

Measuring the Financial Soundness of US Firms 1926-2012*

PRELIMINARY AND INCOMPLETE

Andrew G. Atkeson,[†] Andrea L. Eisfeldt,[‡] and Pierre-Olivier Weill[§]

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Abstract

Building on the [Merton \(1974\)](#) and [Leland \(1994\)](#) structural models of credit risk, we develop a simple, transparent, and robust method for measuring the financial soundness of individual firms using data on their equity volatility. We use this method to retrace quantitatively the history of firms' financial soundness during U.S. business cycles over most of the last century. Our results offer new evidence about the role played by financial frictions and financial firms in U.S. recessions.

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[†]Department of Economics, University of California Los Angeles, NBER, and Federal Reserve Bank of Minneapolis. e-mail: andy@atkeson.net

[‡]Finance Area, Anderson School of Management, University of California, Los Angeles, e-mail: andrea.eisfeldt@anderson.ucla.edu

[§]Department of Economics, University of California Los Angeles, e-mail: poweill@econ.ucla.edu

Summary of Main Findings

Are recessions systematically associated with insolvency crises? We find that the largest recessions of the 1926-2011 period, in 1932-33, 1937, and 2008, were associated with deep *insolvency crises*, in the sense that the distribution of financial soundness across firms collapsed to abnormally low levels for almost all firms. Insolvency crises did not occur during other recessions, but did occur many times outside recessions, for example during the stock market crash of October 1987.

Are insolvency crises driven by leverage or asset volatility? The insolvency crisis of fall 2008 was mainly a result of a sudden increase in the asset volatility, or business risk, facing all firms. Contrary to many theories of financial crises, the contribution of the increase in leverage, induced by a fall in asset values, was relatively small over the time period 2007-2008.

Are financial firms special during insolvency crises? In each insolvency crisis, the timing and the magnitude of the financial soundness collapse is almost exactly the same for financial firms as it is for all firms, both financial and non-financial. This finding holds even if we restrict attention to the distribution of financial soundness across the largest financial firms. Thus, during each of our crisis episodes, there is little evidence that the financial soundness of financial firms deteriorated first, or by more.

Are financial firms that receive government support special during insolvency crises? We also examine the distribution of financial soundness across a smaller group of large financial firms that were at the center of attention of the recent financial crisis: the 18 publicly traded “Stress Test” banks and the six large financial firms that failed during the 2008 crisis (AIG, Bear Stearns, Lehman Brothers, Merrill Lynch, Wachovia, and Washington Mutual). Compared with other firms, both large or small financial firms or large non-financial firms, the financial soundness of these large institutions was quite similar from 1997 to the summer of 2007, but substantially worse for the full four years that have passed since the crisis began. Thus, these government backed large financial firms did not look different than their peers in terms of their financial soundness in advance of the recent financial crises but they do look different afterwards. This finding casts doubt about the effectiveness of the recent regulatory effort in restoring the financial health of these institutions.

1 Introduction

A large literature in macroeconomics argues that financial frictions impair the flow of resources to and across firms and play a key role amplifying and propagating business cycle shocks. Papers in this literature include [Bernanke and Gertler \(1989\)](#), [Carlstrom and Fuerst \(1997\)](#), [Kiyotaki and Moore \(1997\)](#), [Bernanke, Gertler, and Gilchrist \(1999\)](#), [Cooley and Quadrini \(2001\)](#), [Cooley, Marimon, and Quadrini \(2004\)](#), and many others. One central theme in this literature is that the distribution of financial soundness across firms in the economy at any point in time is a state variable that has consequences for the response of the macroeconomy to a variety of aggregate shocks. In particular, in these theories, negative macroeconomic shocks are greatly amplified and propagated when they simultaneously deteriorate the distribution of financial soundness across firms.

In this paper we develop a simple, transparent, and broadly applicable procedure for measuring the distribution of financial soundness across a wide cross-section of firms in the economy at any point in time. We build on the structural credit risk models of [Merton \(1974\)](#) and [Leland \(1994\)](#) and on their empirical and commercial implementations (see, for example, [Duffie, 2011](#); [Sun, Munves, and Hamilton, 2012](#)). Our contribution is to develop a simple summary statistic for a firms' financial soundness that is theoretically grounded and, unlike other empirical implementations, requires only data on the volatility of that firm's equity returns. Because of its simplicity, our procedure allows us to retrace the history of firms' financial soundness quantitatively in real time, for a long time series and a broad cross section of firms. We put forward this procedure as a useful diagnostic tool for evaluating business cycle theories that emphasize the role of financial frictions in shaping macroeconomic dynamics.

Motivated by the literature in macroeconomics relating the distribution of financial soundness across heterogeneous firms, we compute the cross section distribution of our proposed indicator of firms' financial soundness for all publicly traded U.S. firms and all months 1926-2011. We say that the economy experiences a *insolvency crisis* in a month when the financial soundness for *almost all* publicly traded firms deteriorates to a level usually associated with a junk credit rating status or worse. We also explore alternative definitions of an insolvency crisis based on the distribution of financial soundness across large publicly traded firms and across financial firms.

We use our procedure to address three empirical questions regarding the relationship between insolvency crises and U.S. business cycles since 1926. Are U.S. recessions since 1926 systematically associated with insolvency crises? Are insolvency crises driven by changes in firms' leverage or asset volatility? Are financial firms special in terms of the

behavior of their financial soundness during insolvency crises? Are government backed large financial firms special in terms of the behavior of their financial soundness during this most recent insolvency crisis?

Are recessions systematically associated with insolvency crises? Only three recessions (but the largest ones) were associated insolvency crises: the two recessions of the Great Depression, 1932-33 and 1937, as well as the recent recession of 2008. In contrast, we do not find significant insolvency crises in other recessions outside of these three. This includes even the deep recessions of the late 1970's and early 1980's. Thus, the insolvency crises in these three recessions is distinctive and is not characteristic of other recessions. This finding is consistent with the hypothesis that financial frictions played a major role in three of the largest recessions in U.S. history. At the same time, it casts doubt about the importance of financial frictions for U.S. postwar recessions outside of the most recent once.

Insolvency crises with no recession have occurred a number of times over the 1926-2011 period. These insolvency crises include May 1940, September 1946, May 1970, and October 1987. If one defines insolvency crises based on the financial soundness of the largest firms, then October 1974, August and September of 1998, January to April of 2000, and July and October of 2002 are added to the list. As we discuss below, almost all of these episodes coincide with other crises indicators, for example news reports or the quantitative measure of Giesecke, Longstaff, Schaefer, and Strebulaev (2011). Yet, none of them are closely associated with a recession, with the possible exception of October 1974. We interpret this finding as consistent with the hypothesis that an insolvency crisis in and of itself does not cause a recession (see also Giesecke, Longstaff, Schaefer, and Strebulaev, 2012).

We conclude that further research should focus on the question of why an insolvency crisis alone does not lead to recession. What additional factors come into play in determining whether an insolvency crisis impacts the real economy?

Are insolvency crises driven by changes in leverage or in volatility? Our measure of financial soundness builds on the structural credit risk models of Merton (1974) and Leland (1994). In line with their central insight, it accounts both for a firm's *leverage* (how much a firm's assets are worth relative to its liabilities) and its *asset volatility* (also called its *business risk*). In particular, our measure adjusts leverage upwards when volatility is high, and vice versa, since high asset volatility decreases a firm's effective equity cushion.

