following the literature, we focus on US dollar denominated senior unsecured CDS contracts with the modified restructuring clause (e.g. Jorion and Zhang, 2007).

In addition to the corporate opacity parameter λ, there are seven additional inputs required to price the CDS as shown by Eqs. (1)–(6). The time to expiration is fixed at $T = 5$ years. The stock price S is the common stock closing prices from CRSP. Following Hull et al. (2004), the risk-free rate r is the 5-year swap rate minus 10 basis points. Liabilities per share D is total liabilities minus minority interest and deferred taxes divided by the number of shares outstanding. Balance sheet information is from COMPUSTAT, based on the most recent annual statement available to investors at the time the market prices are quoted. The recovery rate R is from the Markit database, following Zhang et al. (2009). Along with CDS quotes, Markit also collects a daily firm-specific estimate of the recovery value on a defaulted bond referenced by the CDS contract, provided by the quoting CDS dealers. Equity volatility σ_S is the 5-year forecast from a GARCH (1,1) model fit on the full sample period, following Engle's (2001) statement that GARCH (1,1) is the "simplest and most robust of the family of volatility models."[9]

The seventh additional input required to price the CDS is the expected default boundary as a fraction of reported liabilities, $\bar{L}$. The CreditGrades Technical Manual (2002) suggests using the expected default boundary $\bar{L} = \frac{1}{2}$ for all firms. We do this as a robustness check. In our base results we choose a different $\bar{L}$ for each industry, chosen in order to maximize the total number of firm-day observations in that industry in which market spreads are within the range of spreads that can be delivered by the CreditGrades model for all values of λ. After finding such $\bar{L}$s, we calibrate λ for each firm-period so as to minimize the sum of squared differences between market and model CDS spreads. Appendix A provides additional details on the CreditGrades model and its calibration.

2.4. Data overview

Our sample includes 252 firms after merging the Markit database with CRSP and COMPUSTAT, excluding financial firms and subsidiaries, and requiring at least 30 quotes per firm in each period. Sample firms are large: only 33 were not part of the S& P500 Index at some point in the sample period. Table 1 contains summary statistics for the spread and its determinants in the pre- and post-SOX periods. The reported means and standard deviations are cross-sectional summary statistics based on firm-specific time-series averages of the corresponding variable. In the table, one minus leverage is the stock price divided by the sum of the stock price and liabilities per share. Spreads are reported in basis points.

The mean spread is $119.3 - 111.2 = 8.1$ basis points lower in the post-SOX period. As the CreditGrades pricing formula shows, the CDS spread is a complex function of the model's eight inputs. Thus, increased reliability in corporate reporting may not necessarily be the driver of the decrease in spreads following SOX. Equity volatility and risk-free rates decreased in the post-SOX period which reduces credit spreads, holding other factors constant. However, average leverage increased and recovery rates decreased in the post-SOX period which increases spreads, holding other factors constant. The mean number of time-series observations in the earlier period is lower than in the post-SOX period, while its standard deviation is higher. This is because the number of firms in the Markit database has increased over time: not all 252 firms in our sample were part of the Markit database as of January 1, 2001. Each firm, however, has at least 30 observations in both the pre-SOX and post-SOX periods.

2.5. Hypotheses

Below we state the three hypotheses whose empirical validity we aim to assess. Throughout, corporate opacity refers to the uncertainty parameter λ calibrated from market prices using the CDS pricing model described earlier.

Hypothesis 1. Corporate opacity is lower for firms that have higher earnings quality, are perceived to be more transparent and to have better corporate governance.

[9] See pages 471–474 of Hull (2006). When the GARCH (1,1) estimation yields a non-stationary ("mean-fleeing") model, which happens in 25 of the 252 sample firms, we use a exponentially smoothed moving average of the previous 252 days with a smoothing coefficient of 0.94.

Table 4
Corporate opacity parameter before and after the passage of SOX. This table reports the distribution (Panel A) and tests statistics for the differences of means and medians (Panel B) between Pre-SOX and Post-SOX opacity parameters.

N = 252	Mean	StDev	Min	25Pct	Median	75Pct	Max
Panel A – Sample distribution of Pre-SOX and Post-SOX opacities							
Pre-SOX opacity	0.656	0.558	0	0.252	0.510	0.925	2.400
Post-SOX opacity	0.450	0.419	0	0.136	0.391	0.636	2.100

N = 252	Pre-SOX opacity	Post-SOX opacity	Difference	p-Val.
Panel B – Is the enactment of Sarbanes–Oxley Act associated with a significant reduction in corporate opacity? The column labeled Difference reports the difference between the mean and median of the corporate opacity parameter across the Pre-SOX and Post-SOX periods. The figures in italics are two-sided p-values for tests of the null hypothesis of no difference in means or medians. P-values are calculated using a paired t-test for means and a (paired) Wilcoxon signed-rank test for medians				
Mean	0.656	0.450	−0.206	<0.000
St. err.	[0.035]	[0.026]		
Median	0.510	0.391	−0.117	<0.000

This can be seen as external validation of the corporate opacity parameter λ. The calibrated parameter presumably measures uncertainty about a firm's true leverage as perceived by investors. We expect this uncertainty to be inversely related to quantitative measures of earnings quality. We focus on three measures: accrual quality (Dechow and Dichev, 2002; Ashbaugh-Skaife et al., 2008), abnormal accruals (Francis et al., 2008; Ashbaugh-Skaife et al., 2008), and earnings conservativism (Basu, 1997; Zhang, 2008). We also expect our calibrated opacity parameter to be inversely related to the number of independent directors in the firm's Board (Anderson et al., 2004). Moreover, calibrated opacity should be higher for younger firms which did not have enough time to build a reputation of reliable reporting, or have not yet "ironed out the kinks" in their internal control systems (Diamond, 1989; Doyle et al., 2007; Hyytinen and Pajarine, 2008). In addition to the aforementioned objective measures, we expect the corporate opacity parameter to be negatively related to measures of corporate transparency based on expert judgment, such as the publicly available S& P Transparency and Disclosure Ratings of Patel and Dallas (2002).

It is important to point out that, for the purposes of this paper, our methodology remains valid even if the calibrated parameter λ is a noisy measure of corporate opacity. Suppose that λ is a catch-all measure affected not only by corporate opacity but also by other factors, such as model error or a firm's attractiveness for leveraged buy-outs. There is no *ex ante* reason to believe that model error should systematically change after the passage of SOX. Thus, assuming its impact is constant in the pre- and post-SOX periods, changes in λ need be due to changes in corporate opacity. Furthermore, leveraged buy-out activity increased substantially following (some would argue because of) the Act, which would act to increase rather than decrease credit spreads, and consequently our calibrated opacity parameter in the post-SOX period.

Hypothesis 2. Corporate opacity decreases after the enactment of Sarbanes–Oxley.

Existing research provides evidence that corporate reporting has become more reliable after SOX (Ashbaugh-Skaife et al., 2008; Cohen et al., 2008; Dyck et al., 2010; Hutton et al., 2009; Singer and You, 2011). Recent surveys confirm research evidence. The majority of 274 finance officers surveyed by the Financial Executives Research Foundation (2006) believe that SOX increased investors' confidence in financial reports. For large firms with more than $25 billion revenues, 83% of executives in the survey agree that investors are more confident in reported numbers as a result of SOX. Furthermore, 82% of audit committee members surveyed by the Center for Audit Quality (2008) think that audit quality has improved in recent years, while 65% of committee members believe that investors have more confidence in capital markets as a result of SOX. Given the research and survey evidence, we argue that CDS market participants are less uncertain about the true level of corporate leverage following the Act. Thus, corporate transparency as perceived by investors has increased after SOX.

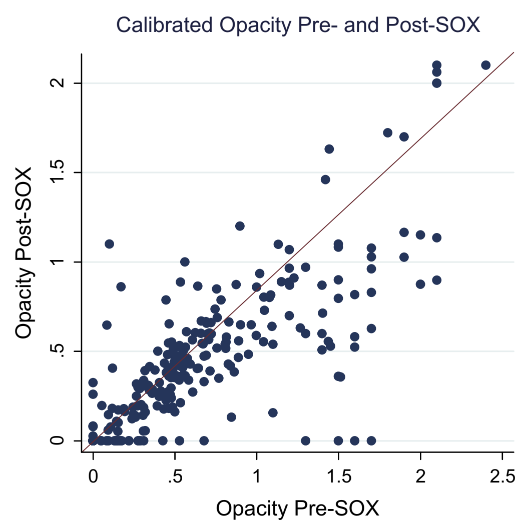

Fig. 2. Calibrated opacity parameter pre- and post-SOX.

Hypothesis 3. After the enactment of SOX, corporate opacity decreases more for firms that are more likely to be affected by the Act.

