Losing Control?
The 20-Year Decline in Loan Covenant Violations*

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Abstract

The annual proportion of U.S. public firms that report a financial covenant violation fell nearly 70% between 1997 and 2016. To understand this trend, we develop a model of covenant design that shows the optimal threshold varies with covenants' ability to discriminate between distressed and non-distressed borrowers and with the relative costs associated with screening incorrectly. We document a steady improvement in covenants' ability to identify distressed borrowers. However, the dramatic fall in violations is best attributed to an increased willingness to forego early detection of marginally distressed borrowers in exchange for fewer inconsequential violations, particularly since 2008-09.

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1 Introduction

Academic theory and practitioner experience explain debt covenants as an important tool that lenders use to protect their interests prior to payment default (see Tirole, 2010, for a summary). Financial covenants, in particular, serve as "tripwires" that monitor borrower performance and grant creditors the right to sever lending commitments, recall outstanding debt, and foreclose on collateral if the borrower breaches a contractual threshold. A growing body of empirical research documents the widespread use of covenants in corporate loan agreements and shows that lenders use their bargaining power after a violation to renegotiate terms of the loan contract and influence borrower policies.[1]

Despite the apparent importance of financial covenants in loan contract design, we find that the incidence of covenant violations among U.S. public firms has fallen dramatically over the last 20 years. Using newly collected data, Figure 1 shows that the annual proportion of U.S. public firms that report a violation decreased by almost 70% over our two-decade sample period. To understand this decline, we develop a simple model of optimal covenant design that balances the costs and benefits of restrictive financial covenants and use our model to empirically decompose the trend into fundamental drivers.

Our model incorporates the insight that restrictive financial covenant packages are beneficial because they are violated frequently, allowing lenders to reassess the borrower's ability to repay based on small changes in observable performance, as in the models of Townsend (1979), Gale and Hellwig (1985), and Williamson (1987). Violations provide lenders with the opportunity to catch – and potentially correct – borrower performance declines early and take steps to protect

[1] See, e.g. Chava and Roberts (2008), Roberts and Sufi (2009), Nini, Smith, and Sufi (2009, 2012), Falato and Liang (2016), Freudenberg, Imbierowicz, Saunders, and Steffen (2017), Chava, Nanda, and Xiao (2017), Ferreira, Ferreira, and Mariano (2018), Balsam, Gu, and Mao (2018), Jiang and Xu (2019), Ersahin, Irani, and Le (2021), Becher, Griffin, and Nini (2021), and Jang (2021).

their financial claim by reducing the loan commitment or requiring early principal repayment, among other actions. Adopting terminology from medical diagnostic testing, a more restrictive covenant package is beneficial because it has a lower probability of a *false negative* outcome, in which the borrower is distressed but fails to violate a covenant.

We highlight, however, that restrictive financial covenants are also costly because they require lender monitoring, reduce borrower operational flexibility, and induce frequent renegotiations (Smith and Warner, 1979; Berlin and Mester, 1992). Since financial covenants are written on accounting metrics that imperfectly measure financial distress, restrictive covenant packages may trigger frivolous violations. Indeed, we document that many violations are resolved with no consequential change to the lending arrangement. In our model, a more restrictive covenant package is costly because it creates a higher probability of a *false positive* outcome, in which the borrower violates despite not being financially distressed.

We model covenant design as a process in which loan parties optimally select the level of restrictiveness – the covenant threshold – to minimize the expected total cost of false positive and false negative outcomes. Based on this model, we identify two fundamental factors that influence the optimal covenant threshold. First, the threshold depends on the ratio of the expected costs of false positives to false negatives, which we refer to as the "preferences" of the loan parties. The optimal threshold is less restrictive when this ratio is larger, reflecting a willingness to forego early detection of some distressed borrowers in exchange for fewer inconsequential violations. Second, the optimal threshold depends on the ability of financial covenant packages to discriminate between distressed and non-distressed borrowers, which we refer to as the covenant "technology." Better technology allows covenants to catch more truly distressed borrowers – *true positives* – without concomitantly increasing the number of false positives.

To map our model into an estimable framework, we decompose the overall covenant violation rate into three pieces: (1) the true positive rate (TPR), defined as the fraction of distressed borrowers that violate a covenant, (2) the false positive rate (FPR), defined as the fraction of non-distressed borrowers that violate a covenant, and (3) the financial distress rate. This classification enables us to express our model in terms of "receiver operating characteristic" or "ROC" curves.[2] In our context, an ROC curve traces out the set of potential outcomes – a combination of TPR and FPR – available for a given covenant technology. Movement along an ROC curve corresponds to changing lender preferences over the optimal choice of TPR and FPR, and a shift outward to a new ROC curve represents an improvement in covenant technology that enables a higher TPR and lower FPR.

This framework yields three potential explanations for the observed decline in loan covenant violations. First, the decline may be the product of a falling rate of financial distress among U.S. public borrowers. Since the TPR is considerably larger than the FPR, less financial distress will lead to a lower rate of violations. Second, the decline may be due to an increase in the expected costs of false positives relative to false negatives. Such a change in preferences would lead to a "move down" the ROC curve, which corresponds to less restrictive loan covenants, and a reduction in both the TPR and the FPR. Finally, the decline may be driven by an improvement in the ability of financial covenant packages to differentiate between distressed and non-distressed borrowers, which corresponds to a "shift out" in the ROC curve. The newly optimal financial covenant packages will generate a higher TPR and a lower FPR, potentially leading to fewer violations overall.

To examine how well these explanations fit the data, we must classify borrowers as distressed or non-distressed. Conceptually, we consider a firm to be distressed if lenders would choose to renegotiate terms of the lending arrangement if they had the right to do so. Therefore, we code

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[2] An ROC curve plots the relationship between the true positive rate and the false positive rate for a binary test. ROC curves are common in literature evaluating medical diagnostics, radar tracking, and machine learning algorithms. See, e.g., Hsieh and Turnbull (1996), Kerekes (2008), and Pepe, Cai, and Longton (2006).

covenant violators as distressed if the violation led to a consequential renegotiation of the loan contract, which we determine by reading loan amendments made public in SEC filings. Consequential renegotiations (*true positives*) include interest rate increases, loan commitment reductions, principal repayment requirements, and forced capital raises or asset sales. Conversely, we consider "waiver only" outcomes as recognition that the violation was a false positive since, upon further monitoring, the lender elected to make no major contractual change. For non-violating firms, we rely on future bankruptcy filings as our proxy of financial distress, under the assumption that lenders would have renegotiated the loan terms if the borrower did violate a covenant. Accordingly, we code a firm that fails to violate a covenant but files for bankruptcy within one year as a *false negative* and all other non-violators as *true negatives*.[3]

The empirical decomposition produces several stylized facts. About one-half of the entire decline in covenant violations over the sample period can be explained by a drop in the FPR, which falls nearly 90% from the late 1990s to 2016. In other words, the largest component of the observed trend represents a substantial drop in the number of false positive violations, where lenders waive the violation without a consequential renegotiation. Conversely, the frequency at which truly distressed borrowers violate a covenant – the TPR – remains relatively constant over the first two-thirds of the sample period but begins to decline following the global financial crisis. By the end of the sample, the TPR falls by one-third relative to its earlier level and explains about 15% of the overall decline in violations. Finally, the rate of distress varies cyclically but, on average, declines during the latter part of the sample period. The decline in the distress rate explains another 30% of the total decrease in covenant violations.

[3] As described more fully below, we examine the robustness of our results using two alternative classifications of distress for non-violating firms. The first strategy classifies a firm as distressed if its estimated probability of default is in the upper 5th percentile of the empirical distribution according to Bharath and Shumway's (2008) default forecasting methodology. The second strategy classifies a firm as distressed if it receives a "going-concern" warning from its auditors. The two alternative approaches yield results similar to those from our main classification system.

We next use the realized TPR and FPR to estimate parameters that govern the preferences and lending technology in our model. The exercise shows that both loan-party preferences and covenant technology have evolved over the sample period. Advances in covenant technology – that is, shifts outward in the ROC curve – improve the TPR by about 10% while reducing the FPR by 14%. Because these changes have opposing effects on the total violation rate, however, the impact of changing covenant technology on overall violations nets out to be small. Instead, changes in loan-party preferences – movements along the ROC curve – explain roughly 85% of the overall decline in violations. In short, the dramatic fall in total violations is best attributed to looser covenants that trade off a modestly lower TPR in exchange for a substantially lower FPR, consistent with an increase in the relative costs of false positive violations over time.

Our paper contributes to the literature studying the design and renegotiation of debt contracts. Our theoretical contribution builds on prior research that justifies the existence of financial covenants (e.g., Aghion and Bolton, 1992; Berlin and Mester, 1992; Garleanu and Zwiebel, 2009) by modeling the optimal restrictiveness of covenants as a tradeoff between the costs of false positives and false negatives. The model delivers the novel predictions that the optimal threshold varies with the ability of financial covenant packages to discriminate between distressed and non-distressed borrowers and with the relative costs associated with screening incorrectly.

Our empirical contribution is to document and assess the trend toward less restrictive financial covenants and fewer realized violations. We show that most of the observed drop can be explained by a substantial reduction in false positive violations and a general decline in the distress rate. This decomposition helps alleviate concerns about excessively loose covenants by showing that the decline in violations is not predominantly driven by an inability of covenants to catch distressed firms early. While we do observe an eventual drop in the TPR, it happens only toward the end of sample period and contributes modestly to the overall fall in violations. Our structural estimation suggests that preferences have evolved so that the optimal covenant threshold has loosened over the sample period. In the closing section of the paper, we conjecture that changes in the loan market, low interest rates, and a low level of corporate distress have contributed to the evolution.[4]

We believe our evidence and analysis may benefit regulators charged with monitoring the stability of the financial system, including, for example, the Federal Reserve and the U.S. Treasury's Financial Stability Oversight Council. These agencies frequently examine the nonprice terms of corporate credit to gauge the level of risk-taking and potential threats to financial stability.[5] We offer a conceptual and empirical framework for interpreting changes in financial covenants and highlight that more restrictive financial covenants can create both benefits and costs.

2 Background and Motivating Evidence

Covenants have long been recognized as an important component of lending arrangements. The current study material for the chartered financial analyst exams includes covenants as one of the four "Cs" of credit analysis.[6] Smith and Warner (1979) emphasize that covenants are designed to minimize conflicts of interest between lenders and stockholders of borrowing companies. Whether these conflicts arise from differences in preferences, differences in the structure of payoffs, or differences in access to relevant information, covenants help ensure that borrowers

[4] For example, Berlin, Nini, and Yu (2020) document an increase in nonbank lenders since the early 2000s and show that the rise can help explain the development of covenant-lite term loans. Roberts and Schwert (2020) show that covenants can weaken when interest rates fall, and Aramonte, Lee, and Stebunovs (2019) show that low long-term interest rates generate "search for yield" behavior in the syndicated loan market.
[5] For example, the 2021 Financial Stability Report from the Federal Reserve writes "…the Federal Reserve also reviews indicators not directly related to an asset's price but that have been associated with periods of elevated risk appetite in the past, such as measures related to trading patterns, underwriting standards, issuance, or investor leverage." (pg. 17, https://www.federalreserve.gov/publications/files/financial-stability-report-20210506.pdf)
[6] The four Cs are capacity, collateral, covenants, and character, according to Fundamentals of Credit Analysis, Christopher L. Gootkind (CFA Institute).

do not take actions that are detrimental to lenders.[7] Minimizing conflicts of interest expands the ex-ante supply of credit and allows firms access to more credit and/or lower interest rates.

2.1 Financial Covenants

The typical credit agreement contains affirmative, negative, and financial covenants. Affirmative and negative covenants minimize incentive conflicts by contracting directly on certain events, such as the distribution of dividends or issuance of additional debt. While these covenants are ubiquitous in public and private debt contracts, their scope is limited by an inability to contract on all possible contingencies (Smith and Warner, 1979). Financial covenants serve as "tripwires" that transfer control rights to lenders only when verifiable financial ratios drop below contractual thresholds (Smith, 1993; Dichev and Skinner, 2002). Due to high monitoring and renegotiation costs of public debt, financial covenants are predominately found in private debt contracts.[8]

Roberts and Sufi (2009) show that more than 95% of private loan agreements contain at least one financial covenant. These covenants are often tailored to each borrower; for instance, Freudenberg, Imbierowicz, Saunders, and Steffen (2017) find more than 80 unique financial covenant descriptions in a sample of nearly 5,000 credit agreements. Although tailored for each borrower, covenants share a similar structure. The most common financial covenants place a limit on the borrowing company's leverage and cash obligations (fixed charge or interest coverage) relative to EBITDA, to proxy for the company's ability to generate operating cash flow to meet

[7] A guide for attorneys on writing credit agreements emphasizes that "covenants, among other things, (1) limit leverage (secured or unsecured) of the borrower and its subsidiaries, (2) focus management on 'deleveraging" the business by limiting acquisitions and capital expenditures in addition to incremental debt and (3) create a 'closed system' (pursuant to which uses of cash are limited to operating the business and paying down debt). . ." Simpson, Thacher, and Bartlett (2005), pg. 120.