In the macroeconomic literature, it has long been recognized that leverage is likely to be a key state variable for determining the effects of financial frictions on the aggregate economy and for evaluating the current viability of the banking sector. There is a significant literature that points to the buildup of leverage as a key precursor to the start of a financial crisis (see for example [Kindleberger and Aliber, 2005](#), and [Reinhart and Rogoff, 2009](#)). The impact of changes in asset volatility or business risk on financial soundness and financial frictions, on the other hand, has been examined more closely only recently, for example by [Bloom \(2009\)](#), [Christiano, Motto, and Rostagno \(2010\)](#), [Gilchrist, Sim, and Zakrajsek \(2010\)](#), [Rampini and Viswanathan \(2010\)](#), [Arellano, Bai, and Kehoe \(2011\)](#), and others.

We use our measure of financial soundness together with accounting data by firms to ask whether the insolvency crisis of 2008 was mostly driven by an increase in leverage, induced by a fall in firms' asset values, or by an increase in firms' asset volatility. Specifically, we decompose the collapse in the distribution of financial soundness across firms that occurred in the fall of 2008 into the component that was due only to an increase in asset volatility and the remainder which was due to leverage increasing. We find that the major portion of the collapse in the distribution of financial soundness that occurred in 2008 was due to an increase in asset volatility (or business risk). This finding stands in contrast to the assumption in most macroeconomic theories of financial frictions cited above that it is an increase in firms' leverage due to a decline in asset values that leads to financial crises.

Moreover, we find it striking that our measure of the distribution of financial soundness across firms both financial and non-financial rose to historically high levels of soundness in advance of the crisis of 2008 despite the increase in leverage that occurred over this period. Hence, our empirical work thus suggests that measures of leverage and a measure of financial soundness that adjusts for volatility behave very differently over time. In particular, in order to understand financial crises, one should account for changes in asset volatility (or business risk) over and above changes in leverage.

Are financial firms special during insolvency crises? The macroeconomic literature cited above highlights the role of financial frictions facing *all firms* in shaping business cycles. There is also a large literature in macroeconomics making the case that frictions facing *financial intermediaries* play perhaps an even larger role in shaping the evolution of the macroeconomy. According to this literature, recessions can be caused by a deterioration in the financial soundness of financial intermediaries alone, due to their central role in reallocating resources in the economy. Important papers in this literature include

Bernanke (1983), and recent surveys of theory by Gertler and Kiyotaki (2010) and of empirical experience with financial crises by Reinhart and Rogoff (2009). One of the main virtues of our proposed method for measuring the financial soundness of firms is that it can easily be applied to financial as well as non-financial firms even though the type and reporting of leverage varies across the two types of firms. In our empirical work, we apply our method to measure the distribution of financial soundness for publicly traded *financial* firms from 1926 through 2011. This allows us to address the question: during the three recessions of 1932-33, 1937, and 2008, is the evolution of the distribution of financial soundness significantly different for financial firms than for other firms?

We first use a broad definition of financial firms, including all firms in the Finance, Insurance, and Real Estate sector (with SIC codes from 6000-6999). Over the last 20 years, there have been roughly 2000 such firms in our dataset each month. We find that the timing and magnitude of the deterioration in the distribution of financial soundness for financial firms in 1932-33, 1937, and 2008 is almost exactly the same as for all firms, both financial and non-financial. There is little evidence during these three recessions that the financial soundness of financial firms deteriorated first, or that it deteriorated by more. Instead, the collapse in the distribution of financial soundness across financial and non-financial firms in these episodes was simultaneous and of comparable magnitude.

This finding puts some discipline on theories in which a deterioration in financial soundness impacts the real economy. In particular, our findings indicate that the transmission of a financial crisis to the real economy (if that is the direction of causation) occurs very rapidly. This empirical finding may be consistent with theories such as those put forward recently by He and Krishnamurthy (2012), Brunnermeier and Sannikov (2012) and Rampini and Viswanathan (2012) in which a deterioration in the financial soundness of financial intermediaries leads to a sudden change in the pricing of capital for all firms. Although it originates in the financial sector, such pricing shock might lead to the observation that the insolvency crises of financial and non-financial firms were simultaneous.

Alternatively, our findings may also be consistent with the models of Gabaix (2012) and Gourio (Forthcoming) in which financial crises and the recessions that accompany them are not caused by issues specific to financial intermediaries but instead are driven by the common cause of time-varying disaster risk. As we discuss below, the collapse in the distribution of financial soundness across all firms that is observed in the fall of 2008 is driven, in an accounting sense, by a substantial increase in the volatility of the value of all firms' assets. A theory driven by a sudden increase in disaster risk has the advantage of being a very parsimonious explanation of the collapses in the distribution of financial soundness across firms observed in these three recessions. Such a theory suffers however,

from the drawback that it does not account for the observation that historical events that might have objectively signaled an increase in disaster risk such as onset of World War II and the events of the Cold War such as the Cuban Missile Crisis are not associated with similar sustained deterioration in the financial soundness of firms.

Perhaps our first definition of financial firms is too broad. Ever since the Federal Deposit Insurance Corporation intervened to save Continental Illinois National Banks, large financial institutions have been deemed “Too Big to Fail” because of the critical role they might play in the economy. According to this view, it is the financial soundness of large financial institutions that plays a prominent role in amplifying macro economic shocks. Small financial institutions are less important. (See, for example, [Stern and Feldman, 2004](#)).

Motivated by these discussions, we use our procedure to measure the distribution of financial soundness across large financial firms. Specifically, we examine whether we find substantial differences in the distribution of financial soundness for large financial firms relative to that for other financial firms and relative that for to other large non-financial firms. We focus on the time period after 1962 as it is only after this date that we have a sufficiently large number of financial firms in our data to distinguish between large and small financial firms. We find that the distribution of financial soundness for the 50 largest financial firms (with firm size measured by stock market capitalization) over the prior 1962-2011 is quite similar to that for all financial firms, and also to that for the 50 largest firms, both non-financial and financial, with size again measured by market capitalization. Thus, we find little evidence suggesting that the distribution of financial soundness across large financial firms was significantly different than that for other financial firms or for other large non-financial firms over this period.

Are government backed large financial firms special during the recent insolvency crisis? In our empirical work, we have found little evidence that the evolution of the distribution of financial soundness across financial firms is significantly different from that for all firms, both financial and non-financial, even if we focus attention on the largest financial firms. There is a large literature, however, that points to a particular subset of financial intermediaries, often termed “banks”, as playing a particularly important role in financial crises and in shaping the impact of such crises on the macroeconomy (see, for example, [Corrigan, 1983](#); [Financial Crisis Inquiry Commission, 2011](#); [Gorton, 2012](#)). The new financial regulatory framework that has emerged in the wake of the most recent crisis is built in large part on the premise that it is possible to identify a set of such *systemically*

important financial institutions ex-ante and prevent further financial crises by subjecting these special institutions to greater regulatory scrutiny and higher standards of safety and soundness.

Motivated by this regulatory approach, we use our empirical procedure to uncover whether there indeed is a set of financial institutions for which the distribution of financial soundness evolved in a distinctive manner either in advance or after this most recent crisis. Specifically, we use our procedure for measuring the financial soundness of a narrower set of large financial firms that we term the *government-backed large financial institutions* over the period 1997-2011. We define this set of government-backed large financial firms as the 18 publicly traded firms currently on the list of the 19 largest bank holding companies subject to the most stringent annual “stress test” by the Federal Reserve together with the six large financial firms that failed during the crisis: AIG, Bear Stearns, Lehman, Merrill Lynch, Wachovia, and Washington Mutual. We compare the distribution of financial soundness for this set of government-backed large financial firms to that for all financial firms and for the 50 largest firms, both non-financial and financial.

We find that over the period 1997 - summer 2007 leading up to the crisis, the distribution of financial soundness across these government-backed large financial firms was quite similar to that for all financial firms and for the 50 largest firms, both non-financial and financial. Moreover, this distribution of financial financial soundness for these firms improved steadily over the period 2002- summer 2007. Thus, our evidence does not indicate that the government-backed large financial firms looked unsound in the years leading up to the crisis, either in comparison to their peers or in absolute terms compared to history. In contrast, we find that starting in the summer of 2007 and over the four years that have followed, the distribution of financial soundness for these government backed large financial firms has looked significantly worse than that for all financial firms and for the 50 largest firms, both non-financial and financial.