Firms whose reports are more reliable prior to SOX presumably already have better internal controls, more detailed disclosure, or more reliable auditing before the Act, which makes them less likely to be affected by the new legislation. Consistent with this notion, Chhaochharia and Grinstein (2007) show that the net benefits of the new legislation are higher for firms that are less compliant with the Act in the pre-SOX period. By the same logic, if the new regulation does indeed affect corporate opacity, we expect its impact to vary with firms' pre-SOX characteristics. Specifically, we predict that the decrease in opacity should be more pronounced for firms that are less transparent and have lower earnings quality in the pre-SOX period, and are more likely to be affected by SOX according to the criteria used by Chhaochharia and Grinstein (2007).

3. Empirical analysis

As explained earlier, we calibrate a corporate opacity parameter before and after the enactment of SOX. We then use this measure to

Table 5
Is the enactment of Sarbanes–Oxley Act associated with a larger reduction in corporate opacity for firms with less reliable corporate reporting before SOX? This table reports mean and medians of the change in corporate opacity parameters following SOX (Post-SOX minus Pre-SOX opacity parameters). Firms are grouped by characteristics related to corporate reporting reliability. The row labeled *Difference* reports the difference between the mean and median of the change in opacity parameter across firm groups. The figures in *italics* are two-sided *p*-values for tests of the null hypothesis of no difference in means or medians. *p*-Values are calculated using *t*-tests with unequal variances for difference of means and Fisher exact *p*-values for difference of medians.

Pre-SOX minus Post-SOX opacity		
	Mean [std. err.]	Median
(A) Accruals quality		
Low	−0.282	−0.166
($N = 115$)	[0.037]	
High	−0.157	−0.100
($N = 115$)	[0.028]	
Diff.	0.125	0.066
p-Val.	0.008	0.035
(B) Discretionary accruals		
Low	−0.192	−0.112
($N = 120$)	[0.033]	
High	−0.221	−0.129
($N = 120$)	[0.031]	
Diff.	−0.029	−0.017
p-Val.	0.513	0.699
(C) Earnings conservativism		
Low	−0.242	−0.123
($N = 103$)	[0.043]	
High	−0.175	−0.120
($N = 104$)	[0.028]	
Diff.	0.067	0.003
p-Val.	0.174	0.890
(D) Firm age		
Young	−0.260	−0.168
($N = 125$)	[0.034]	
Old	−0.149	−0.085
($N = 125$)	[0.027]	
Diff.	0.111	0.083
p-Val.	0.012	0.005
(E) Number of independent directors		
Low	−0.230	−0.137
($N = 80$)	[0.036]	
High	−0.159	−0.102
($N = 111$)	[0.030]	
Diff.	0.071	0.035
p-Val.	0.135	0.242
(F) S P transp. discl. 2002 ratings		
Low	−0.248	−0.144
($N = 65$)	[0.032]	
High	−0.168	−0.091
($N = 124$)	[0.036]	
Diff.	0.080	0.053
p-Val.	0.098	0.032
(G) Chhaochharia and Grinstein's (2007) dummy		
No	−0.186	−0.100
($N = 189$)	[0.026]	
Yes	−0.266	−0.199
($N = 63$)	[0.040]	
Diff.	−0.080	−0.099
p-Val.	0.095	0.041

estimate the impact that a change in the reliability of corporate reporting has had on credit spreads. Fig. 1 presents the time-series of the median observed spread and the median model-implied spread, calculated with the calibrated parameters. Model-implied spreads are based on firm-specific parameters calibrated separately in the pre-SOX and post-SOX periods. There is a pronounced decrease in model spreads at the boundary between the pre-SOX and the post-SOX periods. This is consistent with the idea that the corporate opacity parameter may have decreased in the post-SOX period for the typical firm in our sample. To determine if the model-implied spreads decreased due to a decrease in opacity, however, we must control for the other determinants of credit spreads.

There are cases in which the model over predicts spreads even when the opacity parameter λ is zero. This implies that, conditional on the firm's asset volatility and leverage, on the recovery value of debt and on the level of the risk-free rate, model spreads are too high relative to observed spreads. See Panel B of Table A.1 for additional information on the corner solutions of the calibration procedure.

3.1. Testing hypotheses

In this section we discuss the empirical results of testing the three hypotheses presented earlier. Variable definitions are presented in Table 2.

3.1.1. Hypothesis 1

Table 3 presents means and medians of the pre-SOX opacity parameter λ across firms grouped by characteristics related to financial reporting reliability. In each panel, we test the hypotheses that means and medians of corporate opacity are equal across firms with high and low financial reporting reliability. The total number of observations in each grouping is below 252 when the corresponding characteristic is not available for firms in our sample.[10] Across all Panels, the break down between firms with high or low financial reporting reliability is chosen so that sample sizes across bins are as similar as possible. Panels (A) through (C) of Table 3 are based on quantitative measures of earnings quality. Consistent with Hypothesis 1, the evidence shows that corporations with lower accrual quality, higher discretionary accruals, and less conservative earnings tend to have higher calibrated opacity. Therefore, firms with lower quality earnings tend to have higher cost of debt, *ceteris paribus*.[11] The results in Panels (D) and (E) show that younger firms and firms with a lower number of independent directors tend to have higher calibrated opacity. Panel (F) is based on Standard and Poor's Transparency and Disclosure Index of June 2002, based on expert judgment rather than purely quantitative modeling. According to the measure, more transparent firms tend to have lower corporate opacity.

3.1.2. Hypothesis 2

Table 4 Panel A reports statistics on the calibrated opacity parameter λ in the pre- and post-SOX periods. The post-SOX opacity parameters are less than or equal to the pre-SOX parameters on average and at each quartile. As shown by the scatter plot in Fig. 2, most firms in our sample experience a decrease in the calibrated opacity measure following SOX. The mass of calibrated parameters that equal zero corresponds to lower-bound solutions in the calibration (see Appendix A for details). Untabulated results show that the correlation between pre- and post-SOX opacity parameters is 0.78, while the Spearman rank-correlation is 0.79. The high correlation suggest that λ is associated with a firm's intrinsic characteristics, rather than with noise in CDS spreads.

Table 4 Panel B provides a formal test of the hypothesis that pre- and post-SOX corporate opacity are drawn from distributions

[10] There are 39 firms with virtually identical earnings conservativism, between 0.999 and 1.001. For these firms, the coefficient on negative returns in the Basu (1997) regression was very close to 0. Since the median of earnings conservativism in the sample of 252 firms was 1, and these firms are less than 1/1000 standard deviations apart from each other, keeping these firms in the sample only adds noise. These firms are dropped from the sample in Tables 3 and 5 (but not in Table 9). Had they been kept in the sample, sorting results would go in the same direction of those in Tables 3 and 5, but would be less strong statistically due to increased sampling noise.

[11] Callen et al. (2009) study the impact of earnings (not the reliability of reported earnings) on CDS spreads.

Table 6
Does corporate opacity capture differences in systematic risk premia not accommodated by the CDS Spread pricing model? This table reports mean and medians of Pre-SOX Opacity parameters (left column), Post-SOX opacity parameters (middle column), and changes in opacity parameters (right column). Firms are grouped according to risk factor loadings. Market factor loadings in (A) are calculated using equity returns and are defined in Table 2. Term structure and default factor loadings in (B) are calculated using implied bond returns from CDS prices and are defined in Table 2. The row labeled *Difference* reports the difference between the mean and median of the corporate opacity parameter across firm groups. The figures in *italics* are two-sided *p*-values for tests of the null hypothesis of no difference in means or medians. *p*-Values are calculated using *t*-tests with unequal variances for difference of means and Fisher exact *p*-values for difference of medians.

Pre-SOX opacity			Post-SOX opacity			Pre-SOX minus post-SOX opacity		
	Mean [st. err.]	Median		Mean [st. err.]	Median		Mean [st. err.]	Median
(A) Market factor loading								
Low	0.679	0.528	Low	0.526	0.425	Low	−0.196	−0.101
($N = 126$)	[0.049]		($N = 126$)	[0.040]		($N = 125$)	[0.033]	
High	0.633	0.499	High	0.374	0.321	High	−0.216	−0.140
($N = 126$)	[0.051]		($N = 126$)	[0.033]		($N = 125$)	[0.030]	
Diff.	−0.046	−0.029	Diff.	−0.152	−0.104	Diff.	−0.020	−0.039
p-Val.	0.514	0.529	*p*-Val.	0.004	0.059	*p*-Val.	0.651	0.166
(B) TERM factor loading								
Low	0.589	0.497	Low	0.457	0.406	Low	−0.164	−0.093
($N = 125$)	[0.047]		($N = 125$)	[0.038]		($N = 125$)	[0.031]	
High	0.723	0.549	High	0.444	0.383	High	−0.247	−0.135
($N = 125$)	[0.052]		($N = 125$)	[0.037]		($N = 125$)	[0.031]	
Diff.	0.134	0.052	Diff.	−0.013	−0.023	Diff.	−0.083	−0.042
p-Val.	0.057	0.529	*p*-Val.	0.808	0.706	*p*-Val.	0.061	0.257
(C) DEF factor loading								
Low	0.766	0.590	Low	0.542	0.509	Low	−0.236	−0.120
($N = 125$)	[0.055]		($N = 125$)	[0.035]		($N = 125$)	[0.034]	
High	0.546	0.475	High	0.360	0.220	High	−0.176	−0.117
($N = 125$)	[0.041]		($N = 125$)	[0.038]		($N = 125$)	[0.028]	
Diff.	−0.220	−0.115	Diff.	−0.182	−0.289	Diff.	0.060	0.003
p-Val.	0.002	0.101	*p*-Val.	<0.000	<0.000	*p*-Val.	0.177	1.000

Table 7
Corporate opacity and number of quoting dealers over time. This table reports the mean and median level of opacity and number of quoting dealers for the Pre-SOX, Post-SOX, 2004 and 2005 periods. The column labeled *Difference* reports the difference between the mean and median of the corporate opacity parameter and number of quoting dealers across the sample periods. The figures in *italics* are two-sided *p*-values for tests of the null hypothesis of no difference in means or medians. Standard errors are calculated using a paired *t*-test for means. *p*-Values are calculated using (paired) Wilcoxon signed-rank test for medians.