[8] By "financial covenants," we are referring to "maintenance" financial covenants that require regular (e.g., quarterly) compliance checks by lenders, typically accomplished through compliance forms submitted by the borrower. Public bond contracts can also contain financial ratio thresholds in "incurrence" covenants, but these thresholds are checked only at the incurrence of certain events, such as an acquisition or change of control.

debt obligations.[9] Financial covenants have also typically been written on balance sheet items, including net worth, current ratio, debt-to-equity, and debt-to-asset. As discussed by Demerjian (2011) and Griffin, Nini, and Smith (2021), these balance sheet covenants have become less common over time. Historically, covenants have been set tightly, with the average threshold set close to the company's financial ratio at loan origination (Chava and Roberts, 2008).

Within an incomplete contracting framework, Aghion and Bolton (1992) show that state-contingent control rights can mitigate managerial moral hazard. By assigning control rights to lenders when private benefits are likely to lead to smaller financial returns, financial covenants increase the amount of income that can be pledged to support borrowing. Garleanu and Zwiebel (2009) show that financial covenants facilitate financing when a manager's propensity to pursue private benefits is unobservable. The optimal contract allocates strong ex-ante decision rights to creditors to overcome the adverse selection problem and reallocates control rights to borrowers via ex-post renegotiation to maintain efficient investment. These theories highlight two crucial roles of financial covenants: i) to define the circumstances when creditors receive the right to intervene in management, and ii) to prevent managers from taking privately beneficial actions that may reduce the value of lenders' claims.

2.2 Covenant Violations

The breach of a financial covenant constitutes an event of default and grants lenders the right to sever all lending commitments, recall outstanding debt, and proceed to foreclose on collateral. In practice, lenders typically do not initiate default rights upon a violation, preferring instead to use their bargaining power to do a more extensive check of the borrower's ability to meet its contractual obligations going forward and, in response, to renegotiate terms of the loan contract.

[9] See Simpson, Thacher, and Bartlett (2005), pg. 120.

The renegotiation typically addresses two issues. First, the borrower must "cure" the existing violation to return to compliance with the loan contract. This is often achieved through the granting of a "waiver," whereby lenders formally agree to excuse the borrower from covenant compliance for a fixed period of time. Second, based on the lenders' assessment of the borrowers' ability to meet its obligations going forward, the loan agreement may be adjusted or "amended" to manage the lenders' credit exposure to the borrower. Amendments often impose stricter terms on the borrower, such as reducing the limit on a line of credit, increasing the interest rate, or requiring principal repayments. Amendments also commonly tighten negative covenants that constrain borrower activities, such as debt issuance, capital expenditures, acquisitions, and how cash is directed to entities within the corporation. Further, the borrower may also be required to provide the lender with additional compensation, such as an amendment fee or warrants to purchase the borrower's stock.[10]

A large body of empirical literature shows that this renegotiation process leads to more conservative investment and financial policies. For example, violations are associated with a decline in debt issuance (Roberts and Sufi, 2009), capital investment (Chava and Roberts, 2008), R&D expenditure and patent quantity (Chava, Nanda, and Xiao, 2017; Gu, Mao, Tian 2017), employment (Falato and Liang, 2016), and shareholder payouts (Nini, Smith, and Sufi, 2012).

For a large fraction of covenant violations, however, the follow-up negotiations result in few or no changes to the loan agreement. For example, Chen and Wei (1993) find that 45% of 128 violations they examine during the years 1985-1988 were waived with no additional changes to loan terms, while Chodorow-Reich and Falato (2021) show that during the 2008 financial crisis, only 37% of firms faced a reduction in their credit line following a violation. In our analysis below, we examine a large set of potential actions that can occur following a violation and find

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[10] Ao, Bao, and Kolasinski (2019) show that, following a covenant violation, borrowers pay a fee or agree to a higher interest rate in 22.3% of all renegotiations.

that roughly one-half of all violations are waived with no substantial changes to the loan agreement.[11] We highlight these facts as evidence that covenant violations often result in little action by lenders, presumably because financial covenants are noisy signals of the true underlying status of the borrower. Since violations can be costly in terms of additional information gathering, monitoring, diligence, and negotiation, lenders and borrowers have an incentive to design financial covenants that strategically avoid unnecessary violations.

2.3 Covenant Violation Data

We extend to 2016 the dataset on covenant violations used by Nini, Smith, and Sufi (2012), which originally spanned the years 1997-2008. The data covers all nonfinancial U.S. firm-quarter observations in Compustat that can be matched to a corresponding 10-Q or 10-K SEC filing in EDGAR. As in Nini et al. (2012), we require non-missing data on total assets, total sales, common shares outstanding, closing share price, and calendar quarter of the observation, and we drop firms with average book assets of less than \$10 million in real 2000 dollars. These filters yield a sample of 288,390 firm-quarter observations.

To measure covenant violations, we rely on information reported in quarterly and annual financial statements. Regulation S-X requires "any breach of covenant …, which … existed at the date of the most recent balance sheet being filed and which has not been subsequently cured, [to] be stated in the notes to the financial statements" (CFR § 210.4-08). Further, "[i]f a default or breach exists but … has been waived for a stated period of time beyond the date of the most recent balance sheet being filed, …" Regulation S-X requires the firm to "… state the amount of

[11] As an example of a violation with no consequences, SRI/Surgical Express Inc. reported a covenant violation in their March 31, 2006 10-Q, filed with the SEC on May 9, 2006. In the 10-Q, SRI writes, "The Company's net loss for the first quarter of 2006 resulted in a funds flow coverage ratio of 2.42, which was below the requirement (2.50) of its credit agreement. Both financial institutions issued a waiver of the requirement for the period ended March 31, 2006 and amended the covenant for the balance of 2006." SRI attached the loan amendment to the 10-Q filing, so we can confirm that no other loan terms were changed by the May 8, 2006 amendment that provided the waiver.

the obligation and the period of the waiver" (CFR § 210.4-08). In short, Regulation S-X allows us to identify all covenant violations by firms in our sample, regardless of whether covenants are outstanding or have been cured by a waiver. As in Nini, Smith, and Sufi (2012), we collect reported violations from 10-K/10-Q filings on EDGAR using a text-search algorithm and manual inspection.[12]

To minimize problems associated with quarterly variation in reporting quality, we aggregate all data to the firm-year level.[13] We create an annual violation indicator for each firm-year that equals one when a firm reports a violation during any of the four quarters of the year. We keep the fourth calendar quarter of each firm-year, so that each firm-year observation is measured in calendar years. The resulting sample consists of more than 66,000 firm-year observations from roughly 8,500 public U.S. firms between 1997 and 2016.

Figure 1 plots the fraction of firms that report a covenant violation during a given year. The figure shows that the frequency of violations has decreased substantially over time. Since the recent financial crisis, the violation rate has averaged about 6% per year, which is one-half the rate of the lowest year prior to 2005. Even during the peak of the global financial crisis in 2008 and 2009, the violation rate increased only modestly, continuing its decline to 6% by 2011.

To ensure that the downward trend is not due to biases in our data collection procedure, we consider two alternative violation measures in Appendix 1. This first alternative is the Roberts and Sufi (2009) covenant violation dataset provided online by Michael Roberts.[14] The second alternative uses the methodology of Chava and Roberts (2008) to impute violations from

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[12] See the data appendix in Nini et al. (2012) for details on the text-search algorithm.

[13] As noted in Nini, Sufi, and Smith (2012), firms report violations more frequently in 10-Ks than 10-Qs because firms often summarize the experience of the entire year in annual reports. Moreover, aggregating to the firm-year minimizes the likelihood that our coding procedure fails to identify a violation, since we would have to miss four consecutive quarters of a reported violation.

[14] See https://finance.wharton.upenn.edu/~mrrobert/styled-9/styled-11/index.html. The Roberts and Sufi (2009) text-search algorithm examines a larger set of SEC filings but uses a smaller set of search terms. On net, their procedure identifies fewer violation and shows an even stronger downward trend through 2011 (at which point the dataset ends).

observed accounting ratios and covenant thresholds.[15] Both measures confirm a strong, nearly monotonic decline in covenant violations.

3 A Conceptual Framework for Financial Covenants

In contrast to the extant literature on loan covenant violations, which typically studies how loan terms and firm outcomes change following a violation, we highlight that loan terms are very often left *unchanged*. In such cases, we infer that the lender determined that the borrower's credit quality had not deteriorated sufficiently to impose further conditions on the borrower. Ex-post, these violations impose a cost with little obvious benefit. Ex-ante, both lenders and borrowers would like to design covenants to avoid such costs.

We draw an analogy with medical tests used to diagnose disease. In the event of a positive medical test, further testing is frequently required to confirm a diagnosis and develop a plan for treatment. In some cases, subsequent testing reveals that the patient does not have the disease and requires no treatment. Because medical tests often provide only a probabilistic assessment of disease likelihood, such "false positives" can be quite common. Financial covenants function similarly; they are tests applied periodically to assess the current credit condition of the borrower, and in the case of a violation, prompt additional monitoring and renegotiation during which the lender gathers more information, diagnoses the current credit health of the borrower, and proposes a treatment if needed. In many cases, however, further monitoring reveals that the violation is a false positive and no treatment occurs.

[15] For each firm-quarter with a loan outstanding containing a financial covenant based on the current ratio, total net worth, or tangible net worth, we determine violation status by observing whether the reported quantity in Compustat falls below the contractual threshold in Dealscan. Following Chava and Roberts (2008), we linearly interpolate dynamic covenant thresholds, drop loans that appear to be in violation at origination, and, in the case of overlapping loans, define the relevant package to be the tighter of the two unless the latter deal corresponds to a refinancing.

If monitoring and renegotiation following a violation are costly, there is a tradeoff in the design of financial covenants.[16] Tight covenants catch a large fraction of borrowers whose credit quality has deteriorated sufficiently to warrant intervention by creditors. But tight covenants are also likely to catch a large fraction of borrowers that, upon further monitoring, are revealed to be relatively healthy and require no further action other than a waiver. The optimal contract balances these considerations, and loan parties have an incentive to design financial covenants that better detect when firms are truly financially distressed. We explore these tradeoffs more formally below.

3.1 A Model of Financial Covenant Thresholds

We assume that the population of borrowers contains non-distressed and distressed firms. A "distressed" borrower is in danger of not meeting its debt payment obligations when they come due. We distinguish between non-distressed and distressed borrowers with the variable $\widetilde{D} = \{0,1\}$. This simple dichotomy captures the essence of existing theories of financial covenants, which justify the change in control following a violation based on a worsening agency conflict. In Aghion and Bolton (1992), for example, creditors intervene when managerial private benefits are likely to distort investment decisions of the borrower, and in Garleanu and Zweibel (2009), creditors intervene to prevent firms from transferring value from debt to equity. Such conflicts are more likely to arise when the borrower is in financial distress.

The true status of a firm is unobservable but, as a diagnostic test, the lender can write financial covenants on a set of accounting values correlated with true status. We denote the occurrence of

[16] We take the existence of financial covenants as prima facie evidence of the costs of renegotiation. Instead of financial covenants that trigger renegotiation only occasionally, loan agreements could have very short maturities, which would trigger very frequent renegotiation (see, e.g., Berglöf and von Thadden, 1994). We take the ubiquity of longer maturities and financial covenants as support for our assumption that renegotiation costs are important. Moreover, it is standard to assume that lenders engage in costly screening activities at loan origination, and renegotiation following a covenant violation involves very similar tasks.

a violation by the indicator variable $\tilde{V} = \{0,1\}$. Under this setup, the role of financial covenants becomes one of statistical classification, which we summarize in Figure 2. Because observable performance metrics are imperfect indicators of distress, two types of mistakes will occur. First, the covenant can fail to catch a distressed firm, which is a false negative and occurs with probability $\Pr(V = 0, D = 1)$. Second, the covenant can catch a borrower that is non-distressed, which is a false positive that occurs with probability $\Pr(V = 1, D = 0)$. We denote the cost of each of these mistakes as C_{FN} and C_{FP}.