One might interpret the finding that the government backed large financial institutions began to look substantially less sound than their peers starting in the late summer of 2007 in one of two ways. On the one hand, one might argue that this finding is simply the result of selection ex-post: six of the 24 firms in this group failed by September of 2008, at least two others received explicit bailouts, and many claim that many other firms in this group would have failed without extraordinary government intervention. On the other hand, one might argue that indeed it was this set of firms that was “systemically important” ex-ante and it was their failure that led to insolvency crisis of September of 2008. We cannot resolve which interpretation is correct with the methods presented here.

We do, however, find it striking that the distribution of financial soundness across these

institutions has remained substantially worse than that for all financial firms and than that for all large firms. Basically, the stress test banks and AIG have looked substantially less sound than their peers despite the attention that they have received from regulators in the years following the crisis. In this regard, our findings are consistent with the theories of [Diamond and Rajan \(2011\)](#) and [Admati, DeMarzo, Hellwig, and Pfleiderer \(2012\)](#) arguing that these increased regulatory efforts have not overcome the problems of debt overhang and moral hazard due to government support that hinder the incentives of bank owners and managers to take the steps needed to restore their banks to financial health after a crisis.

The remainder of this paper is organized as follows. In section [2](#), we describe the theory underlying our measurement procedure, in section [3](#) we compare the empirical performance of our measure of financial soundness to other measures of financial soundness, and in section [4](#) we present our empirical results. We conclude with a discussion of the implications of these findings for business cycle research.

2 The Theory Underlying our Measurement

Our empirical work is based on a specific theoretical one-dimensional index of a firm's financial soundness which we term *Distance to Insolvency*.^{[1](#)} To define terms, we say that a firm is *solvent* if its underlying assets are worth more than its liabilities and *insolvent* if this is not the case. More specifically, we define the firm's leverage as the percentage gap between the value of the firm's underlying assets and the firm's liabilities, and we define the volatility of the firm's underlying assets as the (instantaneous) percentage standard deviation of innovations to the value of these assets. A firm's distance to insolvency is defined as the ratio of our measure of leverage to our measure of asset volatility, both dated at a point in time t . Thus, a firm's distance to insolvency is the drop in asset value that would render the firm insolvent, measured in units of the standard deviation of the firm's asset value. In other words, distance to insolvency measures by how many annualized standard deviations of asset value growth the firm's asset value exceeds the promised value of its liabilities.

¹Our concept of *Distance to Insolvency* is closely related to but distinct from the concept of *Distance to Default* defined in structural models of firms' credit risk pioneered by [Merton \(1974\)](#) and [Leland \(1994\)](#).

2.1 Distance to Insolvency: definition

To define terms, we make use of the following notation. The firm has on the left-hand side of its balance sheet assets which yield at time $t \geq 0$ a stochastic cash flow denoted by y_t . Let V_{At} be the market value of the assets' future cash flows, measured using state-contingent prices. On the right-hand side of its balance sheet, the firm has liabilities which we model as a deterministic sequence of cash flows $\{c_t, t \geq 0\}$ which the equity holders of the firm are contractually obligated to pay if they should wish to continue as owners of the firm. Let V_{Bt} be the market value of the liabilities' future cash flows, valued as if they were default free. Of course, since the firm may default on its liabilities, V_{Bt} is larger than the market value of the firm's debt. We say that a firm is *solvent* if its underlying assets are worth more than its liabilities, $V_{At} \geq V_{Bt}$, and *insolvent* otherwise. Let the *asset volatility*, σ_{At} , be the (instantaneous) percentage standard deviation of innovations to V_{At} , representing the business risk that the firm faces. Let the *leverage* be the percentage gap between the value of the firm's underlying assets and the firm's liabilities, $(V_{At} - V_{Bt})/V_{At}$. A firm's distance to insolvency is defined as

$$DI_t = \left(\frac{V_{At} - V_{Bt}}{V_{At}} \right) \frac{1}{\sigma_{At}},$$

the ratio of our measure of leverage to our measure of asset volatility, both dated at a point in time t . Thus, DI_t is the drop in asset value that would render the firm insolvent, measured in units of the firm's asset standard deviation.

We illustrate these concepts graphically in Figure 1. The solid blue line in the figure denotes the evolution of the value of the firm's assets, V_{At} , over time. The solid blue line ends at the current time t . The solid red line denotes the value of the firm's liabilities V_{Bt} . The black arrow denotes the distance between V_{At} and V_{Bt} at time t . The dashed blue lines denote standard error bands around the evolution of V_{At+s} going forward at different time horizons $s > 0$. The likelihood that the firm becomes insolvent in the near term depends both on the distance between V_{At} and V_{Bt} , measured here in percentage terms by the firm's leverage, and the volatility in percentage terms of innovations to the value of the firm's assets. We combine these two factors into Distance to Insolvency which serves as simple one-dimensional index of the firm's financial soundness.

Calculating a firm's distance to insolvency is challenging in practice because it requires one to measure the market value and volatility of a firm's underlying assets, V_{At} and σ_{At} , and the value of its liabilities, V_{Bt} . The former are not directly observable, and the latter is subject to deficiencies and inconsistencies in accounting measures of firms' liabilities across countries, time, and industries. To circumvent these difficulties, we use

a straightforward extension of Leland’s (1994) structural model of credit risk in order to derive two approximation results that dramatically simplify measurement relative to what has been done in the academic literature and in commercial applications.² Specifically, we show that one can approximate a firm’s Distance to Insolvency simply with the inverse of the firm’s equity volatility. This approach has several strengths: it appears to be robust to a variety of model specifications, it does not require the use of accounting data, and it can be implemented over long time periods and across many countries.

2.2 Distance to Insolvency in a simple structural model

Using the Leland (1994) structural model of credit risk, we derive two theoretical approximation results. First, if equity is a claim with limited liability to the cash flow from the assets of the firm, then *the inverse of the (instantaneous) standard deviation of innovations to the firm’s equity value at time t is an upper bound on the firm’s distance to insolvency at time t* . Second, if the firm’s creditors are aggressive in forcing the equity holders to file for bankruptcy as soon as the firm is insolvent, then *this upper bound is tight*.³ We argue that because these findings rely on just a few elementary properties of the value of equity, they are likely to hold in a broad class of models.

The Leland Model. Let interest rates and the market price of risk be constant. On the left-hand side of the firm’s balance sheet, the cash flows derived from the firm’s underlying assets (lines of business) follow a geometric Brownian motion with constant volatility. In this case, the market value of the firm’s asset, V_{At} , also follows a geometric Brownian motion with constant volatility σ_A . In particular, fluctuations in V_{At} are driven entirely by fluctuations in the firm’s projected cash flows. On the right-hand side of its balance sheet, the firm has liabilities given by a perpetual constant flow of payments $c > 0$. Hence, the present value of these payment is constant and equal to $V_B = c/r$, where $r > 0$ denotes the interest rate.

Equity holders have limited liability, in that they can choose to stop making the contractual liability payments, in which case they default and assets are transferred to creditors. Creditors are protected by covenants, allowing them to force equity holders

²Moody’s has implemented and marketed a structural model of firm’s credit risk for the past decade. One of our contributions relative to the work done at Moody’s is to propose a method that allows us to measure credit risk back to 1926.