$N = 237$	Pre-SOX opacity	Post-SOX opacity	Difference	2004 Opacity	2005 Opacity	Difference
Panel A – Sample including firms in all four periods						
Mean	0.655	0.455	−0.200	0.406	0.428	0.021
St. err.	[0.036]	[0.027]	[0.022]	[0.024]	[0.023]	[0.011]
Median	0.501	0.392	−0.109	0.359	0.393	0.034
p-Val.			<0.000			0.014
	Pre-SOX number of dealers	Post-SOX number of dealers		2004 Number of dealers	2005 Number of dealers	
Mean	3.55	6.12	2.57	9.89	14.48	4.59
St. err.	[0.06]	[0.15]	[0.11]	[0.29]	[0.36]	[0.18]
Median	3.46	5.58	2.12	9.92	15.46	5.54
p-Val.			<0.000			<0.000

$N = 379$	2004 Opacity	2005 Opacity	Difference
Panel B – Sample including firms in 2004 and 2005 period only			
Mean	0.454	0.474	0.020
St. err.	[0.022]	[0.021]	[0.011]
Median	0.377	0.412	0.035
p-Val.			0.004
	2004 Number of dealers	2005 Number of dealers	
Mean	7.74	11.52	3.78
St. err.	[0.242]	[0.325]	[0.145]
Median	5.97	10.55	4.58
p-Val.			<0.000

having the same mean or median. The mean (median) opacity parameter is 0.656 (0.510) in the pre-SOX period and decreases to 0.450 (0.391) following the enactment of SOX, a 31% (23%) reduction. The differences in means and medians across sub-periods are significant at the 1% probability level, providing strong statistical support for the hypothesis that the distribution of the corporate opacity parameter shifts downward after SOX. However, it is difficult to gauge the economic relevance of this evidence. Although a one quarter decrease in the opacity parameter appears to be substantial, its economic significance needs to be assessed in light of its effect on model-implied CDS spreads. In the next section, we provide a more detailed discussion of the economic significance of the evidence discussed here.

3.1.3. *Hypothesis 3*

Fig. 2 shows that, even though most firms experience a decrease in calibrated opacity, there is substantial cross-sectional variation in the magnitude of the decrease. Our Hypothesis 3 is that the reduction in the opacity parameter following SOX is larger for firms more likely to be affected by the new legislation. Table 5 presents

Table 8
Does the number of quoting dealers in the CDS market or the introduction of TRACE explain the reduction in the calibrated corporate opacity parameter? The table reports mean and medians of the change in opacity parameters. Firms are grouped according to characteristics that may be associated with credit spreads changes and are not accounted for in the CreditGrades pricing model. The row labeled *Difference* reports the difference between the mean and median of the corporate opacity parameter across firm groups.

Post- Minus Pre-SOX Opacity		
	Mean [st. err.]	Median
Panel A – The panel reports result for the Pre- and Post-SOX sample. The figures in italics are two-sided p-values for tests of the null hypothesis of no difference in means or medians. p-Values are calculated using t-tests with unequal variances for difference of means and Fisher exact p-values for difference of medians		
(A) Change in the number of quoting dealers		
Low	−0.235	−0.125
(N = 126)	[0.032]	
High	−0.176	−0.103
(N = 126)	[0.030]	
Diff.	0.059	0.022
p-Val.	0.182	0.529
(B) Time in TRACE		
Low	−0.202	−0.108
(N = 126)	[0.034]	
High	−0.210	−0.120
(N = 126)	[0.028]	
Diff.	−0.008	−0.012
p-Val.	0.847	0.900
2005 Minus 2004 opacity		
Panel B – The panel reports result for the 2004 and 2005 sample. The figures in italics are two-sided p-values for tests of the null hypothesis of no difference in means or medians. p-Values are calculated using t-tests with unequal variances for difference of means and Fisher exact p-values for difference of medians		
(A) Change in the number of quoting dealers: all four periods required		
Low	0.000	0.000
(N = 119)	[0.018]	
High	0.043	0.016
(N = 118)	[0.014]	
Diff.	0.043	0.016
p-Val.	0.059	0.001
(B) Change in the number of quoting dealers: 2004 and 2005 required		
Low	0.003	0.000
(N = 190)	[0.017]	
High	0.037	0.001
(N = 189)	[0.013]	
Diff.	0.034	0.001
p-Val.	0.124	0.025

evidence consistent with Hypothesis 3. The table reports mean and median changes in the opacity measure for various subsamples obtained by grouping firms based on pre-SOX characteristics. Consistent with Hypothesis 3, firms with lower accrual quality, higher discretionary accruals, and less conservative earnings tend to experience a larger reduction of calibrated opacity following SOX. Moreover, firms with a lower number of independent directors, younger firms, and firms with poorer disclosure quality according to the S& P 2002 rating, also experience a more pronounced drop in opacity following SOX. Panel (G) is based on criteria adopted in Chhaochharia and Grinstein (2007). The authors argue that firms with incidences of insider trading, restatements, and related party-transactions in the pre-SOX period should be more affected by the passage of SOX since these events are typically manifestations of poor governance structures.[12] Panel (G) of Table 5 show that such firms (identified by "Yes" in the table) display larger reductions in corporate opacity λ. The test statistics in the table suggest that differences in the mean and median reduction in opacity are unlikely to be due to chance. Untabulated results show that the larger reduction in opacity for firms flagged by Chhaochharia and Grinstein (2007) is not driven by one of the three criteria in particular: the decrease in opacity is larger for firms grouped according to each of the three criteria.

3.2. Economic significance

Our tests indicate that the CDS-calibrated opacity parameter λ is related to the corporate reporting reliability, and that pre-SOX levels of corporate reliability predict changes in λ following SOX. In this section, we estimate the change in the cost of debt due to increased reliability of corporate reports following SOX, the main economic question of the paper. Specifically, we compute the difference between model-implied spreads in the post-SOX period using post-SOX calibrated opacity parameters versus pre-SOX calibrated parameters for each firm-day in our sample. By keeping all the other seven inputs of the CDS pricing formula unchanged in the post-SOX period, and comparing model-implied spreads calculated with pre-SOX and post-SOX calibrated opacity parameters, we are able to calculate the change in model-implied spreads that is only due to the reduction of corporate opacity. The average spread difference across the 87,663 firm-day observations in the post-SOX period is −20.8 basis points per year, with a standard error of 3.1 basis points. This standard error is heteroskedasticity robust and clustered by firm. The median spread difference is −17.7 basis points per year, with a standard error of 2.6 basis points. This standard error is bootstrapped with clustering by firm. Given that the median spread in the post-SOX period is 111 basis points, the implied decline in the cost of debt is economically substantial.

To better gauge the economic consequences of the increased transparency perceived by investors following SOX, we compute the dollar savings that result from the implied decline in the cost of debt. We obtain from COMPUSTAT the total amount of

[12] We are grateful to Vidhi Chhaoccharia and Yaniv Grinstein for generously providing us with their data. The data includes a fourth dummy variable, audit services, which was zero for all firms in our sample.

Table 9
Does the calibrated corporate opacity parameter reflect publicly available information about capital structure not accommodated by the CDS pricing model? This table reports means and medians of Pre-SOX opacity parameters (left column), Post-SOX opacity parameters (middle column), and changes in opacity parameters (right column). Firms are grouped according to characteristics that may be associated with credit spreads, or credit spread changes, and are not accounted for in the CreditGrades pricing model. The row labeled *Difference* reports the difference between the mean and median of the corporate opacity parameter across firm groups. The figures in *italics* are two-sided *p*-values for tests of the null hypothesis of no difference in means or medians. *p*-Values are calculated using *t*-tests with unequal variances for difference of means and Fisher exact *p*-values for difference of medians.