Adopting the notation of Murfin (2012), we denote the performance metric used in the financial covenant as r and the contractual threshold as t, with the convention that a violation occurs if $r > t$. We assume that distressed and non-distressed firms have (potentially) different distributions over r, so $\Pr(r < t|D = 1) = F_D(t)$ and $\Pr(r < t|D = 0) = F_{ND}(t)$, where $F_D(\cdot)$ and $F_{ND}(\cdot)$ are the conditional distribution functions for the performance variables for distressed and non-distressed firms, respectively. $F_D(\cdot)$ and $F_{ND}(\cdot)$ determine the *false negative rate* and *false positive rate*, which are the conditional probabilities of misclassification and a function of the threshold t. The false negative rate is $FNR(t) = \Pr(r < t|D = 1) = F_D(t)$ and the false positive rate is $FPR(t) = \Pr(r > t|D = 0) = 1 - F_{ND}(t)$.

Because $FNR(t)$ is increasing in t and $FPR(t)$ is decreasing in t, there is a trade-off in setting the covenant threshold; a tighter covenant (lower t) results in a lower probability of a false negative but a higher probability of a false positive. In statistical classification problems, it is common to assess the quality of a diagnostic test based on its receiver operating characteristic (ROC) curve, which is a plot of the relationship between the test's true positive rate (TPR) and FPR. The TPR is the probability of a covenant violation occurring conditional on the borrower being distressed, $TPR(t) = \Pr(r > t|D = 1) = 1 - F_D(t) = 1 - FNR(t)$. Because $TPR(t)$ is decreasing in t, there is a positive relationship between $TPR(t)$ and $FPR(t)$, and ROC curves are upward sloping.

Figure 3 displays ROC curves for two different tests, along with a 45-degree line that represents a completely uninformative test. The ROC curve that pushes further away from the 45-degree line and towards the northwest corner represents a better test, in that it better discriminates between distressed and non-distressed borrowers. This is easiest to see by noting that for a given FPR, a higher curve produces a higher TPR (equivalently, for a fixed TPR, the better test has a lower FPR). At the same time, movements along an ROC curve illustrate the tradeoff that occurs between the TPR and FPR as the test threshold is tightened or loosened. Tightening the threshold moves the test result up and to the right on an ROC, as more distressed firms are caught (a higher TPR), but so are more non-distressed firms (a higher FPR).

We assume that the optimal covenant threshold is set to minimize the total expected costs of false positives and false negatives

$$(1-\bar{\rho})FPR(t)C_{FP} + \bar{\rho}[1-TPR(t)]C_{FN} \,,$$

where $\bar{\rho}$ is the unconditional probability that a firm is distressed, and $1-TPR(t) = FNR(t)$. We view the fraction of distressed firms among a population of borrowers as a random variable with a distribution that may change over time. In that case, $\bar{\rho}$ is the mean of the distribution at the time covenants are set. The first-order condition for the minimization problem yields an intuitive equation that determines the optimal threshold:

$$\frac{(1-\bar{\rho})}{\bar{\rho}}\frac{C_{FP}}{C_{FN}} = \frac{f_D(t^*)}{f_{ND}(t^*)}\,, \tag{1}$$

where $f_D(\cdot)$ and $f_{ND}(\cdot)$ are the density functions corresponding to $F_D(\cdot)$ and $F_{ND}(\cdot)$. The left-hand side of (1) is the ratio of expected costs of false positives to false negatives; we expect $\frac{C_{FP}}{C_{FN}}$ to be much less than 1 and $\frac{(1-\bar{\rho})}{\bar{\rho}}$ to be much larger than 1. The right-hand side of (1) is a likelihood ratio for the relative probabilities of violation for a distressed and non-distressed borrower. At the optimal threshold, the revised odds that the borrower is distressed equals the ex-ante ratio of the expected costs. The right-hand side of (1) is also the slope of the ROC curve, and the optimal threshold is given where the slope of the ROC curve equals the ratio of expected costs, as shown in Figure 3. The ROC curve determines the set of *TPR* and *FPR* that are possible, and the optimal choice is based on the loan-party preferences as summarized by $\frac{(1-\bar{\rho})}{\bar{\rho}}\frac{C_{FP}}{C_{FN}}$, which generates a set of indifference curves in *TPR*, *FPR* space. The optimal contract is determined where the indifference curve is tangent to the ROC curve.

Equation (1) and Figure 3 highlight the two important factors that determine the optimal covenant threshold. First, under the assumption that the financial ratios used in covenants satisfy the monotone likelihood ratio property (MLRP), the right-hand side of (1) is increasing in t^*, so the optimal threshold is increasing in $\frac{(1-\bar{\rho})}{\bar{\rho}}\frac{C_{FP}}{C_{FN}}$.[17] If the expected costs of false positives, $(1-\bar{\rho})C_{FP}$, increases relative to the expected costs of false negatives, $\bar{\rho}C_{FN}$, the optimal threshold will increase – that is, become less restrictive – and both the TPR and FPR will decrease. In Figure 3, this scenario is represented by a steepening of the indifference curve from the red dotted line to the blue dashed line, which moves the optimal contract from Point 1 to Point 2. The ratio of expected costs can increase either because distress becomes less prevalent ($\bar{\rho}$ decreases) or the conditional cost of a false positive rises relative to the cost of a false negative ($\frac{C_{FP}}{C_{FN}}$ increases).

Second, the optimal threshold depends on the ability of financial covenants to discriminate between distressed and non-distressed borrowers, as summarized by the ROC curve. A better covenant technology is associated with an ROC curve that is further to the northwest, and the optimal threshold will adjust to generate a lower FPR and a higher TPR.[18] In Figure 3, this

[17] As shown in Gneiting and Vogel (2018), if $F_D(\cdot)$ and $F_{ND}(\cdot)$ satisfy the MLRP, the corresponding ROC curve will be increasing and concave.

[18] The impact of better covenant technology on the optimal threshold is ambiguous. With better ability to discriminate, a lower threshold need not result in a higher false positive rate and a higher threshold need not result in a lower true positive rate.

scenario is represented by the parallel shift in the red dotted indifference curve and the movement of the optimal contract from Point 1 to Point 3.

Figure 3 highlights a useful way to empirically distinguish between changes in preferences and changes in covenant technology. If, for example, the decrease in covenant violations over time is due to an increase in the relative expected costs of false positives, then both the TPR and FPR will decrease over time. Conversely, if the decrease in violations is due to improving covenant technology, the FPR will decrease but the TPR will not. In the subsequent sections, we use this intuition to assess the factors that have contributed to the observed trend in violations.

4 Assessing the Trend in Reported Violations

In this section, we evaluate the realized decline in covenant violations using the model presented in Section 3. To do so, we collect additional information on violation outcomes and corporate defaults to measure whether each firm-year is distressed or non-distressed, which, combined with information on violation status, allows us to place each firm-year observation into the appropriate cell in Figure 2. Armed with this data, we can decompose the annual violation rate by noting that

$$V_t = \rho_t \cdot TPR_t + (1 - \rho_t) \cdot FPR_t, \tag{2}$$

where V_t is the annual rate of covenant violations, ρ_t is the fraction of distressed firms in year t, TPR_t is the fraction of distressed firms that violate a covenant, and FPR_t is the fraction of non-distressed firms that violate a covenant. The decomposition in equation (2) allows us to assess the extent to which the observed decline in violations is driven by a change in preferences and/or a change in covenant technology. Lenders may be failing to catch truly distressed borrowers (i.e., a lower TPR), reducing unnecessary violations by firms that are in relatively good health (i.e., a lower FPR), or some combination of these factors.

4.1 Measuring Distress

Implementing the decomposition in equation (2) requires that we classify firms as either distressed or non-distressed. We make this assessment, in part, by collecting data from SEC filings on violation outcomes. Companies that disclose a covenant violation also report any steps taken to resolve the violation, including specific changes to loan terms. We read individual SEC filings and record changes to the loan agreement following a violation. Due the time-consuming nature of this data collection, we examine only a subset of the full firm-year sample described above. Specifically, we limit our analysis to the subset of firm-years that have a loan outstanding and covenant data available in Dealscan.[19] Requiring that the firm be covered by Dealscan has two benefits. First, it ensures that the firm has a loan and therefore the potential to violate a financial covenant, so our analysis focuses on the most relevant set of firm-years. Second, the restriction cuts the full sample by about one-half, reducing the cost of data collection. Figure 4 shows the annual frequency of new covenant violations in this subsample.[20] The time-series pattern shown in Figure 4 mimics the pattern from Figure 1 (which included the full sample of firms and violations), suggesting that the analysis sample is representative of the overall population.

For each new violation, we read the corresponding SEC filing, including attached exhibits if necessary, to determine the violation's resolution. We record whether the violation resulted in an amended loan agreement that: (i) raised the interest rate, (ii) reduced the loan commitment, (iii) required repayment of outstanding loan balances, or (iv) forced an asset sale or capital raising. We refer to violations with at least one of these four outcomes as "consequential" and label the violator as distressed. The distressed violators are then bucketed in the Figure 2 classification as

[19] We require that the firm issued a loan that matures after the as-of date of the SEC filing.
[20] Following Nini et al. (2012), we focus on "new" violations – meaning the firm has not violated a covenant in the previous four quarters – to cleanly identify contractual changes attributable to a given violation.

true positives. The remaining new violations in our sample – those for which we find no evidence of a consequential outcome following the violation – are labeled as non-distressed and counted as false positives under the Figure 2 classification.[21] We interpret the lack of consequences to the borrower as a false positive because the lender chose "no treatment" in the wake of the violation.

Our assumption is that, ex-post, a violation with no consequences generates a cost that exceeds any benefit provided by the violation, which is captured by the term C_{FP} in our model. We find that 55% of new violations are false positives, implying that a majority of violations are resolved with little adverse consequence to the borrower. Table 1 provides summary statistics for borrower characteristics split by whether the violation is classified as a true positive or a false positive. The statistics suggest that lenders condition their negotiation based on the condition of the borrower at the time of violation. On average, firms classified as true positives have lower cash flow, higher leverage and interest expense, less liquidity, and a lower market value than false positives. We infer from Table 1 that our classification system properly distinguishes between borrowers that require lender intervention and those that do not.

For each firm-year *not* reporting a violation, we assess distress based on the short-run experience of the firm following the failure to violate. We collect data on bankruptcy filings from Compustat, CRSP, Audit Analytics, and the Bankruptcy Research Database from UCLA-LoPucki, and classify as distressed any non-violating firm that files for bankruptcy protection within one year.[22] The group of non-violating firms that file for bankruptcy within one year constitute false negatives under our Figure 2 classification, and the group of non-violators that

[21] The range of actions that lenders can take after a violation is quite broad, so the four we code are not an exhaustive list. However, we believe the lack of one of these outcomes is a good indicator that the firm faced no other serious consequences. In our reading of SEC filings for violators, we observed no cases in which a reasonable reading of the outcome would suggest that the firm faced adverse consequences while avoiding all four outcomes we code. For this reason, we believe that our classification of false positives is measured with very little error.

[22] We clean data from Compustat and CRSP by hand-collecting bankruptcy filing dates because these data providers only offer deletion and delisting dates, respectively, which do not perfectly correspond to bankruptcy filings.

do not file for bankruptcy within one year are coded as true negatives. The one-year horizon is somewhat arbitrary, but we believe it is a reasonable period for covenants to serve as an early warning signal. If a firm violates a covenant in the same year that it files for bankruptcy, we consider the initial, one-year-ahead, non-violation to be a false negative.

Finally, we exclude all firm-years reporting an "old" violation, meaning the firm was in violation during the previous year. Since these firms recently renegotiated with their lenders, their experience will reflect the updated contract terms and any other changes prompted by the violation. Under the medical test analogy, these firms have already undergone additional screening and, potentially, treatment.

In Appendix 2, we examine the robustness of our estimates to two alternative measures of distress among non-violators. The first uses an estimate of the firm's probability of default based on a Merton (1974) model and the second relies on the issuance of a going concern warning by the firm's auditor. These alternatives use information available at the time of the violation, whereas the bankruptcy outcome depends, in part, on information that arrives after the violation. It is possible that a firm could not be in distress – even if distress was a perfectly knowable state at the time of violation – but still file for bankruptcy within a year. Since probability of default and going concern warnings are measured concurrent with a violation, they lessen this concern.