³Black and Cox (1976) pioneered the study of structural models of credit risk in which creditors add bond provisions to force equity to exercise their right to limited liability when the firm becomes insolvent. Longstaff and Schwartz (1995) build on the Black and Cox model to incorporate both default and interest rate risk.

into default if the value V_{At} of the assets fall below some exogenously given threshold, which we assume is lower than V_B . Using standard arguments, one can show that, when the value of assets falls below some endogenous threshold $V_A^* \leq V_B$, either equity holders exercise their right to default or creditors exercise their protective covenant. The value of equity can be written as $V_{Et} = w(V_{At})$, for some continuous function $w(V_A)$ with key properties illustrated in Figure 2.

Lemma 1. *In Leland (1994) structural model, the value of equity, $w(V_A)$, is greater than $\max\{0, V_A - V_B\}$, non-decreasing, convex, and satisfies $w'(V_A) \leq 1$ as well as $w(V_A^*) = 0$.*

The lower bound, $\max\{0, V_A - V_B\}$, follows from limited liability assumption: the value of equity has to be greater than zero, and it also has to be greater than $V_A - V_B$, its value under unlimited liability. Moreover, in line with the original insights from Merton (1974), the value of equity inherits standard convexity properties of call options. Note in particular that $w'(V_A) \leq 1$, which follows from the fact that the option value of limited liability falls as the value of the firm's assets rises. Finally, the value of equity must be zero at the default point, V_A^* .

Measuring distance to insolvency. As mentioned above, measuring DI_t is challenging because, typically, one does not have data with which to directly measure the firm's asset value and volatility, V_{At} and σ_A , nor the value of its liabilities, V_{Bt} . The approach pioneered by Merton and Leland is to use a specific structural model of the kind above to derive formulas for the value of the firm's equity at t , denoted by V_{Et} , and the standard deviation of the innovations to the logarithm of V_{Et} , denoted by σ_{Et} , as functions of the asset value and volatility and the firm's liabilities, V_B , V_{At} , and σ_A . Given data on the firm's equity value, equity volatility, and liabilities, one can invert the formulas to uncover the unobserved asset value V_{At} and asset volatility σ_{At} . One leading example of a structural credit risk model is implemented by Moody's Analytics (a subsidiary of the credit rating agency) which has sold the model results under the brand name *Expected Default Frequency* or EDF for over a decade. The specification of their model and its empirical implementation is described in Sun, Munves, and Hamilton (2012).

We simplify the approach taken in this literature with the following two approximation results.

Proposition 1. *In a Leland (1994) structural model, Distance to Insolvency, DI_t , is bounded above by the inverse of equity volatility.*

$$DI_t \leq \frac{1}{\sigma_{Et}}.$$

Proof. To prove this result, note first that, by Ito's formula, the volatility of equity solves:

$$\sigma_{Et} = \frac{w'(V_{At})}{w(V_{At})} \sigma_A V_{At} \implies \frac{1}{\sigma_{Et}} = \frac{w(V_{At})}{w'(V_{At})} \frac{1}{\sigma_A V_{At}}.$$

By Lemma 1 we have that $w(V_{At}) \geq V_{At} - V_{Bt}$, and $w'(V_{At}) \leq 1$, and the results follow. \square

Next, consider the question of whether this upper bound on the firm's distance to insolvency is tight. To do this, recall that V_A^* is the threshold asset value at t at which equity exercises its option of limited liability to give up control of the firm's assets in exchange for abandoning the firm's liabilities. We use V_{At}^* to define the concept of *Distance to Default* as

$$DD_t = \left(\frac{V_{At} - V_{At}^*}{V_{At}} \right) \frac{1}{\sigma_A}.$$

Note that default is distinct from insolvency in our theory and that quite generally a firm's distance to default exceeds its distance to insolvency. This is because equity may not walk away immediately from an insolvent firm, but will not choose default if the firm is solvent. With this definition we have our second proposition:

Proposition 2. *In a Leland (1994) structural model, the inverse of a firm's equity volatility lies between its Distance to Insolvency and its Distance to Default.*

$$DI_t \leq \frac{1}{\sigma_{Et}} \leq DD_t$$

Proof. This proposition follows from the convexity of the value of the firm's equity as a function of the value of the firm's assets at each time t and because $w(V_A^*) = 0$. \square

We illustrate the proof of these two propositions in Figure 2. At time t , the value of the firm's equity as a function of the value of its assets is a convex function with slope less than or equal to one that lies above the horizontal axis (exceeds zero) and the line $V_{At} - V_B$ giving the value of the firm's equity under unlimited liability. The value of the firm's equity hits the horizontal axis at the default point V_{At}^* . Define X_t to be the point at which the tangent line to the value of equity V_{Et} at the current asset value V_{At} hits the x -axis. All these lines and points are drawn in this figure.

By the convexity of $w(V_A)$, we have $V_{At}^* \leq X_t \leq V_{Bt}$. Simple algebra then delivers that

$$\frac{1}{\sigma_{Et}} = \left(\frac{V_{At} - X_t}{V_{At}} \right) \frac{1}{\sigma_A}$$

which proves the result.

With these two results, we have that the inverse of a firm’s equity volatility is an accurate measure of its distance to insolvency if the firm’s distance to default is close to its distance to insolvency. That is, the bound is tight if creditors quickly force insolvent firms into default. Proving that a firm’s distance to default will be close to its distance to insolvency as a theoretical matter relies on the specifics of the model. As an empirical matter however, the economics of creditors’ incentives to force a firm that is insolvent into bankruptcy as soon as possible to avoid further costs of financial distress suggest that firms with alert and aggressive creditors should satisfy this condition.

While we have established our approximations in the context of a simple model, our results rely on just a few elementary properties of the value of equity, which are likely to hold in a broad class of models used in applied work. First, the proof requires that the value of equity be a convex function of the value of assets with slope less than one, a property that is typical of structural credit risk models. Second, the proof requires that the value of equity is the only state variable following a diffusion. Thus our results hold if there are others state variables, for interest rate, market price of risk, or liability payments, as long as these are “slower moving”, in the sense of being continuous time Markov processes.

In our empirical work, we use data from the CRSP database on daily equity returns to measure a firm’s equity volatility σ_{Et} , and we use this measure to approximate the firms’ true Distance to Insolvency. For the remainder of this paper, in a slight abuse of terminology, we will refer to this equity volatility-based approximation directly as the firm’s Distance to Insolvency.

3 Distance to Insolvency and Financial Soundness

To establish empirical benchmarks for interpreting the level of a firm’s Distance to Insolvency, we compare it to other measures of financial soundness.

3.1 Distance to Insolvency and credit ratings

We first compare the inverse of firms’ equity volatility to their credit ratings as reported quarterly in COMPUSTAT. We pool all the firm-month observations since 1985 for which we simultaneously have a credit rating from COMPUSTAT and daily stock return data from CRSP. We find that there is a clear systematic relationship between firms’ credit ratings and firms’ Distance to Insolvency. In particular, when we compute the cross-

section distribution of Distance to Insolvency conditional on S&P credit rating in the pooled data, we find that this conditional distribution declines monotonically (in the sense of first-order stochastic dominance) with a decline in credit rating. We also find that this relationship between credit ratings and firms' Distance to Insolvency is nearly identical for financial firms as it is for all firms, financial and non-financial combined.

In Figure 3, we plot the median of the cross-section distribution of firms' Distance to Insolvency conditional on S&P credit rating. As shown in the figure, for highly rated firms (AAA and similar ratings), the median distance to insolvency is 4, for firms at the margin between investment grade and speculative grade (BBB- vs. BB+), the median distance to insolvency is 3, while for firms with a rating of C or D (indicating that they have filed for bankruptcy and/or have defaulted on a bond) the median distance to insolvency is 1.