Pre-SOX opacity			Post-SOX opacity			Post-minus Pre-SOX		
	Mean [st. err.]	Median		Mean [st. err.]	Median		Mean [st. err.]	Median
(A)								
Low	0.558	0.475	Low	0.389	0.391	Low Δ	−0.184	−0.120
($N = 126$)	[0.041]		($N = 126$)	[0.028]		($N = 126$)	[0.031]	
High	0.754	0.545	High	0.511	0.388	High Δ	−0.227	−0.113
($N = 126$)	[0.056]		($N = 126$)	[0.044]		($N = 126$)	[0.032]	
Diff.	0.196	0.070	Diff.	0.122	−0.003	Diff.	−0.043	0.007
p-Val.	0.005	0.166	*p*-Val.	0.022	1.000	*p*-Val.	0.325	0.900
(B)								
Low	0.594	0.466	Low	0.387	0.340			
($N = 159$)	[0.041]		($N = 159$)	[0.026]				
High	0.763	0.577	High	0.558	0.475			
($N = 93$)	[0.064]		($N = 93$)	[0.0541]				
Diff.	0.169	0.111	Diff.	0.171	0.135			
p-Val.	0.027	0.019	*p*-Val.	0.005	0.036			

(interest-bearing) debt for each firm in our sample throughout the post-SOX period. We then multiply the spread difference for each firm on each day by the corresponding level of debt and compute the time series median of this annual dollar saving value for each firm. Taking the cross-sectional median of the time-series median annual dollar saving value, we estimate that the implied savings related to the cost of debt amount to $2.75 million per year for the typical firm in our sample. Summing the median dollar savings across the 252 firms, we estimate that the passage of SOX is associated with a total reduction in the cost of debt of $844 million per year for our sample firms as a result of enhanced transparency.

4. Robustness checks

We perform two kinds of robustness checks in this section. First, we explore the validity of other plausible explanations for the results presented earlier. Then, we assess the robustness of our main findings to changes in the way we calibrate the CDS pricing model.

4.1. Systematic risk: risk loadings and the price of risk

The CreditGrades model does not accommodate for differences in CDS spreads due to differences in systematic risk. It is possible that spreads are relatively higher for firms with asset values that co-vary strongly with the overall state of the economy (e.g. Tang and Yan, 2010). Therefore, one could argue that the corporate opacity parameter λ simply proxies for a premium for bearing systematic risk. In the cross-section, we explore this possibility by comparing the calibrated λs across subsamples of firms that have different CAPM betas calculated with equity returns. We also measure bond systematic risk by calculating the loadings on corporate bond factors used by Fama and French (1993) and Gebhardt et al. (2005). We measure returns by calculating CDS-implied corporate bond returns, as in Longstaff et al. (2011). The two corporate bond factors are calculated using Merrill Lynch bond index returns. The first, TERM, is the returns of a zero-investment portfolio long in long-term government bonds and short in T-Bills. The second, DEF (for default), is the return of a zero-investment portfolio long in BBB corporate bonds and short in AAA corporate bonds. Table 6 contains the results of this analysis.

The first two columns of Table 6 report test statistics for equality of means and medians of calibrated opacity across subsamples of firms having high versus low risk loadings. There are six of such tests, encompassing three kinds of risk loadings and the pre- and post-SOX periods. Contrary to the risk-based explanation of our results, calibrated opacities are negatively related to loadings on the Market and the DEF risk factors in this sample. We argue that this result is driven by endogenous leverage: more opaque firms, recognizing that they are charged relatively higher interest rates, choose to take on less debt. This makes them less prone to suffer from liquidity shortages during recessions.[13]

It turns out that pre-SOX opacities are positively related to loadings in the TERM factor. However, the evidence is not robust to using medians rather than averages, which suggests that this result is driven mainly by outliers. Moreover, post-SOX opacities are not positively related to post-SOX loadings in the TERM factor. Since there is as much cross-sectional variation in the TERM factor before and after SOX, the finding that opacities are related to loadings on the TERM factor is not robust. The combined results indicate that, to the extent that loadings on CAPM and Fama–French bond factors are good proxies for exposure to systematic risk, a systematic risk explanation of our results does not hold in the cross-section of opacity levels.

The last column of Table 6 examines the possibility that the documented decrease in corporate opacity is actually picking up the effect of a decrease in the market-wide price of risk. For constant risk loadings, a decrease in the price of risk would have caused a decrease in systematic risk premia for all firms, which we would capture in the form of lower opacity parameters. We test a cross-sectional implication of this explanation: since the risk premium is the product of an asset-specific risk loading and a market-wide price of risk, this alternative explanation implies that a decrease in the market-wide price risk should affect more firms with high risk loadings. Therefore, firms with higher pre-SOX risk loadings would display larger decrease in the opacity parameter. Similar to the tests in levels of corporate opacity, results for the Market and DEF risk factors do not support the risk-based explanation. For the TERM risk factor, results are mixed. The mean test shows that there was indeed a larger reduction in opacity for firms with high loadings in the TERM factors, but the difference in median opacity between firms with high and low TERM betas is much smaller than the difference in means, and not statistically significant at 10%.

[13] Acharya et al. (2011) make a similar endogenous choice argument to explain their result that credit spreads are positively associated to cash holdings. They argue that risky firms choose to hold more cash which reduces the default risk in the short-run, but over the long-run their higher risk is reflected in higher credit spreads.

Table 10
Multiple regression analysis of Hypotheses 1 and 3: what explains levels and changes in levels of the corporate opacity parameter?

Panel A – Panel A contains results of OLS, Tobit and Censored Least Absolute Deviations regressions of pre-SOX opacity onto explanatory variables. Standard errors are reported in parentheses below the coefficient estimates. Standard errors are robust to heteroskedastiscty and based on percentile bootstraps with 1000 repetitions for the CLAD regression.

Dep. variable: Pre-SOX opacity	OLS (1)	OLS (2)	Tobit (3)	Tobit (4)	CLAD (5)	CLAD (6)
Constant	−0.087	0.308	−0.150	0.308	0.456***	1.139**
	(0.333)	(0.344)	(0.366)	(0.376)	(0.056)	(0.581)
Accruals quality	−8.822***	−7.476***	−9.842***	−8.610***	−9.184***	−6.973***
	(1.867)	(1.887)	(1.988)	(1.966)	(2.843)	(2.554)
Discretionary accruals	−0.122	−0.174	−0.168	−0.240	0.225	−0.407
	(0.216)	(0.208)	(0.247)	(0.238)	(0.803)	(0.320)
Earnings conservativism	−0.086***	−0.082***	−0.094***	−0.089***	−0.095**	−0.088*
	(0.024)	(0.024)	(0.024)	(0.025)	(0.048)	(0.049)
Firm age	−0.095***	−0.091***	−0.108***	−0.102***	−0.105***	−0.049
	(0.022)	(0.022)	(0.024)	(0.024)	(0.030)	(0.034)
Stock return volatility	0.113	0.200	−0.150	−0.061	0.578	0.471
	(0.454)	(0.427)	(0.500)	(0.469)	(0.838)	(0.826)
Market capitalization	0.009	0.007	0.008	0.006	0.009	−0.007
	(0.011)	(0.010)	(0.012)	(0.011)	(0.015)	(0.013)
Ratio of short-term to total liabilities	0.506**	0.476**	0.537**	0.467**	0.573*	0.277
	(0.231)	(0.219)	(0.239)	(0.227)	(0.310)	(0.334)
Market factor loading	−0.165	−0.191	−0.163	−0.177	−0.339	−0.110
	(0.132)	(0.128)	(0.144)	(0.137)	(0.228)	(0.212)
TERM factor loading	−1.266*	−0.690	−1.325	−0.998	−1.419	−2.442
	(0.762)	(0.689)	(0.793)	(0.811)	(1.326)	(1.850)
DEF factor loading	−0.339***	−0.165*	−0.259**	−0.235	−0.547*	−0.411
	(0.127)	(0.095)	(0.116)	(0.144)	(0.300)	(0.407)
Credit rating	−0.339***	−0.165*	0.176***	0.132***	0.176***	0.043
	(0.127)	(0.095)	(0.044)	(0.045)	(0.062)	(0.064)
Number of quoting dealers	−0.088**	−0.087**	−0.096**	−0.094**	−0.061	−0.092
	(0.041)	(0.039)	(0.044)	(0.043)	(0.057)	(0.057)
Debt-to-equity		−0.117**		−0.124*		−0.809***
		(0.058)		(0.065)		(0.280)
N	222	222	222	222	222	222
Pseudo-R^2	0.3692	0.4174	0.230	0.276	0.223	0.334