4.2 Decomposing the Trend in New Violations

The process of assigning firms into distressed and non-distressed categories creates an annual count of firms in the four cells of Figure 2, which we tabulate in Appendix 2. Under each approach for measuring distress, the vast majority (over 90%) of firm-years are true negatives, reflecting the fact that firms rarely violate financial covenants and very few non-violators are in distress. According to our primary distress measure, about 1.5% of firm-years are false negatives, meaning the firm does not violate a covenant but files for bankruptcy within a year. About 3% of firms are false positives, meaning the firm violates a covenant but faces no consequential penalty, and slightly less than 3% are true positives, meaning the firm violates a covenant and receives consequential treatment.

We use these data to decompose the trend into the three components shown in equation (2): the realized distress rate ($\rho_t = \frac{FN+TP}{N}$), the realized false positive rate ($FPR_t = \frac{FP_t}{FP_t+TN_t}$), and the realized true positive rate ($TPR_t = \frac{TP_t}{TP_t+FN_t}$). Figure 5 displays the time series of each of the three rates along with the estimated 95% confidence interval for the proportions. Appendix 2 shows the same series using alternative measures of distress.

Panel A of Figure 5 shows that the estimated distress rate is cyclical, with peaks during business cycle contractions in 2001 and 2008. Nevertheless, since 2010, the distress rate has remained consistently below the lowest levels experienced over the 1997 to 2009 period. This low level of distress has contributed to the low rate of violations since the financial crisis. Panel B shows that the true positive rate has also declined over our sample period, although most of the drop occurs after 2009. Between 1997 and 2009, roughly two-thirds of distressed firms would violate a financial covenant. However, by 2013, the TPR drops to around 45%, which corresponds to a modest increase in the fraction of distressed firms that fail to violate a covenant. Perhaps the most striking time-series pattern is presented in Panel C, which shows a steady and substantial decline in the FPR over the entire sample period. By 2016, the rate at which non-distressed firms violate covenants is one-eighth of the level from the late 1990s. This dramatic decrease reflects the fact that covenant violations towards the end of the sample period are much more likely to be accompanied by consequential amendments to the borrower's loan agreement. Appendix 2 confirms these patterns using our additional measures of distress.

As an alternative visualization, Figure 6 shows a scatterplot of the realized TPR and FPR, which is an empirical analog to the ROC curve in Figure 3. In the early years of the sample, the realized TPR and FPR are both quite high. During the middle years of the sample, the TPR remains mostly stable, but the FPR declines steadily, suggesting that the ROC curve shifted outward – a conjecture we confirm in the next section. In the final years of the sample, however, the TPR declines along with the FPR, suggesting a movement along the ROC curve rather than a continued shifting of the curve. In the next section, we assume a functional form for the ROC curve and quantify the observed trend as a combination of shifts in the ROC curve and movements along the ROC curve.

Our final decomposition exercise is to assess the contribution of the distress rate, the TPR, and the FPR to the overall fall in realized violations. To do so, we group the years into the three periods highlighted in Figure 6: 1997-2002, 2003-2009, and 2010-2016. Besides being about equal in length, these periods seem to correspond to three different regimes. Panel A of Table 2 reports the realized TPR, FPR, distress rate, and violation rate for each of the three periods. The evidence shows that the violation rate falls by about 85% across the three periods, with the TPR, FPR, and distress rate each contributing to the decline. Panels B, C, and D assess the contribution of each factor by holding the other factors constant at the 1997-2002 level and allowing only a single factor to vary according to the actual experience. The hypothetical violation rate is computed according to equation (2).

Panel B of Table 2 shows that, absent any changes in the FPR or TPR, the declining rate of financial distress among U.S firms would have reduced the overall violation rate by about 18% during the middle period and about 30% during the latter period, as compared with the earliest period. Although the distress rate is cyclical, Figure 5 shows that it falls and remains low during the latter part of the sample. Since the TPR is considerably larger than the FPR, a lower distress rate translates into a substantial decrease in violations.[23] Therefore, even absent any change in

[23] For a fixed level of the TPR and FPR, equation (2) implies that the change in violation rates across time periods is $\Delta V_t = (TPR - FPR)\Delta\rho_t$. In the first period of the sample, $TPR - FPR = 62.4\%$, so more than 60% of the decrease in the distress rate flows through to the violation rate.

underlying loan-party preferences or covenant technology, violations would have fallen roughly 30% due to falling distress rates.

Panel C shows that the declining TPR, which happens only during the third period, explains about 15% of the fall in violations during 2010-2016. Because the distress rate is so low during the latter part of the sample, the lower TPR has only a muted effect on the overall violation rate. By contrast, Panel D shows that the substantial decline in the FPR contributes significantly to the fall in the violation rate. Absent any changes in the TPR or distress rate, the considerable decline in the FPR would have caused the violation rate to drop by about one-half. The combined evidence in Table 2 suggests that the observed drop in violations can primarily be explained by a decline in the number of distressed public firms and a lower frequency of false positives among non-distressed firms, rather than a failure of covenants to catch distressed firms.

5 A Structural Decomposition

In this section, we impose some additional assumptions on the process generating the data summarized in Figures 5 and 6. With these assumptions, we can use equation (1) to estimate the underlying fundamentals of loan-party preferences and covenant technology that would lead to the observed patterns in the figures.

5.1 Structural Assumptions and Estimating Equations

We first assume that the performance metric used in financial covenant packages is normally distributed with unknown parameters. This assumption determines the shape of ROC curves in the space of Figure 3. We then use our data on the observed TPR and FPR to estimate the parameters of the distribution that form the actual ROC curves. Second, we assume that covenants are set according to equation (1), in which case the slope of the ROC curve at the observed TPR and FPR determines $\frac{(1-\bar{\rho})}{\bar{\rho}}\frac{C_{FP}}{C_{FN}}$. Because we observe the TPR and FPR for each year in our sample, we can decompose the time series trend into shifts in the ROC curve and movements along the ROC curve.

Specifically, we assume that the covenant performance metric is normally distributed with a mean that depends on the underlying status of the borrower; $r \sim N(\mu_D, 1)$ for distressed firms and $r \sim N(\mu_{ND}, 1)$ for non-distressed firms.[24] Without loss of generality, we assume that $\mu_{ND} = 0$, so the quality of the performance metric is parameterized by μ_D. The mean μ_D captures the level of covenant technology. When $\mu_D = 0$, the covenant signal cannot distinguish between distressed and non-distressed borrowers; a larger μ_D corresponds to a better signal. The right side of equation (1) becomes

$$\frac{f_D(t^*)}{f_{ND}(t^*)} = e^{\frac{[(2t^* - \mu_D)(\mu_D)]}{2}}.$$

Defining the left side of (1) as $R \equiv \frac{(1-\bar{\rho})}{\bar{\rho}}\frac{C_{FP}}{C_{FN}}$, solving for t^* yields the optimal threshold as

$$t^* = \frac{2\ln(R) + \mu_D^2}{2\mu_D} \quad . \tag{3}$$

The parameter R captures loan-party preferences that trade off the expected relative costs of false positives and negatives. Under the above assumptions, the TPR and FPR are given by

$$TPR = 1 - \Phi(t^*;\ \mu_D) \tag{4}$$

$$FPR = 1 - \Phi(t^*;\ 0) \tag{5}$$

where $\Phi(\cdot;\mu)$ denotes the normal CDF with mean μ and unit variance.

With data on the observed TPR and FPR, we can use equations (3), (4), and (5) to estimate t^*, μ_D, and R through a straightforward application of the method of moments. Beginning with

[24] We assume a variance of 1 because the variance of the distribution is unidentified. Since the TPR and FPR are proportions, we can estimate either the threshold or the variance, as in a probit model for a binary outcome. We normalize the variance to unity and estimate the threshold.

(5) and the realized FPR, we estimate the threshold t^*. With $\widehat{t^*}$ and the realized TPR, we use (4) to estimate μ_D. Finally, we use $\widehat{t^*}$, $\widehat{\mu_D}$, and (3) to estimate R. We rely exclusively on the model to estimate R, using the assumption that the optimal threshold is determined as a known function of preferences (R) and the covenant technology (μ_D). Because the parameter estimates are functions of sample statistics with known sampling variances, we use the delta method to estimate the standard errors of the model parameters. To increase the statistical precision of our estimates, we group the data into the same three periods used in Table 2.

5.2 Parameter Estimates

Table 3 reports the estimated parameters and Figure 7 displays the ROC curves implied by the parameter estimates. By construction, the realized TPR and FPR are points on ROC curves, and we infer the level of R based on the slope of the relevant ROC curve.

The estimates of μ_D, which can be interpreted as the difference in mean covenant values (measured in standard deviations) between distressed firms and non-distressed firms, range between 2.08 and 2.37. The estimates reflect the large differences between the TPR and the FPR, implying the financial ratios used in covenant packages are quite good at discriminating between distressed and non-distressed borrowers. Between the first period and the second period, the estimate of μ_D increases significantly, reflecting the decrease in the FPR but little change in the TPR. Figure 7 shows that the estimated ROC curve shifted between the first and second periods, implying that ability of covenants to discriminate between distressed and non-distressed borrowers improved in the early 2000s. Between the second and third period, both the TPR and FPR decrease, which can be rationalized by a movement along a relatively constant ROC, and the estimates suggest that covenant technology has remained constant since the financial crisis.

The estimates of preferences R are determined by the slope of the fitted ROC curve at the observed level of the TPR and FPR. In each period, the estimate of R is greater than 1, meaning that the expected cost of a false positive is larger than the expected cost of a false negative.[25] Across the three periods, the estimated level of R increases by a factor of more than 6, with much of the increase occurring between the second and third period.

Given the improvement in the ROC curve between the first and second period, the model would forecast an increase in the TPR (and a small decrease in the FPR) absent any change in R. In Figure 7, this counterfactual is represented by the 'X', which we compute using the estimated R from the 1999-2002 period and the ROC curve for the 2003-2009 period. The difference between this counterfactual and the actual point on the ROC curve is explained by an increase in R; that is a movement down the ROC curve. Because the ROC curve is relatively flat in this region, the estimated R increases by a factor of less than 2. Between the middle and late periods, however, the entire change in the TPR and FPR is explained by a movement along the ROC curve, since the estimated curves are nearly identical across the periods. Given the relatively steep ROC curve in this region, the estimated R increases by a factor of more than 3.5 between these periods.

The model also produces an estimate of the covenant threshold that determines violations. Between the first and second period, the estimated threshold increases by about 20%, implying that covenants have become less restrictive. But the loosening of covenants does not come entirely at the cost of capturing fewer true positives, since the better screening technology allows lenders to raise the TPR even with less restrictive covenants. According to the counterfactual captured in the 'X' in Figure 7, roughly one-quarter of the increase in the threshold is due to better covenant technology and the remainder is due to the higher R. Between the middle and

[25] The model draws this conclusion based on the shape of the ROC curves and the realized TPR and FPR. Only at much larger levels of each would the ROC curve become flat enough to have a slope near 1. Based on the estimated ROC curves, the slope would become 1 at an FPR of about 15%, which would correspond to a TPR of about 85%. Given actual FPRs of below 6%, the model infers a level of R well above 1.

later period, however, the roughly 30% increase in the threshold is entirely due to the higher level of R, since the ROC curves are unchanged between these periods.

Appendix 2 reproduces the estimates in Table 3 using our alternative measures of distress. Although point estimates vary slightly across approaches, the general patterns and conclusions are very similar. Each approach suggests that the covenant technology has improved somewhat, though the exact timing differs slightly. Relative to the realized bankruptcy measure, the alternative measures of distress suggest that some of the improvement in covenant technology happened in more recent years. Nevertheless, the point estimates and time series pattern of the estimates of R are remarkably similar across each approach, providing confidence that the increase in estimated R is not an artifact of how we measure distress. Each approach suggests that R has increased by a factor of more than 5 over the sample, with the bulk of the increase happening since the financial crisis.

5.3 Counterfactual Analysis

To quantify how the evolution of fundamentals has affected the frequency of realized covenant violations over time, we conduct two sets of counterfactual analyses using the model from Section 3 and the estimated parameters in Table 3.

First, we quantify the impact of changing covenant technology by fixing the preference parameter (R) across the three time periods and allowing the covenant technology (μ_D) to vary according to our estimates in Table 3. Panel A of Table 4 reports the counterfactual t^*, TPR, FPR, and violation rate in the latter two periods. The exercise shows that, although we estimate a statistically significant improvement in covenant technology over time, this improvement explains a relatively small portion of the fall in realized covenant violations. There are two reasons for this. First, the model-implied impact on the optimal threshold and the FPR is small. The optimal threshold increases in the second period as loan parties respond to improved technology. In our model, this leads to a reduction in the FPR, which we estimate to be a decline of about 13% relative to the first period. All else equal, the magnitude of this decline implies a reduction in the violation rate of only 0.6%. The second factor is that not all else is equal. Even with a higher optimal threshold, the improved covenant technology would yield a larger TPR, as shown by the 'X' in Figure 7, which is the optimal TPR and FPR holding constant R at the level from the first period. The higher level of TPR generates a higher frequency of covenant violations, and as shown in Table 4, the rise in the TPR largely offsets the fall in the FPR. Altogether, the improvement in covenant technology only reduces covenant violations by about 3%, and the reduction happens entirely between the first and second period.