We identify financial firms in our data as those firms with an SIC code ranging from 6000 to 6999. These SIC codes cover the industries of Finance, Insurance, and Real Estate (FIRE). In Figure 4 we compare the median of firms' Distance to Insolvency conditional on S&P credit rating for financial firms shown in the blue line and compare it to the median of firms' Distance to Insolvency conditional on S&P credit rating for all firms shown in the red line. As shown in the figure we find that the relationship between the inverse of a firm's equity volatility and its credit rating using the same pooled data since 1985 is nearly identical for financial firms as it is for all firms.

Using the results in these two charts as guidelines for interpreting the preliminary empirical work that follows, we find that, according to their credit rating, firms with a Distance to Insolvency over 4 have low credit risk, firms with a Distance to Insolvency near 1 have very high credit risk, and firms with a Distance to Insolvency near 3 are at the borderline of investment grade versus junk status. Moreover, these numerical benchmarks are the same for non-financial and financial firms with a credit rating.

To give a sense of the dispersion of the distribution of Distance to Insolvency by credit rating, we show the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of the cross-section distribution of Distance to Insolvency conditional on S&P credit rating from the pooled data in Figure 5. We find that over 95 percent of highly rated firms (AAA and similar ratings) have a Distance to Insolvency over 2 and that over 95 percent of very low rated firms have a Distance to Insolvency under 4. Hence we can say that firms with a Distance to Insolvency below 2 are extremely unlikely to also have a high credit rating and firms with a Distance to Insolvency over 4 are extremely unlikely to have a very low credit rating. For values of Distance to Insolvency between 2 and 4, no such sharp statistical statements can be made.

3.2 Distance to Insolvency and bankruptcy

We have also examined Distance to Insolvency as an indicator of a firm’s subsequent probability of bankruptcy. To do so, we merged two data sets on bankruptcy filings by publicly traded firms collected by [Chava and Jarrow \(2004\)](#) and the UCLA-LoPucki bankruptcy database. The results that we find are consistent with the results found on the conditional distribution of distance to insolvency for firms with a credit rating of C or D (indicating that they have already filed for bankruptcy and/or defaulted on a bond). Specifically, a Distance of Insolvency near 1 is a strong indicator that a firm will file for bankruptcy in the near term (less than six months). The relationship is weaker at longer horizons.

Moreover, we find that the distribution of insolvency for those firms that do end up filing for bankruptcy deteriorates steadily in the months prior to bankruptcy. In [Figure 6](#), we show the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of the distribution of the distance to insolvency for those firms that end up filing for bankruptcy in the sixty months prior to filing for bankruptcy or being delisted. As one can see, these percentiles decline monotonically as bankruptcy approaches. Twelve months prior to bankruptcy, these percentiles are all roughly half the corresponding percentiles of the pooled cross-section distribution of distance to insolvency for all firms. We see in this figure that nearly all firms that end up filing for bankruptcy have a distance to insolvency under two immediately prior to filing, a distance to insolvency under three three months prior to filing, and a distance to insolvency under four 18 months prior to filing.

We interpret these results as being consistent with the view that firms with a Distance to Insolvency over 4 have low risk of bankruptcy in the near term and that firms with a Distance to Insolvency near 1 have very high bankruptcy risk in the near term.

In the empirical work below, we also examine, as a case study, the evolution of Distance to Insolvency for six firms that failed in the financial crisis of 2007-2008: AIG, Bear Stearns, Lehman, Merrill Lynch, Wachovia, and Washington Mutual. As we discuss below, we find that distance to insolvency for these firms declined to very low levels in advance of failure in a manner consistent with the general pattern shown in [figure 6](#).

There is a large empirical literature in corporate finance that examines the performance of *Distance to Default* computed using data on a firm’s equity value and volatility together with accounting data on a firm’s liabilities as an indicator of the likelihood that a firm will declare bankruptcy and/or default on a bond. [Duffie \(2011\)](#) is an important recent survey of such work. [Duffie et al. \(2009\)](#) and [Duffie et al. \(2007\)](#) document the economic

importance of distance to default in determining default intensities.⁴ Moody’s Analytics produces and sells estimates of the likelihood that publicly traded firms will default on their bonds using a similar methodology. (See [Sun, Munves, and Hamilton, 2012](#)). One next step for future research is to examine the difference between *Distance to Default* computed using various structural models and methodologies for incorporating accounting data on firms’ liabilities to our simple *Distance to Insolvency* measure as an indicator of corporate credit risk. The work of [Bharath and Shumway \(2008\)](#) suggests that simple indicators such as *Distance to Insolvency* should perform quite well empirically.

3.3 Distance to Insolvency and Credit Default Swap Rates

In the past decade, a broad market in credit default swaps has emerged. This market allows investors to bet directly on corporate credit risk. [Hart and Zingales \(2010\)](#) and others have proposed using credit default swap rates as an indicator of firms’ financial soundness in devising market driven regulation of risk taking by large financial firms. One next step for future research is to examine the relationship between our measure of Distance to Insolvency and credit default swap rates with the view that both of these measures are indicators of some underlying latent firm “financial soundness” variable.

We have conducted some initial exploratory work in this vein examining the relationship between firms’ distance to insolvency, computed above as the inverse of realized equity volatility over the trading days in a month, with credit default swap rates computed using the average rate over the trading days within the month on a 5-year credit default swap using data from Markit. We have done so initially using the set of government backed large financial institutions⁵ studied in this paper over the period January 2001 through June 2012. In [Figure 7](#) we show a scatter plot using the pooled monthly data on the logarithm of firms’ Distance to Insolvency on the horizontal axis and the logarithm of the same firms’ swap rate on 5 year credit default swaps. A clear negative linear relationship is evident in the figure. We interpret this finding as consistent with the hypothesis that our simple Distance to Insolvency measure is indeed indicative of firm’s credit risk.

We have marked firm/month data from different years in the figure in different colors. As suggested by the figure, a regression with simple time dummies indicates that there are significant time effects in this relationship between Distance to Insolvency and credit default swap rates. Further research is needed to understand the implications of this

⁴[Duffie et al. \(2007\)](#) reports that a 10% reduction in distance to default causes an estimated 11.3% increase in default intensity, and reports that distance to default is the most economically important determinant of the term structure of default probabilities.

⁵We are required to match firms across CRSP and Markit data sets manually at this time. We will expand our analysis once we are able to automate the matching of firms.

finding of time effects. We will also look for evidence of firm effects once we have matched more firms in the two databases.

4 Financial soundness during U.S. Business Cycles

We now use our measure of Distance to Insolvency to retrace the history of U.S. firms' financial soundness, from 1926 to now. We use data from the CRSP database on daily equity returns to calculate σ_{Et} for each firm and each month from 1926 to 2012.⁶ Precisely, we approximate σ_{Et} by the square root of the average squared daily returns in the month.⁷ We annualize this standard deviation by multiplying by $\sqrt{252}$ where 252 is the average number of trading days in a year. We then plot, for each month, the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles, of the cross-sectional distribution of $1/\sigma_{Et}$. We break our plots into 15 year long time periods so that fluctuations in the distribution of Distance to Insolvency across firms can be seen in the graphs.

4.1 Are recessions systematically associated with insolvency crises?

Figure 8 starts with a plot of the evolution of the distribution of Distance to Insolvency across firms over the period 1926-1940 by plotting the time series of the percentile cutoffs for firms' Distance to Insolvency. The vertical scale on this plot (and all of our subsequent plots) runs from 0 to 10 where, again, our measure of Distance to Insolvency is in units of annualized standard deviations of the gap between the value of a firm's assets and the value of its liabilities. As we saw above, a value of Distance to Insolvency over 4 corresponds to a high credit rating or a very low credit risk. A value of Distance to Insolvency of 1 corresponds to a very low credit rating and a very high credit risk. A value of Distance to Insolvency of 3 corresponds to the borderline between an investment grade and a speculative grade credit rating and hence corresponds to a moderately high credit risk. We say that the economy experiences a *insolvency crisis* in a month when the financial soundness for almost all publicly traded firms deteriorates to a level usually associated with a junk credit rating status or worse.