Panel B – Panel B contains results of OLS and Median regressions of the change in opacity parameters following SOX onto explanatory variables. Standard errors are reported in parentheses below the coefficient estimates. Standard errors are robust to heteroskedasticty

Dep. variable: Post-SOX minus pre-SOX opacity	OLS (1)	OLS (2)	Median (3)	Median (4)
Constant	0.274	−0.006	0.090	−0.138
	(0.282)	(0.300)	(0.265)	(0.260)
Accruals quality	4.171***	3.125**	4.354***	1.104
	(1.495)	(1.555)	(1.405)	(1.380)
Discretionary accruals	−0.187	−0.154	−0.011	−0.195
	(0.203)	(0.200)	(0.183)	(0.161)
Earnings conservativism	0.100**	0.098**	0.086***	0.082***
	(0.041)	(0.040)	(0.022)	(0.021)
Firm age	0.051***	0.043***	0.034**	0.038**
	(0.022)	(0.016)	(0.016)	(0.016)
Chhaochharia & Grinstein dummy	0.013	0.031	−0.011	−0.020
	(0.052)	(0.052)	(0.055)	(0.051)
Stock return volatility	−0.370	−0.443	−0.153	−0.045
	(0.416)	(0.426)	(0.319)	(0.300)
Market capitalization	0.003	0.005	0.000	0.005
	(0.007)	(0.006)	(0.000)	(0.006)
Change in ratio of short-term to total liabilities	−0.685*	−0.688*	−0.056	0.056
	(−0.396)	(−0.393)	(0.329)	(0.311)
Market factor loading	0.158*	0.166*	0.048	0.018
	(0.095)	(0.094)	(0.086)	(0.082)
TERM factor loading	−0.031	−0.556	−0.101	0.071
	(0.775)	(0.772)	(0.842)	(0.789)
DEF factor loading	0.263***	0.151	0.186	0.096
	(0.090)	(0.106)	(0.133)	(0.130)
Change in market factor loading	−0.131	−0.138	−0.117	−0.023
	(0.128)	(0.123)	(0.138)	(0.135)
Change in TERM factor loading	−0.170	−0.461	−0.338	−0.299
	(0.607)	(0.659)	(0.638)	(0.610)
Change in DEF factor loading	0.155*	0.108	0.085	0.042
	(0.091)	(0.089)	(0.098)	(0.093)
Credit rating	−0.060**	−0.031	−0.035	−0.023
	(−0.028)	(0.029)	(0.029)	(0.029)
Number of quoting dealers	−0.030	−0.035	0.006	−0.010
	(0.032)	(0.032)	(0.033)	(0.030)
Change in number quoting dealers	−0.007	0.000	−0.005	−0.001
	(0.015)	(0.000)	(0.017)	(0.033)

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Table 10 (*continued*)

Dep. variable: Post-SOX minus pre-SOX opacity	OLS (1)	OLS (2)	Median (3)	Median (4)
Debt-to-equity		0.090***		0.065*
		(0.030)		(0.034)
Change in debt-to-equity		0.039	0.053	
	(0.042)	(0.041)		
Time in TRACE	0.017	0.021	−0.010	0.039
	(0.053)	(0.050)	(0.059)	(0.058)
N	222	222	222	222
Pseudo-R^2 or R^2	0.240	0.279	0.103	0.122

* Mean significance at the 10% level.
** Mean significance at the 5% level.
*** Mean significance at the 1% level.

Table A.1
Additional information on calibration results.

		Expected default barrier	
Panel A – expected default boundary by Fama–French 11 industry classification (Financials are excluded from sample)			
Durables goods		0.37	
Energy		0.52	
Hi-Tech		1.00	
Health		1.00	
Manufacturing		0.51	
Non-durable goods		1.00	
Shops		0.95	
Telecommunication		0.80	
Utilities		0.56	
Other		0.80	
	$L = 0.5$	*L* by industry	$L = 0.77$
Panel B – Interior and corner solutions for each of the three calibrations discussed in the paper			
Lower bound pre-SOX period	22	31	37
Upper bound pre-SOX period	72	43	37
Lower bound post-SOX period	35	50	60
Upper bound post-SOX period	30	12	12
Interior solutions	345	368	358
Total calibrations	504	504	504

Assuming that loadings in the Market, TERM, and DEF factors indeed capture exposure to systematic risk, and that the price of risk of the TERM factor is not much greater than the prices of risk in the Market and DEF factors combined,[14] these results suggest that it is unlikely that a reduction in the price of risk story is driving the bulk of our results.

4.2. Liquidity of the CDS market and the introduction of TRACE

The CreditGrades model does not implicitly capture liquidity and microstructure effects that could influence the price of default insurance (e.g. Tang and Yan, 2008). The CDS market rapidly expanded during our sample period and continued to do so until 2007. The International Swaps and Derivatives Association (ISDA) reported that the total amount of credit default swaps outstanding at the end of 2001 was approximately \$800 billion gross notional and climbed to \$3.8 trillion by the end of 2003. The expansion of liquidity in the market could have decreased the average level of spreads due to a reduction in a liquidity premium. We explore this alternative explanation by examining the impact of the continued expansion of the CDS market on λ after the post-SOX period ended. The ISDA reports that the total gross notional amount of CDS continued to grow at a similar percent for the next several years; the market more than doubled in size in 2004 and 2005. We expect the continued growth in liquidity in the market to influence λ in a similar manner in 2004 and 2005. If liquidity is driving our result, lambda should continue to decline in 2004 and 2005, controlling for other factors. The relative impact of liquidity on CDS spreads is hard to quantify without a formal model, however we argue that there should be a statistical and economic difference in the level of λ in 2004 and 2005, if liquidity is the driver of our pre- and post-SOX results.

We observe a rapid increase in the amount of dealers providing quotes in the pre- and post-SOX periods, consistent with an increase in liquidity in the market during this period. The number of dealer quotes continued to increase in 2004 and 2005 as well. We use the number of dealers participating in the market as a proxy for liquidity at each point in time. As the dealer depth grows, the liquidity premium could decrease the average level of spreads and hence λ. Table 7 contains statistics that document the impact of dealer depth on λ. We calibrated λ for all firms with enough data in 2004 and 2005 and tabulated the mean and median level of opacity relative to changes in dealer depth. In Panel A of Table 7, we merge all firms in the pre-SOX, post-SOX, 2004, and 2005 periods. We retain most of the 252 firms, with a sample of 237 remaining. The change in average dealer depth is 2.57 during our sample period, which is a 72% increase. The average dealer depth increases from 9.89 at the end of 2004, to 14.48 at the end of 2005, which is a 46% increase in depth. The average level of opacity is much more stable in 2004 and 2005, while the liquidity of the market continues to increase. This is evidence against the argument that λ is a proxy for liquidity. To ensure that the sample we focus on in our study is not influencing our liquidity test results, we also look at the change in opacity for all firms we are able to calculate opacity for in 2004 and 2005 (379 firms). The results are in Panel B of Table 7. The pattern is clear; there is a large increase in dealer depth from 2004 to 2005, but the average level of opacity actually increases by a small amount. The difference in mean and median opacity is marginally statistically significant, but not economically significant. This is additional evidence that the continued rapid expansion of the CDS market is not driving the results in our pre- and post-SOX sample period.

We continue to explore the liquidity argument by looking at the impact of the change in dealer depth from pre-SOX to post-SOX and from 2004 to 2005. We expect the firms with the largest increase in dealer depth to experience the largest decline in opacity if a reduction in liquidity premia is driving the results. Therefore, we separate the firms into two groups based on the change in dealer depth from the two periods. Panel A shows that the firms with a larger increase in dealer depth actually had a smaller average decline in opacity. This evidence conflicts a liquidity argument for our results. Panel B displays the results of the same analysis for 2004 and 2005. We calculate the statistics for both the overlapping sample (237 firms) and the larger sample (379 firms). We show

[14] Fama and French (1993) conclude that the price of risk of TERM (and DEF) factors is close to zero. Gebhardt et al. (2005) find that the point estimates of the prices of risk of TERM and DEF are similar, but the DEF factor price of risk is statistically significant, whereas the TERM factor price of risk is not.

Table B.1
Unique default barrier $L = 0.77$. Panels A, B, and C contain results of testing Hypotheses 1, 2, and 3 of the paper, now assuming a unique default barrier equal to 77% of total adjusted liabilities.