Panel B shows the results of the second counterfactual analysis where we fix the distress rate and covenant technology (μ_D) across the three time periods and allow the preferences (R) to vary according to our estimates in Table 3. As shown in Table 4, changing preferences alone can account for a substantial portion of the fall in violation rates. The large increase in the estimated R would lead to a fall in violations of more than 70% absent any other changes. The reason is that an increase in the ratio of the expected costs of false positives to false negatives leads to a substantially higher optimal threshold, which lowers both the TPR and the FPR, each contributing to a lower violation rate. Across the three periods, the higher threshold leads to about a 50% fall in the TPR and nearly a 90% decrease in the FPR, highlighting that the change in R has a larger effect on the FPR than the TPR. Even between the first and second period (when the estimated R increases only modestly and the TPR falls by only about 15%), the FPR falls by more than 40%.

Without a model to help estimate the underlying parameters and compute counterfactuals, it would be tempting to ascribe the decrease in the FPR to an improvement in covenant technology, but the concomitant fall in the TPR suggests that it is changing preferences that have predominately pushed down violation rates. Together, the observed fall in the TPR and FPR generate the substantial decrease in the violation rate. The remaining fall in the violation rate, not accounted for by changing preferences, can be attributed to the decrease in the distress rate documented in Table 2.

Appendix 2 confirms that these conclusions are robust to alternative measures of distress. According to each measure, changes in covenant technology can explain very little of the fall in the violation rate. Instead, changing preferences and, to a lesser extent, a falling distress rate are the driving force for the fall in realized violations.

6 Discussion

In this section, we discuss some changes in the corporate loan market that may have contributed to the trends we document in this paper

6.1 Changing Preferences

Our evidence suggests a considerable change in preferences over the relative expected costs of false positives to false negatives, which we have termed $R \equiv \frac{(1-\bar{p})}{\bar{p}}\frac{C_{FP}}{C_{FN}}$. The estimates in Tables 3 and 4 show that R has increased by more than a factor of six and that the increase in R can account for nearly 85% of the fall in realized violations.[26] We highlight three factors that may have contributed to the change in preferences.

First, the loan market, particularly for leveraged loans, has undergone significant structural changes over the last two decades. Most notable is the rise of nonbank investors, particularly mutual funds and collateralized loan obligations (CLOs), which has resulted in larger and more diverse loan syndicates. Berlin, Nini, and Yu (2020) show that term loans funded by nonbank

[26] The fall in realized violations between periods 1 and 3 is 7.6% (8.9%-1.3%), and the fall due to just changing R is 6.4% (8.9%-2.5%).

investors have different covenant packages and are much more likely to be "covenant-lite," meaning the loan facility lacks traditional financial maintenance covenants. Becker and Ivashina (2016) attribute this difference to the high costs of renegotiation for loans with large syndicates composed of transactional lenders. A rise in in renegotiation costs would lead to a higher cost of false positive violations and an increase in R.

A second potential explanation for changing preferences is concomitant changes in the macroeconomy, particularly risk-free interest rates, during our sample period. Our sample period includes two recessions that led to long periods of very low risk-free interest rates. Roberts and Schwert (2020) argue that loan contracts, including control rights embedded in financial covenants, endogenously respond to the level of interest rates and show that control rights can weaken when rates are low. Aramonte, Lee, and Stebunovs (2019) show empirically that lower long-term interest rates generate "search for yield" behavior in the syndicated loan market, particularly by nonbank investors. Combined with the result in Ivashina and Vallee (2020), who show that negative covenants in loans funded by nonbank investors become particularly weak at times of high nonbank loan supply, the long period of low interest rates following the 2008-09 recession may contribute to the increase in R we document.

Finally, we suggest that lenders may have anticipated the downward trend in the level of corporate distress, which would raise R by increasing the term $\frac{(1-\bar{\rho})}{\bar{\rho}}$. The parameter $\bar{\rho}$ is the expected level of distress at the time covenants are set, but for illustrative purposes, we assume that the expected level of distress equals the realized level of distress during the period. Using the levels of distress reported in Panel A of Table 2, the decrease in distress from 6.0% during 1997-2002 to 1.6% during 2010-2016 would lead to an increase in R by a factor of nearly four, which would explain roughly 60 percent of the increase in R.[27] Although lenders may not have anticipated the full decrease in distress that actually occurred, they likely expected some of it in response to the low level of interest rates. Roberts and Schwert (2020) propose that low interest rates make borrowers less vulnerable to cash flow shocks because firms' interest expenses are lower. We leave it to future research to quantify the importance of this channel, but it seems plausible that lower expected distress has contributed to optimally looser covenants.

6.2 Changing Covenant Technology

Our evidence in Figures 6 and 7 and estimates in Table 3 suggest that covenant technology has improved over time, particularly during the first half of our sample period. Based on existing research, we conjecture that the improvement in covenant technology has been driven by a change in the *type* of financial covenants used in loan contracts.

Demerjian (2011) documents a sharp decline in the use of balance sheet-based financial covenants from the late 1990s through 2007 and argues that the decline was driven, in part, by changes in accounting standards that made balance sheet line items less useful for contracting.[28] Griffin, Nini, and Smith (2021) show that the decline in balance sheet-based covenants extends through 2016, but is not accompanied by a reduction in cash-flow based covenants.[29] The combination led to a significant reduction in the number of covenants used in loan agreements. Whereas the typical loan in the late 1990s had three or four covenants written on a combination

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[27] In the early period, $\frac{(1-.060)}{.060} = 15.67$, and in the late period $\frac{(1-.016)}{.016} = 61.50$. Based on Table 3, the increase in R is $\frac{22.30}{3.40} = 6.56$

[28] Balance sheet covenants typically include current ratios, quick ratios, debt-to-asset ratios, and the level of net worth. The popularity of these covenants is evident in early studies of financial covenants in loan agreements. See, e.g., Beneish and Press (1993, 1995); Sweeney (1994; Defond and Jiambalvo (1994); Dichev and Skinner (2002).

[29] Cash flow covenants typically include debt-to-EBITDA, interest coverage, and fixed charge coverage ratios. While the number of cash flow-based covenants has remained fairly constant, there is evidence that the components of EBITDA – a non-GAAP concept whose definition can vary by contract – have changed through time, including the use of more forward-looking "add-backs" that incorporate projected savings and synergies. See, for example, Badawi, Dyreng, de Fontenay, and Hills (2021).

of balance sheet and cash flow metrics, loans in more recent years rely almost exclusively on one or two covenants that benchmark performance against borrower EBITDA. Griffin et al. (2021) provide evidence that this shift has enabled lenders to rely on fewer, but higher quality, covenants that better discriminate between borrowers and reduce the expected number of false positive violations.

7 Conclusion

This paper presents a novel empirical finding – realized violations of financial covenants in U.S. corporate loan agreements have become considerably less common over the last 20 years – and uses this finding to understand the evolution of loan covenants. We model covenant design as a tradeoff between setting the threshold tight, which might lead to violations even when the borrower is not in danger of financial distress (a false positive), and setting the threshold loose, which may result in a failure to violate even when the borrower is financially distressed (a false negative). Our model predicts that the optimal covenant threshold is a function of the participants' preferences, which include the unconditional probability of distress and the relative costs of false positives to false negatives, and the ability of financial covenant packages to discriminate between healthy and distressed borrowers.

Using the model to assess the period 1997-2016, we find: (i) the false positive rate has decreased steadily and substantially during our sample period, (ii) the true positive rate remained relatively constant during the first two-thirds of the sample but has fallen since the financial crisis, and (iii) the financial distress rate among public firms has been lower during the latter part of the sample. We rationalize the observed decline in violations as reflecting a gradual improvement in covenant technology and a substantial shift in preferences towards a willingness to forego early detection of some distressed borrowers in exchange for fewer false-positive violations.

References

Aghion, P. and Bolton, P., 1992. An incomplete contracts approach to financial contracting. The Review of Economic Studies, 59(3), pp.473-494.

Ao, M., Bao, J., and Kolasinski, A. 2019. How does lender health affect covenant-violating borrowers? Working Paper.

Aramonte, S., Lee, S.J. and Stebunovs, V., 2019. Risk taking and low longer-term interest rates: Evidence from the US syndicated term loan market. Journal of Banking & Finance, p.105511.

Badawi, A.B., Dyreng, S., de Fontenay, E., and Hills, R. (2021). Contractual Complexity in Debt Agreements: The Case of EBITDA. Working Paper.

Balsam, S., Gu, Y. and Mao, C.X., 2018. Creditor Influence and CEO Compensation: Evidence from Debt Covenant Violations. The Accounting Review, 93(5), pp.23-50.

Becher, D., Griffin, T.P. and Nini, G., 2021. Creditor Control of Corporate Acquisitions. Review of Financial Studies, Forthcoming.

Becker, B. and Ivashina, V., 2016. Covenant-light contracts and creditor coordination. Working Paper.

Beneish, M.D. and Press, E., 1993. Costs of technical violation of accounting-based debt covenants. The Accounting Review, pp.233-257.

Beneish, M.D. and Press, E., 1995. The resolution of technical default. The Accounting Review, pp.337-353.

Berglöf, E. and Von Thadden, E.L., 1994. Short-term versus long-term interests: Capital structure with multiple investors. The Quarterly Journal of Economics, 109(4), pp.1055-1084.

Berlin, M. and Mester, L.J., 1992. Debt covenants and renegotiation. Journal of Financial Intermediation, 2(2), pp.95-133.

Berlin, M., Nini, G. and Yu, E., 2020. Concentration of control rights in leveraged loan syndicates. Journal of Financial Economics 137(1), pp. 249-271.

Bharath, S.T. and Shumway, T., 2008. Forecasting default with the Merton distance to default model. The Review of Financial Studies, 21(3), pp.1339-1369.

Chava, S., Nanda, V. and Xiao, S.C., 2017. Lending to innovative firms. The Review of Corporate Finance Studies, 6(2), pp.234-289.

Chava, S. and Roberts, M.R., 2008. How does financing impact investment? The role of debt covenants. The Journal of Finance, 63(5), pp.2085-2121.

Chen, K.C. and Wei, K.J., 1993. Creditors' decisions to waive violations of accounting-based debt covenants. The Accounting Review, pp.218-232.

Chodorow-Reich, G. and Falato, A., 2021. The loan covenant channel: How bank health transmits to the real economy. Journal of Finance, Forthcoming.

DeFond, M.L. and Jiambalvo, J., 1994. Debt covenant violation and manipulation of accruals. Journal of Accounting and Economics, 17(1-2), pp.145-176.

Demerjian, P.R., 2011. Accounting standards and debt covenants: Has the "balance sheet approach" led to a decline in the use of balance sheet covenants? Journal of Accounting and Economics, 52(2-3), pp.178-202.

Dichev, I.D. and Skinner, D.J., 2002. Large–sample evidence on the debt covenant hypothesis. Journal of Accounting Research, 40(4), pp.1091-1123.

Ersahin, N., Irani, R.M. and Le, H., 2021. Creditor control rights and resource allocation within firms. Journal of Financial Economics, 139(1), pp.186-208.

Falato, A. and Liang, N., 2016. Do creditor rights increase employment risk? Evidence from loan covenants. The Journal of Finance, 71(6), pp.2545-2590.

Ferreira, D., Ferreira, M.A. and Mariano, B., 2018. Creditor control rights and board independence. The Journal of Finance, 73(5), pp.2385-2423.

Freudenberg, F., Imbierowicz, B., Saunders, A. and Steffen, S., 2017. Covenant violations and dynamic loan contracting. Journal of Corporate Finance, 45, pp.540-565.

Gale, D. and Hellwig, M., 1985. Incentive-compatible debt contracts: The one-period problem. The Review of Economic Studies, 52(4), pp.647-663.

Garleanu, N. and Zwiebel, J., 2009. Design and renegotiation of debt covenants. The Review of Financial Studies, 22(2), pp.749-781.

Gneiting, T. and Vogel, P, 2018. Receiver operating characteristic (ROC) curves. arXiv preprint arXiv:1809.04808.

Griffin, T.P., Nini, G. and Smith, D.C., 2021. How Well Do Financial Covenants Detect Distress? Working Paper.