⁶The CRSP daily dataset on equity returns includes NYSE daily data beginning December 1925, Amex (formerly AMEX) daily data beginning July 1962, NASDAQ daily data beginning December 1972, and ARCA daily data beginning March 2006.

⁷One could also compute volatility using a range of alternative methods including a rolling window of returns, the latent-variable approach of stochastic volatility models, or using option-implied equity volatilities as measures of σ_{Et} . We have chosen our measure primarily to ensure that it does not use overlapping daily data and for the convenience of correspondence with the monthly calendar. Moody's uses a much longer window to compute equity volatility in its KMV model.

In Figure 8 covering the Great Depression period, from 1926 to 1940, we see two insolvency crises: in the recession of 1932-33 and in the recession of 1937. In both of these recessions, the median Distance to Insolvency (shown in bright red and labeled perc50) falls from 4 (safe) to 1 (very high credit risk) and the Distance to Insolvency for the 95th percentile (shown in dark blue and labeled perc95) collapses from a very high level to 3 (borderline junk). Thus, in both of these recessions, we have that the financial soundness of the median firm fell to near bankruptcy and the financial soundness of the 95th percentile firm fell to borderline junk status.

Next, compare the Great Depression to the recent recession of 2008. Figure 9 below shows the evolution of the distribution of Distance to Insolvency over the time period 1997 to 2008. In this figure we clearly see an insolvency crisis occurring in the fall of 2008. Just as during the Great Depression, in this recession, the median Distance to Insolvency (shown in bright red and labeled perc50) falls from 4 (safe) to 1 (very high credit risk) and the Distance to Insolvency for the 95th percentile (shown in dark blue and labeled perc95) falls from a very high level to 3 (borderline junk). Again, in this recession, we have that the financial soundness of the median firm fell to near bankruptcy and the financial soundness of the 95th percentile firm fell to borderline junk status.

These two figures document our first result that the recessions of 1932-33, 1937, and 2008 were all associated with significant insolvency crises.

We find that such insolvency crises did not occur in other recessions. To illustrate this result, we show the evolution of the distribution of financial soundness across firms in other recessions. In the figure covering the period 1997-2011, we have shaded the months of the recession of 2001 in grey. There is no similar collapse in the distribution of financial soundness across firms in this recession. In Figure 10, we show the evolution of the distribution of Distance to Insolvency across firms for the period 1979-1996. In this figure, we have shaded in grey the months of the three recessions in this time period. As one can clearly see in this figure, the distribution of the Distance to Insolvency across firms in these three recessions does not collapse significantly. In contrast, one of the striking features of the data in this figure is the stability in the cross-section distribution of Distance to Insolvency across firms over time except around the stock market crash of October 1987. But note that the crash was not followed by a recession.

In Figures 11 and 12 we show the evolution of the distribution of Distance to Insolvency across firms for the periods 1962-1978 and 1941-1961. Again, in these figures we do not see insolvency crises recessions, with the possible exception of the recession in 1970. In figures 8 through 12, we also see a number of instances in which the distribution of distance to insolvency collapses briefly as it did in October 1987. These episodes include September

1939, May 1940, December 1941, August 1946, and May 1970. Each of these episodes was associated with a sudden large drop in the overall stock market, but not with a recession.

Large Firms To this point, we have defined an insolvency crisis as a collapse in the distribution of financial soundness for all firms. In doing so, we have treated each firm equally regardless of size in computing the percentiles of the cross section distribution of distance to insolvency each month. As a sensitivity analysis, we also examine the role of firm size in insolvency crises by computing the distribution of distance to insolvency across firms each month using only the largest 50 firms in terms of stock market capitalization each month. We propose as an alternative definition of an insolvency crisis a month in which the 90th percentile of Distance to Insolvency for the 50 largest firms drops below 3. If one uses this alternative definition, then October 1974, August and September of 1998, January to April of 2000, and July and October of 2002 are added to the list of insolvency crises.

To illustrate the empirical differences between our baseline definition of an insolvency crisis as a month in which the 95th percentile of distance to insolvency for all firms falls below 3 and our alternative definition of an insolvency crisis as a month in which the 90th percentile of the distribution of distance to insolvency for the largest 50 firms by market capitalization falls below 3, we plot these two percentiles monthly from 1926 through 2011 in Figure 13. In the figure, the 90th percentile for the 50 largest firms is marked in light blue while the 95th percentile for all firms is marked in dark blue. The horizontal yellow line at 3 marks our proposed boundary for defining an insolvency crisis.

As can be seen clearly in the figure, for most of the 1926-2011 time period, these two alternative definitions of an insolvency crisis coincide. The period around October 1974 and from 1997-2002 is distinctive in that the 90th percentile of the distribution of distance to insolvency for the 50 largest firms was substantially lower than the 95th percentile of the distribution of distance to insolvency across all firms. In a sense, we might term these episodes as *insolvency crises for large firms*. Almost all of these insolvency crises for large firms coincide with other crises indicators, for example news reports (the LTCM and Russian crises of 1998 and the peak and then fall of the stock market in early 2000) or the quantitative measure of corporate defaults of Giesecke, Longstaff, Schaefer, and Strebulaev (2011). Yet, none of them are closely associated with a recession, with the possible exception of October 1974.

We interpret this finding as consistent with the hypothesis that an insolvency crisis in and of itself does not cause a recession (see also Giesecke, Longstaff, Schaefer, and Strebulaev, 2012). Further research is required to understand why the relationship between

insolvency crises and recession is not systematic.

4.2 Are insolvency crises driven by leverage or asset volatility?

Next we consider the source of the 2008 insolvency crisis. Given the definition of Distance to Insolvency, this distribution can collapse for two reasons: one due to an increase in leverage (a drop in $(V_{At} - V_{Bt})/V_{At}$) and the other due to an increase in asset volatility (an increase in business risk, σ_{At}). Most of the current literature on financial frictions in macroeconomics envisions that the shock that drives a deterioration in the distribution of financial soundness across firms is a decline in asset values V_{At} and hence an increase in leverage. Moreover, most models of agency costs focus on the effects of leverage alone on managerial and equity holder decisions.

To examine whether such an increase in leverage occurred in the fall of 2008, we conduct a model-based decomposition of the decline in the distribution of Distance to Insolvency to determine the extent to which the decline occurred due to an increase in leverage or an increase in asset volatility. To do so, we use data from COMPUSTAT to construct a measure of firm liabilities V_{Bt} (here simply the book value of liabilities) and use the simplest structural model in which equity has unlimited liability to construct the following decomposition. For October 2007 and October 2008, we construct V_{Bt} from COMPUSTAT data on total liabilities and construct V_{At} from $V_{At} = V_{Et} + V_{Bt}$ where V_{Et} is the firm's market value of equity from CRSP. We also construct the corresponding terms for leverage and asset volatility $\sigma_{At} = (V_{Et}/V_{At})\sigma_{Et}$ by direct calculation. We then compare the percentiles of the cross-section distribution of Distance to Insolvency in October 2008, to the cross-section distribution of Distance to Insolvency in October 2007 that would have occurred if leverage for each firm had remained at its level from October 2007 and only asset volatility had risen to its level in October 2008.

These percentiles are shown in Figure 14. The first column of colored bars shows the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of the cross section distribution of distance to insolvency in October 2007. The second column of colored bars shows the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of the cross section distribution of distance to insolvency in October 2008. The third column of colored bars shows the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of the cross section distribution of distance to insolvency computed firm-by-firm using that firm's leverage in October 2007 and its asset volatility in October 2008. As is clear in the figure, the percentiles of this counterfactual cross-section distribution of the Distance to Insolvency shown in the third column are quite similar to those found for the actual distribution in October 2008

(shown in the second column) and quite different from those found for the cross-section distribution in October 2007 (shown in the first column).