Pre-SOX opacity		
	Mean [st. err.]	Median
Panel A – Are better corporate governance and more accounting transparency associated with lower corporate opacity?		
(A) Accruals quality		
Low	0.820	0.732
($N = 115$)	[0.061]	
High	0.468	0.358
($N = 115$)	[0.040]	
Diff.	−0.352	−0.374
p-Val.	<0.000	0.113
(B) Discretionary accruals		
Low	0.571	0.361
($N = 120$)	[0.051]	
High	0.661	0.508
($N = 120$)	[0.054]	
Diff.	0.090	0.147
p-Val.	0.226	0.155
(C) Earnings conservativism		
Low	0.688	0.424
($N = 103$)	[0.063]	
High	0.546	0.420
($N = 104$)	[0.049]	
Diff.	−0.142	−0.004
p-Val.	0.076	1.000
(D) Firm age		
Young	0.757	0.547
($N = 125$)	[0.059]	
Old	0.464	0.341
($N = 125$)	[0.042]	
Diff.	−0.293	−0.206
p-Val.	<0.000	0.002
(E) Number of independent directors		
Low	0.744	0.544
($N = 80$)	[0.071]	
High	0.563	0.386
($N = 111$)	[0.053]	
Diff.	−0.181	−0.158
p-Val.	0.045	0.188
(F) S& P transp. & discl. 2002 ratings		
Low	0.689	0.500
($N = 65$)	[0.065]	
High	0.545	0.348
($N = 124$)	[0.056]	
Diff.	−0.144	−0.152
p-Val.	0.098	0.170

$N = 252$	Pre-SOX opacity	Post-SOX opacity	Difference	*p*-Val.
Panel B – Is the enactment of Sarbanes–Oxley Act associated with a reduction in corporate opacity?				
Mean	0.612	0.431	−0.181	<0.000
St. err.	[0.036]	[0.029]		
Median	0.427	0.310	−0.117	<0.000

Pre-SOX minus post-SOX opacity		
	Mean [st. err.]	Median
Panel C – Is the enactment of Sarbanes–Oxley Act associated with a larger reduction in corporate opacity for less transparent firms?		
(A) Accruals quality		
Low	−0.244	−0.137
($N = 115$)	[0.033]	
High	−0.142	−0.096
($N = 115$)	[0.027]	
Diff.	0.102	0.041
p-Val.	0.016	0.187
(B) Discretionary accruals		
Low	−0.168	−0.103
($N = 120$)	[0.029]	
High	−0.194	−0.101
($N = 120$)	[0.030]	
Diff.	−0.026	0.002
p-Val.	0.516	1.000
(C) Earnings conservativism		

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Table B.1 (*continued*)

Pre-SOX minus post-SOX opacity	Mean [st. err.]	Median
Low	−0.198	−0.096
(N = 103)	[0.033]	
High	−0.165	−0.130
(N = 104)	[0.027]	
Diff.	0.033	−0.034
p-Val.	0.474	0.267
(D) Firm age		
Young	−0.223	−0.181
(N = 125)	[0.034]	
Old	−0.134	−0.077
(N = 125)	[0.027]	
Diff.	0.089	0.104
p-Val.	0.027	0.005
(D) Number of independent directors		
Low	−0.226	−0.138
(N = 80)	[0.036]	
High	−0.155	−0.095
(N = 111)	[0.031]	
Diff.	0.071	0.043
p-Val.	0.138	0.381
(E) S& P transp. & discl. 2002 ratings		
Low	−0.206	−0.058
(N = 65)	[0.036]	
High	−0.142	−0.139
(N = 124)	[0.032]	
Diff.	0.064	−0.081
p-Val.	0.148	0.014
(F) Chhaochharia and Grinstein's (2007) dummy		
No	−0.166	−0.093
(N = 189)	[0.024]	
Yes	−0.226	−0.150
(N = 63)	[0.036]	
Diff.	−0.060	−0.057
p-Val.	0.170	0.145

that for a different time period and with additional firms in the sample, firms with a larger increase in liquidity experienced a larger positive change in opacity. This is the opposite direction from what we would expect if liquidity is driving the opacity measure. Given the time-series and cross-sectional out-of-sample test results, we argue that a reduction in opacity post-SOX is not driven by a decline in liquidity premia.

We also explore an additional microstructure effect that may influence security prices in Table 8. One could argue that the July 2002 introduction of TRACE in the corporate bond market and the associated increase in market transparency is responsible for the reduction of credit spreads (in excess of traditional spread determinants) we document. Goldstein et al. (2007) provide some evidence that credit spreads decrease for bonds whose trading becomes more transparent with TRACE. It is possible that such reduction is transmitted to the CDS market by the CDS and bond arbitrage relationship (Duffie, 1999). We investigate one cross-sectional implication of this alternative explanation.

The introduction of TRACE was gradual and most firms did not have bonds in the system until much later than July 2002. This allows us to test whether the effect we document is at least partly driven by increased transparency in the bond market. We compute the fraction of the post-SOX period (August 2002 to December 2003) in which each firm in our sample has bonds on TRACE, and label this fraction "time in TRACE." For example, time in TRACE is one for companies with bonds in TRACE since July 2002, 0.5 for companies with bonds first added to TRACE at the mid-point of the post-SOX period (April 2002), and 0 if no bonds were added by the end of 2003. Since our calibration uses spreads throughout the entire post-SOX period, the alternative explanation examined here implies that there should be a larger reduction in opacity for firms with higher time in TRACE. The evidence in Panel A of Table 8 shows that this conjecture is not supported by data. The mean and median decreases in opacity are very close for high and low time in TRACE firms.

4.3. Ratings and liability structure

The CreditGrades model does not differentiate between types of liabilities nor does it incorporate non-public information about liabilities available to rating analysts and incorporated in credit ratings. Perhaps we feed the model an overly coarse measure of liabilities, while the market takes a much more nuanced look at the liability side of a firm's balance sheet. For example, while we ignore differences between short- and long-term liabilities, these differences may affect CDS spreads and impact our calibrated opacity parameter. Analogously, since rating agencies have access to non-public information and incorporate such information in the rating process, it could be the case that CDS spreads reflect not only public balance sheet information but also non-public information conveyed by credit ratings. If that is the case, our measure of opacity could simply be proxying for the structure of a firm's liabilities and for the special information conveyed by ratings. We examine this possibility by comparing our opacity parameters across subsamples segmented by credit ratings and the ratio between short- and long-term liabilities. The results are contained in Table 9.

The evidence in Table 9 shows that calibrated opacity is actually higher for firms with higher credit ratings. This contradicts the argument outlined above. Therefore, calibrated opacity is not capturing information available in credit ratings which is missing from the balance sheet. The positive relationship between opacity and credit rating could be driven by an endogenous leverage effect:

Table B.2
Unique default barrier $L = 0.50$. Panels A, B, and C contain results of testing Hypotheses 1, 2, and 3 of the paper, now assuming a unique default barrier equal to 50% of total adjusted liabilities.

Pre-SOX opacity		
	Mean [st. err.]	Median
Panel A – Are better corporate governance and more accounting transparency associated with lower corporate opacity?		
(A) Accruals quality		
Low	1.138	1.115
($N = 115$)	[0.064]	
High	0.732	0.649
($N = 115$)	[0.050]	
Diff.	−0.406	−0.466
p-Val.	<0.000	0.008
(B) Discretionary accruals		
Low	0.850	0.642
($N = 120$)	[0.061]	
High	0.947	0.836
($N = 120$)	[0.059]	
Diff.	0.097	0.194
p-Val.	0.254	0.014
(C) Earnings conservativism		
Low	0.956	0.767
($N = 103$)	[0.066]	
High	0.865	0.731
($N = 104$)	[0.061]	
Diff.	−0.091	−0.036
p-Val.	0.313	0.782
(D) Firm age		
Young	1.056	1.003
($N = 125$)	[0.059]	
Old	0.731	0.551
($N = 125$)	[0.053]	
Diff.	−0.325	−0.452
p-Val.	<0.000	<0.000
(E) Number of independent directors		
Low	1.061	0.998
($N = 80$)	[0.078]	
High	0.792	0.649
($N = 80$)	[0.059]	
Diff.	−0.269	−0.349
p-Val.	0.006	0.057
(F) S& P Transp. & Discl. 2002 ratings		
Low	0.994	0.846
($N = 65$)	[0.078]	
High	0.790	0.620
($N = 124$)	[0.060]	
Diff.	−0.204	−0.226
p-Val.	0.039	0.047

$N = 252$	Pre-SOX opacity	Post-SOX opacity	Difference	*p*-Val.
Panel B – Is the enactment of Sarbanes–Oxley Act associated with a reduction in corporate opacity?				
Mean	0.893	0.679	−0.214	<0.000
St. err.	[0.041]	[0.037]		
Median	0.740	0.559	−0.181	<0.000

Pre-SOX minus post-SOX opacity		
	Mean [st. err.]	Median
Panel C – Is the enactment of Sarbanes–Oxley Act associated with a larger reduction in corporate opacity for less transparent firms?		
(A) Accruals quality		
Low	−0.256	−0.148
($N = 115$)	[0.041]	
High	−0.184	−0.130
($N = 115$)	[0.030]	
Diff.	0.072	0.018
p-Val.	0.155	0.792
(B) Discretionary accruals		
Low	−0.201	−0.120
($N = 120$)	[0.039]	
High	−0.225	−0.155
($N = 120$)	[0.029]	
Diff.	−0.024	−0.035
p-Val.	0.624	0.245
(C) Earnings conservativism		