Gu, Y., Mao, C.X. and Tian, X., 2017. Banks' interventions and firms' innovation: Evidence from debt covenant violations. The Journal of Law and Economics, 60(4), pp.637-671.

Hsieh, F. and Turnbull, B.W., 1996. Nonparametric and semiparametric estimation of the receiver operating characteristic curve. Annals of Statistics, 24(1), pp.25-40.

Ivashina, V. and Vallee, B., 2020. Weak credit covenants. Working Paper.

Jang, Y.S., 2021. Lender leniency towards covenant violation. Working Paper.

Jiang, B., and Xu, D, 2019. Covenant amendment fee and value of creditor intervention after covenant violations. Working paper.

Kerekes, J., 2008. Receiver operating characteristic curve confidence intervals and regions. IEEE Geoscience and Remote Sensing Letters, 5(2), pp.251-255.

Merton, R.C., 1974. On the pricing of corporate debt: The risk structure of interest rates. The Journal of Finance, 29(2), pp.449-470.

Murfin, J., 2012. The supply-side determinants of loan contract strictness. The Journal of Finance, 67(5), pp.1565-1601.

Nini, G., Smith, D.C. and Sufi, A., 2009. Creditor control rights and firm investment policy. Journal of Financial Economics, 92(3), pp.400-420.

Nini, G., Smith, D.C. and Sufi, A., 2012. Creditor control rights, corporate governance, and firm value. The Review of Financial Studies, 25(6), pp.1713-1761.

Pepe, M.S., Cai, T. and Longton, G., 2006. Combining predictors for classification using the area under the receiver operating characteristic curve. Biometrics, 62(1), pp.221-229.

Roberts, M.R. and Schwert, M., 2020. Interest Rates and the Design of Financial Contracts. Working Paper.

Roberts, M.R. and Sufi, A., 2009. Control rights and capital structure: An empirical investigation. The Journal of Finance, 64(4), pp.1657-1695.

Simpson, Thatcher, and Bartlett LLP, 2005. Senior Credit Agreement with Commentary (Leveraged Transactions). New York, NY.

Smith, C., 1993. A perspective on violations of accounting-based debt covenants. Accounting Review, 68(2), pp.289-303.

Smith Jr, C.W. and Warner, J.B., 1979. On financial contracting: An analysis of bond covenants. Journal of Financial Economics, 7(2), pp.117-161.

Sweeney, A.P., 1994. Debt-covenant violations and managers' accounting responses. Journal of Accounting and Economics, 17(3), pp.281-308.

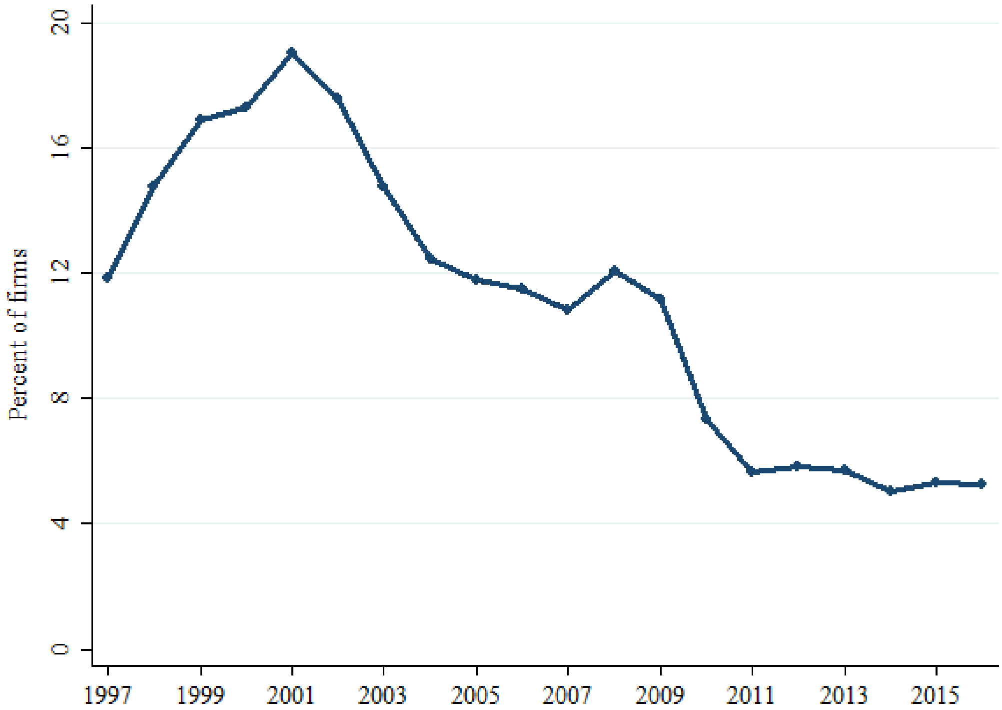
Tirole, J., 2010. The Theory of Corporate Finance. Princeton, NJ: Princeton University Press.

Townsend, R.M., 1979. Optimal contracts and competitive markets with costly state verification. Journal of Economic Theory, 21(2), pp.265-293.

Williamson, S.D., 1987. Costly monitoring, loan contracts, and equilibrium credit rationing. The Quarterly Journal of Economics, 102(1), pp.135-1.

Figures and Tables

Figure 1: Reported Covenant Violations



Note: This figure displays the annual percent of firms that report a financial covenant violation in a 10-K or 10-Q filing between 1997 and 2016. The sample consists of 66,589 firm-year observations from 8,499 U.S. nonfinancial firms that can be matched to EDGAR and have data available in Compustat.

Figure 2. Statistical Classification

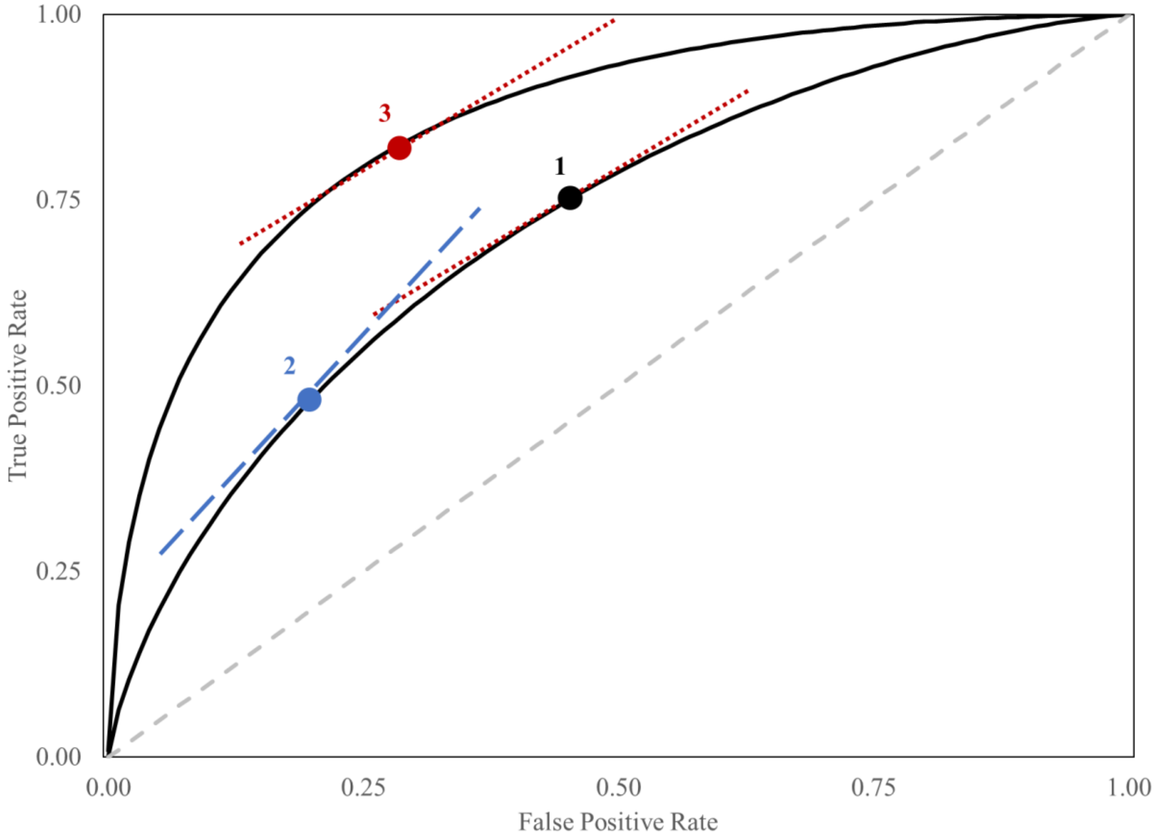
	Non-Distressed $(D = 0)$	Distressed $(D = 1)$
Non-Violator (V= 0)	True Negative	False Negative
Violator (V= 1)	False Positive	True Positive

$$FNR = \frac{Non - Violator}{Distressed}$$

$$FPR = \frac{Violator}{Non - Distressed}$$

$$TPR = \frac{Violator}{Distressed}$$

Figure 3. ROC Curves and the Optimal Threshold

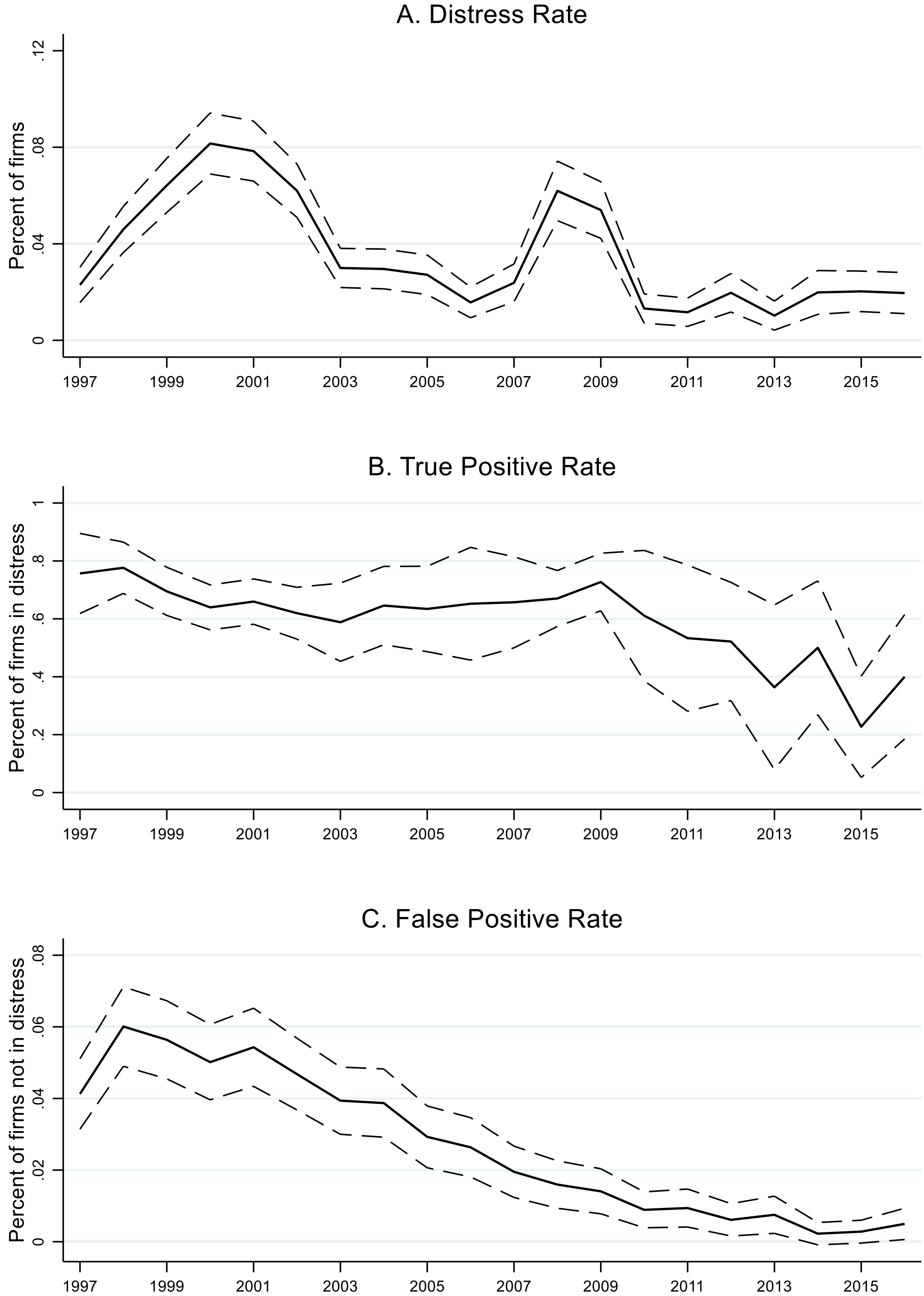


Note: The figure displays simulated ROC curves along with the optimal outcomes according to the model in Section 3. The 45-degree line represents an uninformative statistical test, and the ROC curve further to the upper left represents a superior statistical test. Points 1, 2, and 3 represent the TPR and FPR outcomes under the optimal threshold. Points 1 and 3 are based on the same level of $\frac{(1-\bar{\rho})}{\bar{\rho}}\frac{c_{FP}}{c_{FN}}$, and Point 2 is based on a larger value of $\frac{(1-\bar{\rho})}{\bar{\rho}}\frac{c_{FP}}{c_{FN}}$.