On the basis of this evidence, we argue that the collapse of the distribution of Distance to Insolvency in the fall of 2008 is primarily due, in an accounting sense, to an increase in asset volatility rather than an increase in leverage. In this sense, the collapse in the cross-section distribution of the Distance to Insolvency in the fall of 2008 does not appear to be due to an increase in leverage (a drop in net equity) as would be predicted by many current models of financial frictions and business cycles.

4.3 Are financial firms special during insolvency crises?

A large literature in macroeconomic and finance argues that, when financial intermediaries are financially unsound, they amplify and propagate negative shocks to the real economy. In fact, a commonly held view is that the weak financial soundness of financial intermediaries caused the large recession of 1932-33, 1937, and 2008. Our Distance to Insolvency measure does not lend strong support to this view: the timing and magnitude of the collapse is similar during the three recessions when comparing all firms to financials. We find similar results when we focus simply on the largest financial intermediaries, where we measure size by stock market capitalization.

4.3.1 Financials, 1926-2011

To address intermediaries' financial soundness with the longest possible time series, we identify financial firms as those firms in CRSP with an SIC code in the range of 6000-6999. We measure the Distance to Insolvency for these financial firms in exactly the same way that we do for all firms. Namely, we construct, every month, the percentiles of the cross-section distribution of Distance to Insolvency across these financial firms.

Consider first the two recessions of the Great Depression. In Figure 15 below we show the 50th and 90th percentiles of the cross-section distributions of Distance to Insolvency across all firms and across only financial firms for the time period 1926 to 1940. As is evident in this figure, the evolution of these percentiles of the distribution of Distance to Insolvency for financial firms over this time period is almost exactly the same as the evolution of the corresponding percentiles of the distribution of Distance to Insolvency for all firms. Hence, we conclude that the timing and the magnitude of the collapse of the distribution of Distance to Insolvency across financial firms is almost exactly the same as that for all firms in the two recessions of the Great Depression.

Consider now the recession of 2008. In Figure 16 below we show the 50th and 95th

percentiles of the cross-section distribution of Distance to Insolvency across all firms and across only financial firms for the time period 1997-2011. In contrast to the data for the Great Depression, in the data for the period 1997-2011, it appears that the distribution of Distance to Insolvency across financial firms is higher, in the sense of first order stochastic dominance, than that for all firms. We show in Figure 17, however, that the median, or 50th percentile of the distribution of Distance to Insolvency across financial firms (shown in light red) matches up almost exactly with the 75th percentile of the distribution of Distance to Insolvency across all firms (shown in orange-yellow) over the same time period.⁸ Hence, we conclude that the timing and the magnitude of the collapse of the distribution of Distance to Insolvency across financial firms is almost exactly the same as that for all firms in the 2008 recession.

4.3.2 Large financials, 1962-2011

A widely held view is that it is the financial soundness of large financial institutions that plays a prominent role in amplifying macro economic shocks, perhaps because such large financial institutions are deemed systemically important. Small financial institutions are less important. We thus examine the evolution of the distribution of financial soundness for large financial firms. We focus on the time period after 1962 as it is only after this date that we have a sufficiently large number of financial firms in our data to distinguish between large and small financial firms. Every month over this time period, we calculate the distribution of Distance to Insolvency for the top 50 financial firms, as measured by market capitalization. As shown in Tables 1 and 2, these top firms can be banks (such as Wells Fargo), investment firms (such as Berkshire Hathaway), or insurance companies (such as United Healthcare).

We see in Figure 18 that the evolution over the 1962-2012 time period, of the median Distance to Insolvency for the largest 50 financial firms (by market capitalization) is quite similar to that for the median Distance to Insolvency for all financial firms, particularly since the late 1990's. We see little evidence here for the hypothesis that large financial firms look systematically different from financial firms as a whole in terms of their Distance to Insolvency.

Figure 19 illustrates that the median Distance to Insolvency for these 50 large financial firms is not much different from that for the largest 50 firms by market capitalization, both non-financial and financial. As clear from the figure, the two time series are again

⁸The distribution of Distance to Insolvency for financial firms shifted up relative to the distribution of Distance to Insolvency for all firms in a gradual process that started in the early 1970s and was complete in the mid 1990s. This may have occurred as a result of financial regulation or, alternatively, as a result of the opening up of NASDAQ as a market for the shares of less creditworthy non-financial firms.

very similar. Hence, we also see little evidence here for the hypothesis that large financial firms look systematically different from large firms as a whole in terms of their Distance to Insolvency.

4.3.3 Government-backed financial firms, 1997-2011

In the empirical work discussed above, we have focused on a broad definition of financial firms and even of large financial firms and we have found that the evolution of the distributions of financial soundness for these two sets of firms do not show distinctive patterns relative to other firms, even in those time periods that are called financial crises.

One might argue that our findings here are driven by our failure to identify the right set of financial firms to examine. Perhaps financial crises get started and economic shocks are amplified only when the financial soundness of an even narrower subset of “systemically important financial institutions” (SIFIs) deteriorates. Identifying the correct set of “systemically important financial institutions” is of particular importance going forward given that the thrust of much of the new regulatory framework that has been implemented in the wake of the recent crisis is aimed at identifying SIFIs and placing them in a special regulatory category. Historically, however, many different types of financial institutions have been deemed “systemically important” by regulators: large commercial banks such as Continental Illinois, universal banks such as Wachovia, Bank of America, and Citicorp, dealer banks such as Bear Sterns, Lehman Brothers, and Merrill Lynch, hedge funds such as Long Term Capital Management, and insurance companies such as AIG. Because these firms have been engaged in very different line of business within the financial sector, it is quite challenging to identify them *ex-ante*.

In an effort to examine whether the distribution of financial soundness for a group of SIFIs behaved in a distinctive manner in this most recent crisis, we examine the Distance to Insolvency of a set of institutions identified as “systemically important” *ex-post*: the 18 publicly traded bank holding companies that the Federal Reserve recently subjected to stress tests, together with six large financial institutions that failed during the most recent crisis (AIG, Bear Stearns, Lehman, Merrill Lynch, and Wachovia). We refer to this set of firms as *government-backed large financial institutions* (GBLFIs) and list their names in Table 3. We focus on the 1997-2011 time period.

In Figure 20 we show the 10th (in grey), 50th (in red), and 90th (in orange) percentiles of the distribution of Distance to Insolvency for the set of GBLFIs together with the median (in purple) of the distribution of Distance to Insolvency for all financial firms. As is clear in this figure, from 1997 to the summer of 2007, the distribution of Distance to Insolvency for the GBLFIs is centered on the median for all financial firms. In contrast,

from the late summer of 2007 through 2011, the distribution of Distance to Insolvency of the GBLFIs lies well below the median for all financial firms. In fact, for most of this period, the median financial firm has a Distance to Insolvency at or above the 90th percentile for the set of GBLFIs. Thus, we find in this figure that the distribution of the Distance to Insolvency for the GBLFIs was quite similar to that for all financial firms in advance of the most recent crisis but has been substantially worse than that for all financial firms in the four years since the crisis began.