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Table B.2 (*continued*)

Pre-SOX minus post-SOX opacity	Mean [st. err.]	Median
Low	−0.216	−0.125
(N = 103)	[0.042]	
High	−0.212	−0.153
(N = 104)	[0.033]	
Diff.	0.004	−0.028
p-Val.	0.934	0.405
(D) Firm age		
Young	−0.248	−0.181
(N = 125)	[0.032]	
Old	−0.175	−0.105
(N = 125)	[0.035]	
Diff.	0.073	0.076
p-Val.	0.127	0.312
(E) Number of independent directors		
Low	−0.247	−0.189
(N = 80)	[0.039]	
High	−0.162	−0.110
Diff.	0.085	0.079
p-Val.	0.107	0.242
(F) S& P transp. & discl. 2002 ratings		
Low	−0.253	−0.186
(N = 65)	[0.042]	
High	−0.173	−0.072
(N = 124)	[0.035]	
Diff.	0.080	0.114
p-Val.	0.143	0.066
(G) Chhaochharia and Grinstein's (2007) dummy		
No	−0.189	−0.117
(N = 189)	[0.028]	
Yes	−0.287	−0.207
(N = 63)	[0.045]	
Diff.	−0.098	−0.090
p-Val.	0.070	0.145

more opaque firms, recognizing that they are charged relatively higher interest rates on debt, choose to take on less leverage, and thus tend to have higher credit ratings.

The evidence in Table 9 suggests that the ratio of short-term to total liabilities may contaminate the calibrated measure of corporate opacity. The test statistics for the equality of means and medians show that, in the pre-SOX period, firms with relatively more short maturity debt tend to have higher calibrated opacity. However, the evidence is weaker in the post-SOX period: the medians of opacity are very close for firms with low and high ratios of short-term to total liabilities. It may also be the case that more opaque firms endogenously choose shorter term debt, which could lead to a reduction of total debt costs over longer time periods. Finally, the last set of results in Table 9 are inconsistent with the maturity composition of debt, explaining away our results. In this test, we group firms according to the change in the ratio of short-term to total liabilities from the pre- to the post-SOX periods, and calculate means and medians of the change in calibrated opacity. If the drop of calibrated opacity were explained by firms lengthening the maturity of their liabilities, we would expect to see a larger reduction in opacity for firms experiencing a larger decrease in the ratio of short-term to total liabilities. Our tests do not support this conjecture.

4.4. Multiple regressions

The evidence presented so far is based on univariate sorting procedures. In this subsection, we address the possibility that some unforeseen interaction between potential explanatory variables may weaken our interpretation of the univariate results. In Panel A of Table 10, we report results of multiple regressions of the levels of pre-SOX calibrated opacity. Panel B contains results of multiple regressions of the changes in calibrated opacity from the pre- to the post-SOX periods. Explanatory variables are winsorized at 1% in each tail. In addition to the alternative explanatory variables described in the previous subsections, we include two control variables not explored in the paper before, volatility of stock returns and market capitalization. Volatility is an important control variable given Liu and Wysocki's (2008) critique that pricing effects attributed to accruals quality are due to innate business risk rather than accounting quality. We also include the number of quoting dealers to control for liquidity. Finally, we control for debt-to-equity since leverage choice is related to the level of opacity. We report the estimates with and without debt-to-equity in the regressions to gauge the interaction with the other variables. Note that the sample size drops from 252 to 222 because 30 firms do not have all the accounting information needed to compute the accounting-based proxies of corporate reporting reliability.[15]

Columns (1) and (2) of Table 10 Panel A contain results of a baseline OLS regressions, with and without debt-to-equity. Columns (3) and (4) contain results of Tobit Regressions, while Columns (5) and (6) contain results of a Censored Least Absolute Deviation (CLAD) Regression (Powell, 1984; Chay and Powell, 2001). These types of regressions are needed because the opacity parameter is bounded below by 0. With the exception of Discretionary Accruals, the coefficients on financial reporting reliability variables have the correct sign in all three regressions. Firms with

[15] We do not report results including the S& P Transparency and Disclosure Index or the Number of Independent Directors as explanatory variables because their inclusion reduce the sample size from 222 to 174 and 175 respectively. Results are robust to inclusion of these variables.

Table B.3
Only interior solutions. Panels A, B, and C contain of results of testing Hypotheses 1, 2, and 3 of the paper, now discarding firms with corner solutions in the calibration process either in the *Pre-SOX* period or in the *Post-SOX* one. The sample size drops from 252 firms to 156 firms accordingly.

Pre-SOX opacity	Mean [st. err.]	Median
Panel A – Are better corporate governance and more accounting transparency associated with lower corporate opacity?		
(A) Accruals quality		
Low	0.650	0.574
(N = 73)	[0.041]	
High	0.556	0.513
(N = 74)	[0.032]	
Diff.	−0.094	−0.061
p-Val.	0.073	0.250
(B) Discretionary accruals		
Low	0.603	0.551
(N = 74)	[0.035]	
High	0.593	0.522
(N = 75)	[0.039]	
Diff.	−0.010	−0.029
p-Val.	0.842	0.414
(C) Earnings conservativism		
Low	0.597	0.506
(N = 65)	[0.040]	
High	0.550	0.500
(N = 65)	[0.037]	
Diff.	−0.047	−0.006
p-Val.	0.387	1.000
(D) Firm age		
Young	0.613	0.574
(N = 78)	[0.034]	
Old	0.563	0.494
(N = 78)	[0.038]	
Diff.	−0.050	−0.080
p-Val.	0.334	0.631
(E) Number of independent directors		
Low	0.694	0.644
(N = 50)	[0.047]	
High	0.541	0.482
(N = 50)	[0.043]	
Diff.	−0.153	−0.162
p-Val.	0.014	0.069
(F) S& P transp. & discl. 2002 ratings		
Low	0.657	0.549
(N = 44)	[0.045]	
High	0.575	0.515
(N = 73)	[0.040]	
Diff.	−0.082	−0.034
p-Val.	0.173	0.449

N = 156	Pre-SOX opacity	Post-SOX opacity	Difference	*p*-Val.
Panel B – Is the enactment of Sarbanes–Oxley Act associated with a reduction in corporate opacity?				
Mean	0.588	0.452	−0.136	<0.000
St. err.	[0.026]	[0.020]		
Median	0.526	0.415	−0.111	<0.000

Pre-SOX minus post-SOX opacity	Mean [st. err.]	Median
Panel C – Is the enactment of Sarbanes–Oxley Act associated with a larger reduction in corporate opacity for less transparent firms?		
(A) Accruals quality		
Low	−0.152	−0.123
(N = 73)	[0.030]	
High	−0.130	−0.101
(N = 74)	[0.023]	
Diff.	0.022	0.022
p-Val.	0.561	0.324
(B) Discretionary accruals		
Low	−0.135	−0.106
(N = 74)	[0.023]	
High	−0.151	−0.107
(N = 75)	[0.028]	
Diff.	−0.016	−0.001
p-Val.	0.663	1.000
(C) Earnings conservativism		

(*continued on next page*)

Table B.3 (*continued*)

Pre-SOX minus post-SOX opacity		
	Mean [st. err.]	Median
Low	−0.140	−0.116
(N = 65)	[0.032]	
High	−0.139	−0.107
(N = 65)	[0.021]	
Diff.	0.001	0.009
p-Val.	0.991	1.000
(D) Firm age		
Young	−0.141	−0.120
(N = 78)	[0.022]	
Old	−0.129	−0.102
(N = 78)	[0.029]	
Diff.	0.012	0.018
p-Val.	0.746	0.873
(E) Number of independent directors		
Low	−0.194	−0.143
(N = 47)	[0.034]	
High	−0.118	−0.092
(N = 50)	[0.023]	
Diff.	0.076	0.051
p-Val.	0.071	0.146
(F) S& P transp. & discl. 2002 ratings		
Low	−0.145	−0.186
(N = 44)	[0.038]	
High	−0.165	−0.072
(N = 73)	[0.024]	
Diff.	−0.020	0.114
p-Val.	0.656	0.182
(G) Chhaochharia and Grinstein's (2007) dummy		
No	−0.121	−0.098
(N = 118)	[0.021]	
Yes	−0.179	−0.146
(N = 38)	[0.034]	
Diff.	−0.058	−0.048
p-Val.	0.157	0.351

lower accrual quality, less conservative earnings, and younger firms tend to have higher calibrated opacity. Coefficients on these variables are statistically significant at 5% in the OLS, Tobit, and CLAD specifications. The coefficients on Discretionary Accruals are statistically insignificant in all three regressions. Note that the magnitude of the coefficients on the financial reporting quality variables is reasonably close in the three sets of regressions, alleviating concerns that outliers could be driving the results. The coefficients on stock return volatility and market capitalization are statistically insignificant.