Figure 4: Reported New Covenant Violations

Note: This figure displays the annual percent of firms that report a new financial covenant violation in a 10-K or 10-Q filing between 1997 and 2016. The sample includes firms covered by Dealscan, and a new covenant violation is defined as a reported violation following four quarters of no reported covenant violation.

Figure 5. Decomposing the New Violation Rate

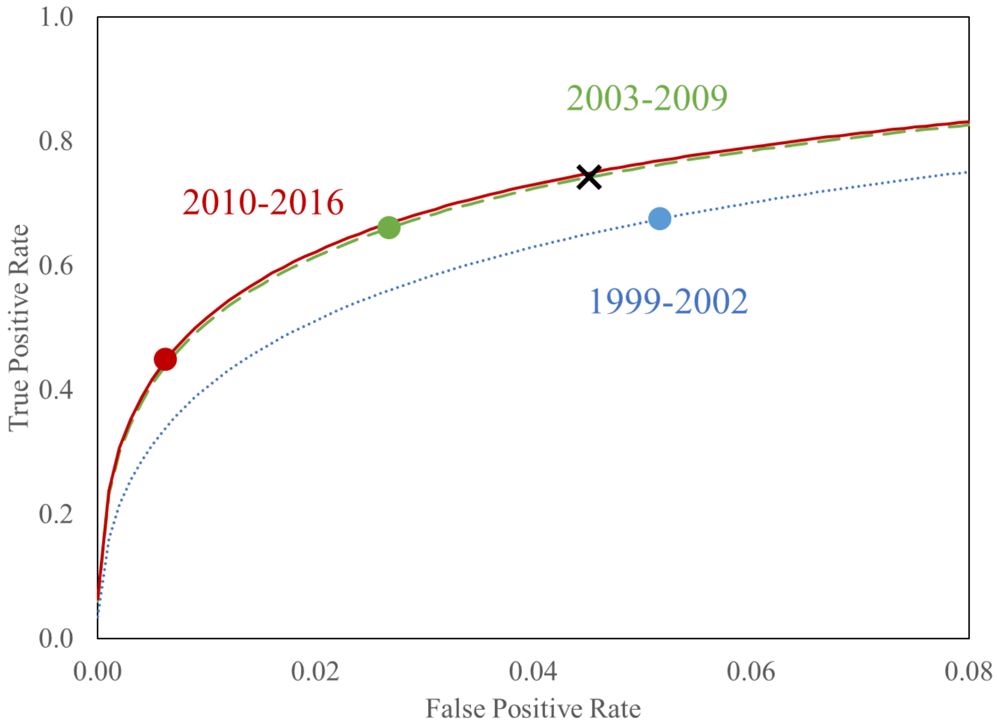


Note: Panel A displays the annual fraction of all firms in distress, defined as a consequential violation or a realized bankruptcy within one year. Panel B reports the annual fraction of distressed firms that report a covenant violation (TPR). Panel C reports the annual fraction of non-distressed firms that report a covenant violation (FPR). The dashed lines show a 95% confidence interval for the annual proportion.

Figure 6. Realized TPR and FPR in ROC Space

Note: The figure displays a scatterplot of realized true positive and false positive rates for the 20 years from 1997-2016. The blue diamonds show years 1997-2002, the green circles show years 2003-2009, and the red squares show years 2010-2016.

Figure 7. Estimated ROC Curves and Optimal TPR, FPR



Note: The figure displays the estimated ROC curves and realized TPR, FPR for the three periods: 1997-2002, 2003-2009, and 2010-2016. The black 'X' shows the model-based estimate of the point on the 2003-2009 ROC curve that would have prevailed if the estimated ratio of expected costs of false positives to false negatives remained at the 1999-2002 level.

Table 1: Borrower Characteristics at Violation

This table presents summary statistics for U.S. nonfinancial firms following a new covenant violation. We classify a violation as a false positive it was resolved through a waiver or an amendment that does not raise interest rates, force repayment, reduce the loan commitment, or force an asset sale/capital raising; all other violations are classified as a true positive. The borrower characteristics are taken as of the quarter of the reported violation, and flow variables are for the prior four-quarters. Operating cash flow is operating income before depreciation; debt is long-term debt plus debt in current liabilities; current ratio is current assets divided by current liabilities; market-to-book ratio is the ratio of the market value of assets, computed as the book value of debt plus the market value of equity, to the book value of assets.

	False Positive	**True Positive**	**p-value**
Operating cash flow / assets	0.007	-0.027	0.002
Debt / assets	0.316	0.411	0.000
Interest expense / assets	0.026	0.035	0.000
Current ratio	1.937	1.655	0.000
Market-to-book ratio	1.441	1.205	0.000
Cash / assets	0.088	0.063	0.000

Table 2: Decomposing the New Violation Rate by Period

Panel A decomposes the violation rate in three periods into the TPR, the FPR, and the distress rate, based on equation (2). Panels B, C, and D show the hypothetical violation rate during the latter two periods assuming that only the distress rate (Panel B), TPR (Panel C), or FPR (Panel D) evolve according to the actual experience. The other two parameters are held constant at their value from the 1997-2002 period.

	TPR	FPR	Distress	Violation
A. Actual				
1997-2002	67.6%	5.2%	6.0%	8.9%
2003-2009	66.1%	2.7%	3.4%	4.9%
2010-2016	44.9%	0.6%	1.6%	1.3%
B. Impact of distress				
2003-2009	67.6%	5.2%	3.4%	7.3%
2010-2016	67.6%	5.2%	1.6%	6.2%
C. Impact of TPR				
2003-2009	66.1%	5.2%	6.0%	8.8%
2010-2016	44.9%	5.2%	6.0%	7.5%
D. Impact of FPR				
2003-2009	67.6%	2.7%	6.0%	6.6%
2010-2016	67.6%	0.6%	6.0%	4.6%

Table 3: Structural Decomposition

This table presents the sample statistics and parameter estimates for the empirical model in Section 5. μ_D represents the difference in the means, between distressed and non-distressed firms, of the distributions generating the signals used in financial covenants. t^* is the optimally chosen threshold for a violation, and R is the ratio of expected costs of false positives to false negatives $\frac{(1-\rho)}{\rho}\frac{C_{FP}}{C_{FN}}$. Standard errors are reported below the parameter estimates in parentheses.

	μ_D	R	t^*
1997-2002	2.08	3.40	1.63
	(0.10)	(0.59)	(0.02)
2003-2009	2.35	5.91	1.93
	(0.15)	(1.55)	(0.03)
2010-2016	2.37	22.30	2.50
	(0.41)	(10.45)	(0.05)

Table 4: Counterfactual Analysis

This table presents two sets of counterfactual analyses. In Panel A, the distress rate and preference parameter (R) are held constant at their level in the 1997-2002 period, and the covenant technology parameter (μ_D) varies according to the estimated value in Table 3. In Panel B, the distress rate and technology parameter (μ_D) are held constant at their level in the 1997-2002 period, and the preference parameter (R) varies according to the estimated value in Table 3. The optimal threshold is determined according to the model in Section 3, and the resulting TPR, FPR, distress rate, and violation rate are determined as in Sections 4 and 5.

	Parameters		Implied Outcomes				
	μ_D	R	t^*	TPR	FPR	Distress	Violation
A. Impact of Changing Technology							
1997-2002	2.08	3.40	1.63	67.6%	5.2%	6.0%	8.9%
2003-2009	2.35	3.40	1.69	74.3%	4.5%	6.0%	8.7%
2010-2016	2.37	3.40	1.70	74.7%	4.5%	6.0%	8.7%
B. Impact of Changing Preferences							
1997-2002	2.08	3.40	1.63	67.6%	5.2%	6.0%	8.9%
2003-2009	2.08	5.91	1.89	57.5%	2.9%	6.0%	6.2%
2010-2016	2.08	22.30	2.53	32.7%	0.6%	6.0%	2.5%

Appendix 1: Comparison of Different Measures of Covenant Violations

Table A.1 reports the annual count of covenant violations based on three alternative approaches to identifying a violation. The first column is based on Nini, Sufi, and Smith (2012) that we extended through 2016. RS (2009) refers to reported violations as produced by Roberts and Sufi (2009), and CR (2008) is based on violations imputed from financial covenants and realized accounting ratios using the methodology of Chava and Roberts (2008).

Table A.1

Year	Reported violations	RS (2009) Reported violations	CR (2008) Imputed violations
1997	519	238	65
1998	635	296	105
1999	695	296	115
2000	711	313	87
2001	758	307	112
2002	665	230	116
2003	525	193	73
2004	428	137	41
2005	387	138	39
2006	374	116	32
2007	342	117	32
2008	377	127	45
2009	339	98	38
2010	216	50	34
2011	160	25	26
2012	164	.	15
2013	138	.	13
2014	144	.	22
2015	153	.	9
2016	122	.	9

Appendix 2: Alternative Measures of Distress for Non-Violating Firms

This appendix tests the robustness of our trend decomposition using alternative distress measures.

Table A.2 reports the annual decomposition of firms into true negatives (TN), false negatives (FN), false positives (FP), and true positives (TP). A TN is a firm that is not in distress and does not violate a covenant; a FN is a firm that is in distress and does not violate a covenant; a FP is a firm that is not in distress and does violate a covenant; and a TP is a firm in distress that violates a covenant. For violating firms, distress is determined as a consequential violation. For non-violating firms, distress is based on three alternative methods. In Panel A, non-violating firms are classified as in distress if the firm files for bankruptcy within one year. In Panel B, non-violating firms are classified as in distress if the firm's estimated probability of default is in the upper 5$^{\text{th}}$ percentile of the full sample distribution. In Panel C, non-violating firms are classified as in distress if the firm receives a going concern warning from their auditor. We note that going concern warnings are only available from Audit Analytics starting in 2000.

Figures A.1 and A.2 replicate Figure 5 from the main paper using two alternative measures of distress for non-violating firms. In Figure A.1, non-violating firms are classified as in distress if the firm's estimated probability of default is in the upper 5$^{\text{th}}$ percentile of the full sample distribution. In Figure A.2, non-violating firms are classified as in distress if the firm receives a going concern warning from their auditor. In each figure, Panel A displays the annual fraction of all firms in distress, Panel B reports the annual fraction of distressed firms that report a covenant violation (TPR), and Panel C reports the annual fraction of non-distressed firms that report a covenant violation (FPR). The dashed lines show a 95% confidence interval for the annual proportion.

Table A.3 reports the parameter estimates for the empirical model in Section 5. As in Table 3 of the main paper, μ_D represents the difference in the means, between distressed and non-distressed firms, of the distributions generating the signals used in financial covenants, t^* is the optimally chosen threshold for a violation, and R is the ratio of expected costs of false positives to false negatives $\frac{(1-\rho)}{\rho}\frac{C_{FP}}{C_{FN}}$. Standard errors are reported below the parameter estimates in parentheses. In Panel A, non-violating firms are classified as in distress if the firm files for bankruptcy within one year. In Panel B, non-violating firms are classified as in distress if the firm's estimated probability of default is in the upper 5$^{\text{th}}$ percentile of the full sample distribution. In Panel C, non-violating firms are classified as in distress if the firm receives a going concern warning from their auditor.

Table A.4 reports the results of the counterfactual analyses presented in Table 4 for alternative measures of distress. In the top panel, the distress rate and preference parameter (R) are held constant at their 1997-2002 level, and the covenant technology parameter (μ_D) varies according to the estimated value in Table 3. In bottom panel, the distress rate and technology parameter (μ_D) are held constant at their 1997-2002 level, and the preference parameter (R) varies according to the estimated value in Table 3. The optimal threshold is determined according to the model in Section 3, and the resulting TPR, FPR, distress rate, and violation rate are determined as in Sections 4 and 5. In Panel A, non-violating firms are classified as in distress if the firm files for bankruptcy within one year. In Panel B, non-violating firms are classified as in distress if the firm's estimated probability of default is in the upper 5$^{\text{th}}$ percentile of the full sample distribution. In Panel C, non-violating firms are classified as in distress if the firm receives a going concern warning from their auditor.

Table A.2

	A. Realized Bankruptcy				B. Probability of Default				C. Going Concern			
Year	TN	FN	FP	TP	TN	FN	FP	TP	TN	FN	FP	TP
1997	1,510	9	65	28	1,499	20	63	30	1,519	0	65	28
1998	1,658	19	106	66	1,613	64	101	71	1,677	0	110	62
1999	1,623	36	97	82	1,592	67	91	88	1,659	0	102	77
2000	1,572	53	83	94	1,453	172	67	110	1,541	84	80	97
2001	1,567	48	90	93	1,468	147	83	100	1,534	81	89	94
2002	1,629	43	80	70	1,550	122	74	76	1,582	90	80	70
2003	1,585	21	65	30	1,566	40	59	36	1,555	51	63	32
2004	1,514	17	61	31	1,511	20	64	28	1,491	40	62	30
2005	1,425	15	43	26	1,424	16	44	25	1,413	27	42	27
2006	1,403	8	38	15	1,401	10	38	15	1,391	20	38	15
2007	1,406	12	28	23	1,405	13	28	23	1,402	16	28	23
2008	1,356	30	22	61	1,268	118	20	63	1,349	37	21	62
2009	1,330	21	19	56	1,243	108	16	59	1,325	26	18	57
2010	1,336	7	12	11	1,336	7	12	11	1,327	16	12	11
2011	1,263	7	12	8	1,247	23	12	8	1,261	9	12	8
2012	1,137	11	7	12	1,145	3	7	12	1,142	6	7	12
2013	1,055	7	8	4	1,059	3	8	4	1,057	5	8	4
2014	887	9	2	9	885	11	3	8	891	5	3	8
2015	1,059	17	3	5	1,048	28	3	5	1,067	9	3	5
2016	996	12	5	8	990	18	4	9	1,001	7	5	8

Figure A.1. Decomposing the New Violation Rate: Distress Measured Using Probability of Default

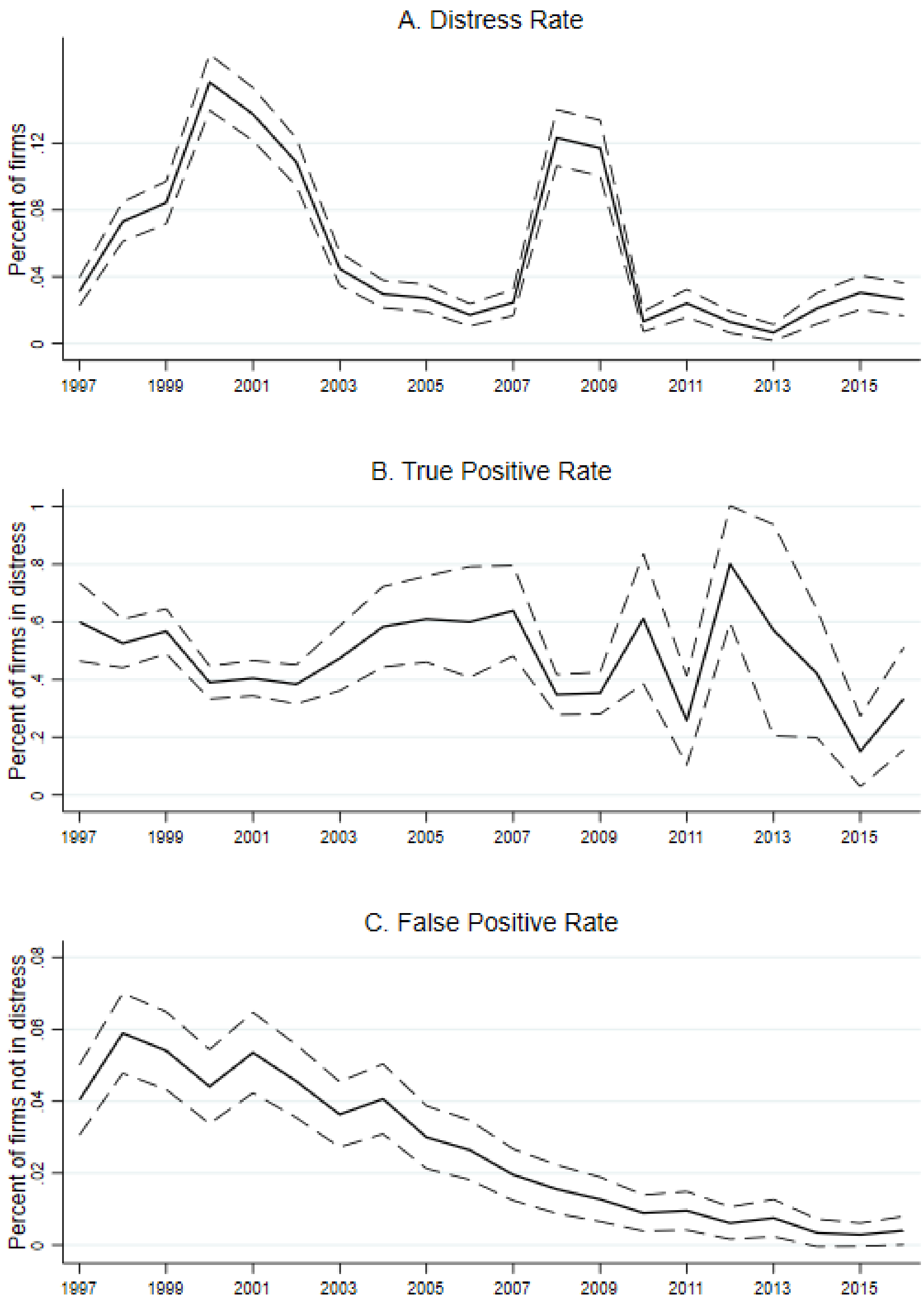


Figure A.2. Decomposing the New Violation Rate: Distress Measured Using Going Concern Warning

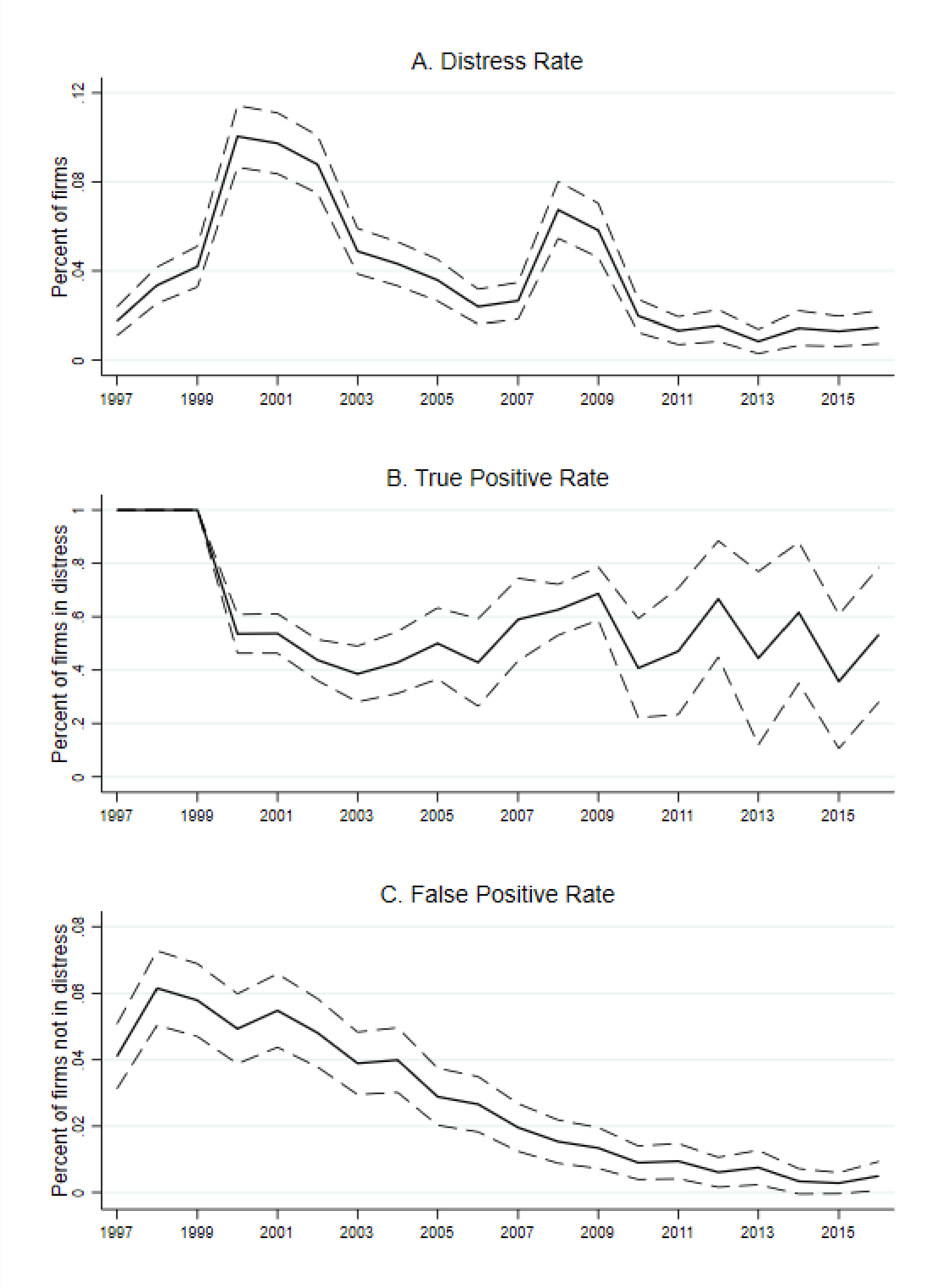


Table A.3

	A. Realized Bankruptcy			B. Probability of Default			C. Going Concern		
	μ_D	R	t^*	μ_D	R	t^*	μ_D	R	t^*
1997-2002	2.08	3.40	1.63	1.51	3.86	1.65	1.94	3.54	1.62
	(0.10)	(0.59)	(0.02)	(0.08)	(0.29)	(0.02)	(0.09)	(0.51)	(0.02)
2003-2009	2.35	5.91	1.93	1.77	6.38	1.93	2.01	6.45	1.93
	(0.15)	(1.55)	(0.03)	(0.12)	(0.82)	(0.03)	(0.13)	(1.16)	(0.03)
2010-2016	2.37	22.30	2.50	2.19	21.40	2.49	2.48	22.12	2.49
	(0.41)	(10.45)	(0.05)	(0.38)	(8.24)	(0.05)	(0.43)	(11.52)	(0.05)

Table A.4

	A. Realized Bankruptcy				B. Probability of Default				C. Going Concern			
	TPR	FPR	Distress	Violation	TPR	FPR	Distress	Violation	TPR	FPR	Distress	Violation
Impact of Changing Technology												
1997-2002	67.6%	5.2%	6.0%	8.9%	44.5%	5.0%	10.0%	8.9%	62.7%	5.2%	6.4%	8.9%
2003-2009	74.3%	4.5%	6.0%	8.7%	54.7%	5.0%	10.0%	9.9%	64.7%	5.1%	6.4%	8.9%
2010-2016	74.7%	4.5%	6.0%	8.7%	68.4%	4.4%	10.0%	10.7%	76.7%	4.0%	6.4%	8.6%
Impact of Changing Preferences												
1997-2002	67.6%	5.2%	6.0%	8.9%	44.5%	5.0%	10.0%	8.9%	62.7%	5.2%	6.4%	8.9%
2003-2009	57.5%	2.9%	6.0%	6.2%	31.9%	2.4%	10.0%	5.3%	50.6%	2.7%	6.4%	5.7%
2010-2016	32.7%	0.6%	6.0%	2.5%	10.2%	0.3%	10.0%	1.3%	26.8%	0.5%	6.4%	2.2%
Impact of Distress Rate												
1997-2002	67.6%	5.2%	6.0%	8.9%	44.5%	5.0%	10.0%	8.9%	62.7%	5.2%	6.4%	8.9%
2003-2009	67.6%	5.2%	3.4%	7.3%	44.5%	5.0%	5.4%	7.1%	62.7%	5.2%	4.3%	7.7%
2010-2016	67.6%	5.2%	1.6%	6.2%	44.5%	5.0%	1.9%	5.7%	62.7%	5.2%	1.4%	6.1%