Panel B of Table 10 contains results of OLS regressions in Columns (1) and (2) and Median regressions in Columns (3) and (4). To interpret the sign of the coefficients, recall that a negative sign means a larger decrease in the opacity parameter following SOX for larger values of the explanatory variable. In other words, negative signs are associated with "bad" characteristics from a cost of debt perspective. Confirming the results in the levels specification of Panel A, the coefficients on accrual quality, firm age, and earnings conservativism have the correct sign and are statistically significant at the 5% level. Coefficients on Discretionary Accruals and on Chhaochharia and Grinstein (2007) Dummy are not statistically significant. Finally, as in Panel A, the coefficients on stock return volatility and market capitalization are statistically insignificant.

4.5. Changes in calibration procedure

In our baseline results we choose a different expected default boundary $\bar{L}$ for each industry using Fama and French's 11-industry classification before we calibrate the corporate opacity λ for each firm-period (see Appendix A for details). In Table B.1 we present an alternative calibration in which $\bar{L}$ is constrained to be equal to 0.77 across all industries. This is the single value of $\bar{L}$ across all firms that maximizes the number of firm-day spread observations falling within the boundaries of the CreditGrades model. All our results still hold. Table B.2 contains results of calibration using $\bar{L} = \frac{1}{2}$ for all firms. This is the expected default boundary suggested by the CreditGrades Technical Manual (2002). Most of our results hold in this alternative (worse) calibration. Finally, Table B.3 uses $\bar{L}$s chosen for each industry of our baseline results, but removing from the sample the firms in which the calibrated opacity was a corner solution either on the pre-SOX or on the post-SOX periods. The total sample size drops from 252 to 156. The results are likely to be weaker than our baseline ones for two reasons. First, the sample size drops considerably, which reduces the power of our tests. Second, extreme firms (very opaque or very transparent) likely to contain a lot of information about the relationship between spreads and opacity are dropped from the sample. Nonetheless, Table B.3 shows that most of our results still hold in this subsample of interior solutions only.

5. Conclusion

Following a mounting number of high-profile corporate scandals, the US Congress passed the Sarbanes–Oxley Act in July 2002 in an attempt to restore public trust in US capital markets. The legislation aims to improve corporate transparency by altering governance, disclosure, internal control, and auditing practices of publicly traded companies. In this study, we investigate the impact of such changes on the cost of debt capital.

In order to compute changes in the cost of debt capital due to changes in corporate transparency after SOX, we use daily CDS spreads and a structural CDS pricing model to calibrate a corporate opacity parameter for 252 firms in each of the pre-SOX (January 2001 to July 2002) and post-SOX (August 2002 to December 2003) time periods. First, we show that the opacity parameter is significantly associated with firm characteristics related to the reliability of corporate reports. Firms with lower quality accruals, less conservative earnings, a lower number of independent directors, lower S& P Transparency and Disclosure rating, and younger firms tend to have higher CDS-calibrated opacity, and consequently higher cost of debt *ceteris paribus*. Second, we show that corporate opacity parameters tend to be significantly lower in the post-SOX than in the pre-SOX period. Third, the decrease in the opacity parameter tends to be larger for firms more likely to be affected by the new legislation. These firms have lower accrual quality, less conservative earnings, a lower number of independent directors, lower S& P Transparency and Disclosure rating, and are younger and less compliant with SOX according to criteria in Chhaochharia and Grinstein (2007).

We do not attempt to gauge our calibrated opacity parameter against alternative measures of corporate transparency or accounting/earnings quality, which may be a fruitful venue for future research. We argue, however, that our calibrated opacity parameter is uniquely well suited to our goal of studying the effect of changes in corporate transparency on the cost of debt. Our results indicate that the passage of SOX is associated with a substantial decline in the cost of debt due to increased reliability of corporate reports after SOX. We estimate that the reduction of opacity following SOX implies a 17.7 bp decrease in the 5-year CDS spread of the median firm in our sample. Furthermore, we document that our results are robust to changes in our calibration procedure, and show the data does not support plausible alternative explanations for our findings.

Appendix A. Model and calibration details

The CreditGrades model (2002) is an adaptation and extension of the Black and Cox (1976) debt pricing model. Total firm value per equity share is a Geometric Brownian Motion with zero drift and volatility σ. Reported liabilities per equity share is constant at D. Default happens the first time the value process hits an uncertain default boundary given by LD, where L is lognormally distributed and independent of the value process V_t. The expected value of L is $\bar{L}$, and the standard deviation of the log of L is λ. Note that $\bar{L}$ can be below one: structural models with endogenous default (e.g. Leland, 1994) show that equity holders may be willing to keep the firm alive even when the current value of assets is below the face value of debt. If the firm defaults before the expiration of the CDS contract, the seller of protection stops receiving spread payments and has to make a lump-sum payment pay of $(1-R)$. Given the assumptions, the CreditGrades manual (2002) shows that the fair CDS spread is well approximated by the closed-form formula in Section 2.1.

It is important to mention that the credit spread is not a monotonic function of the uncertainty parameter λ. Given the other seven inputs of the CDS pricing formula, there is a λ^* such that the function $c(T,\lambda)$ reaches a maximum spread. This is the only critical point of the function $c(T,\lambda)$: the function is monotonically increasing for $0 < \lambda < \lambda^*$, and monotonically decreasing in $\lambda > \lambda^*$. This is an unpleasant feature of the model, and a consequence of simplifying assumptions such as exogenous recovery. We address this issue by performing a constrained optimization: we minimize the sum of squared differences between market and model spreads under the constraint that the calibrated $\hat{\lambda}$ for a given firm-period has to be in the interval $[0, \bar{\lambda}^*]$, where $\bar{\lambda}^*$ is the time-series median value of λ^* for each firm. This implies that there can be corner solutions both on the low side, when market spreads tend to be below the model spread at $\lambda = 0$, and on the high side, when market spreads tend to be above the model spread when $\lambda = \bar{\lambda}^*$.

In our baseline results, we first obtain $\bar{L}$ for each industry before we calibrate $\hat{\lambda}$ for each firm-period. This is because structural models such as Fan and Sundaresan (2000) show that the default boundary depends on business risk, marginal tax rates, liquidation costs, and the relative bargaining power between shareholders and debt holders in the event of default; that is, attributes that display much higher cross-industry than within-industry variation.[16] Therefore, calibrating a different $\bar{L}$ for each industry is a way to control for industry affiliation within the structural pricing model. Using the Fama–French 11 industry classification, for each industry we choose the $\bar{L}$ that maximizes the number of observations in which market spreads are within the range that can be delivered by the CreditGrades model. This proceeds as follows: for each firm-day observation, we compute the λ that maximizes the spread (i.e., the critical λ^* mentioned above). Then, for each firm-day observation grouped by industry, and each value of $\bar{L}$ from 0 to 1 in 0.01 steps, we compute the minimum (i.e. at $\lambda = 0$) and maximum (i.e. at $\lambda = \lambda^*$) model-implied spreads. Then, for each firm-day observation, we check whether the market CDS spread is between the minimum and maximum model-implied spreads. We add across firm-days observations in the same industry to find the value of $\bar{L}$ that maximizes the number of times that market spreads are within the interval that can be generated by the model. The chosen values of $\bar{L}$ are shown in Panel A of Table A.1. These are the values used in our baseline results. As a robustness check, we repeat all our analysis using the CreditGrades Manual (2002) recommended value of $\bar{L} = \frac{1}{2}$ for all firms. We also use $\bar{L} = 0.77$ which is the single value of $\bar{L}$ that maximizes the number of times we find a non-boundary solution across firms.

Panel B of Table A.1 shows that using different $\bar{L}$s per industry increases the number of interior solutions for the calibrated opacity parameters, which reduces the noise in our remaining empirical analyses.

Finally, we briefly discuss the downside of two alternative methods that calibrate $\bar{L}$s and λs jointly rather than sequentially. First, we could choose $\bar{L}$ for each industry in order to minimize the sum of squared differences between market and model spreads. The problem with this approach is that it effectively gives more weight to high market CDS spread observations. This is undesirable given that there are substantial differences of average market spreads across firms in the same industry. Untabulated results show that, due to this bias, this procedure actually reduces rather than increases the number of interior solutions compared to the single $\bar{L} = \frac{1}{2}$ case. Alternatively, we could calibrate a different $\bar{L}$ for each firm. The problem here is one of econometric identification: *ceteris paribus*, a higher CDS spread could be due to either higher opacity λ or higher expected default boundary $\bar{L}$, and we are skeptical about the CreditGrades' model (or any structural model's) ability to disentangle these two effects across firms in different industries using CDS data only.

[16] Garlappi et al. (2008) use industry concentration, R& D expense ratio, and asset tangibility as proxies for liquidation costs and shareholder bargaining power.

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