In Figure 21 we show the 10th (in grey), 50th (in red), and 90th (in orange) percentiles of the distribution of Distance to Insolvency for the set of GBLFIs together with the median (in purple) of the distribution of Distance to Insolvency for the 50 largest firms by market capitalization, both non-financial and financial. As is clear in this figure, from 1997 to the summer of 2007, the distribution of Distance to Insolvency for the GBLFIs is centered on the median for all large firms. In contrast, from the late summer of 2007 through 2011, the distribution of Distance to Insolvency of the GBLFIs lies well below the median for all large firms. For most of this period, the median large firm has a Distance to Insolvency at or above the 90th percentile for the set of GBLFIs. Thus, again we find in this figure that the distribution of the Distance to Insolvency for the GBLFIs was quite similar to that for all large firms in advance of the most recent crisis but has been substantially worse than that for all large firms in the four years since the crisis began.

As a final empirical exercise, we examine whether the evolution of Distance to Insolvency for the six institutions in the set of GBLFIs that failed during the most recent crisis was distinctive in advance of their failure relative to the evolution of the distribution of Distance to Insolvency for all of the GBLFIs. In the six panels of Figures 22 and 23 we show the 10th (in grey), 50th (in red), and 90th (in orange) percentiles of the distribution of Distance to Insolvency for the set of GBLFIs together with the Distance to Insolvency (in purple) for each of AIG, Bear Stearns, Lehman, Merrill Lynch, Wachovia, and Washington Mutual.

Clearly, in all of these figures we see that Distance to Insolvency for these six failing firms fell to a very low level (below 1) in advance of failure. In this sense, our findings are consistent with the more general pattern of Distance to Insolvency in advance of bankruptcy shown in Figure 6. More striking, however, is the clear evidence that the cross-section variation in Distance to Insolvency for these GBLFIs in any given month is quite small relative to the movement in the distribution of Distance to Insolvency over time: during this time period the risk that any one GBLFI is unsound relative to the others is small relative to the risk that the whole group of GBLFIs becomes unsound together. This pattern is particularly apparent in the fall of 2011: these figures indicate

that the whole group of GBLFIs was nearly as unsound at that time as they were in early 2008 or mid 2009.

5 Conclusion

This paper is intended as a contribution to measurement: we propose a simple and transparent method for measuring the financial soundness of firms that can be broadly applied to all publicly traded firms in the economy. Many of our findings echo those that others have found (particularly Moody’s Capital Markets Research) using fully developed structural credit risk models, spreads on credit default swaps, and spreads on corporate bonds as alternative market-based indicators of the financial soundness of firms. Clearly much more work needs to be done to examine the theoretical and empirical relationship between these alternative indicators of financial soundness.

We identify three recessions in which a macroeconomic downturn coincides or follows shortly after a substantial insolvency crisis: 1932-33, 1937, and 2008. We find that the other recessions in this time period are not associated with significant deteriorations insolvency crises. Of course, since our findings uncover only a correlation (or lack thereof) between insolvency crises and recession, they do not establish causation. We do, however, see our findings as consistent with the hypothesis that financial frictions may have played a significant role in the recessions of 1932-33, 1937, and 2008, and that financial frictions (as envisioned by current theories) did not play a significant role in other recessions during this time period. We hope that our research will provoke more detailed studies of the differences between these three recessions and other recessions to see if a stronger empirical and theoretical basis for causal links between financial frictions and the evolution of the macroeconomy can be developed.

A decomposition of our distance to insolvency measure into its leverage and asset volatility components attributes most all of the 2008 insolvency crisis to an increase in asset volatility, or business risk. Distortions to managerial and equity holder decisions occur when the likelihood of insolvency is high for either reason. Thus, considering the only effects of leverage on agency costs may leave out quantitatively important variation due to time varying asset volatility.

We also find little or no evidence that the evolution of financial soundness across financial firms differs meaningfully from that for all firms, even during the three crisis episodes. In the recessions of 1932-33, 1937, and 2008, the timing and magnitude of the insolvency crisis was the same as that for all firms, financial or non-financial, large or small. We find only weak evidence that the distribution of financial soundness for a set

of “systemically important financial institutions” deteriorated in a distinctive manner in advance of the most recent financial crisis.

Finally, we find it distressing that government-backed large financial institutions continued to appear weak in terms of their financial soundness since the summer of 2007, in spite of the heightened regulatory scrutiny they have received. Why it is that these firms continue to look financially weak relative to their peers is an open question that calls for further research.

A Leland (1994) structural model

Under the true “physical” measure, the value of the firm’s assets, V_A , follows a Geometric Brownian motion with drift μ_A and volatility σ_A . The firm pays a dividend δV_A per period. Under the risk-neutral measure, the value of the firm’s assets follows

$$dV_{At} = (r - \delta)V_{At} dt + \sigma_A V_{At} dB_t^Q.$$

The intuition for the risk neutral drift of $r - \delta$ is simply that, under the risk neutral measure, the expected return from buying the assets at V_{At} , selling at V_{At+dt} and receiving the dividend flow $\delta V_{At} dt$, should be equal to $r dt$. Assume that the equity holders have to pay c (per unit of time) to the debt holders until either (i) equity holders choose to default or, (ii) creditor exercise their right to force equity holders to default, when the value of asset reaches a protective covenant threshold V_A^P . Let τ_P be the first time asset value falls below the protective covenant threshold, V_A^P . Equityholders’ problem is to choose a stopping time τ in order to solve

$$w(V_A) = \sup_{\tau} \mathbb{E}^Q \left[\int_0^{\tau \wedge \tau_P} (\delta V_{At} - c) e^{-rt} dt \right].$$

Consider equity holders starting with two different initial levels of assets, $V_{A0} < V'_{A0}$. Clearly, the equity holders starting with V'_{A0} can always mimic the policy of equity holders and creditors starting at V_{A0} and would earn a higher payoff, implying that $w(V_A)$ is non-decreasing. This also shows that an optimal policy is of the threshold form: there is a V_A^* such that when $V_A \leq V_A^*$, equity holders default, or are forced into default by creditors, and continue operating the firm otherwise. Thus, the Bellman equation for the value of equity is:

$$V_A \leq V_A^* : w(V_A) = 0$$

$$V_A \geq V_A^* : rw(V_A) = -c + \delta V_A + w'(V_A)(r - \delta)V_A + w''(V_A)\frac{\sigma_A^2}{2}V_A^2.$$

A particular solution to the second-order ODE is $V_A - V_B$, where $V_B = c/r$. The general solution of the corresponding homogenous ODE is of the form $K_1 V_A^\phi + K_2 V_A^{-\theta}$, where K_1

and K_2 are constant, while ϕ and θ are the positive roots of:

$$\begin{aligned}\phi^2 \frac{\sigma_A^2}{2} + \phi \left(r - \delta - \frac{\sigma_A^2}{2} \right) - r &= 0 \\ \theta^2 \frac{\sigma_A^2}{2} - \theta \left(r - \delta - \frac{\sigma_A^2}{2} \right) - r &= 0.\end{aligned}$$

When $V_A \rightarrow \infty$, the value of equity has to asymptote to $V_A - V_B$, implying that $K_1 = 0$. The constant K_2 is found by value matching $w(V_A^*) = 0$, which delivers:

$$K_2 = f(V_A^*) \text{ where } f(x) \equiv -(x - V_B)x^\theta.$$

The optimal threshold maximizes $f(x)$ subject to $x \geq V_A^P$. Differentiating $f(x)$ with respect to x reveals that it is hump shaped and reaches a unique maximum at $\frac{\theta}{1+\theta}V_B$. Therefore, the optimal threshold is:

$$V_A^* = \max \left\{ V_A^P, \frac{\theta}{1+\theta}V_B \right\} \text{ and } w(V_A) = V_A - V_B - (V_A^* - V_B) \left(\frac{V_A}{V_A^*} \right)^{-\theta}.$$

Convexity follows because $V_A^* \leq V_B$ by our assumption that $V_A^P \leq V_B$. Simple calculation show that $w'(V_A^*) \geq 0$ and that $w'(\infty) = 1$, implying that $w(V_A)$ is non-decreasing and has a slope less than one.

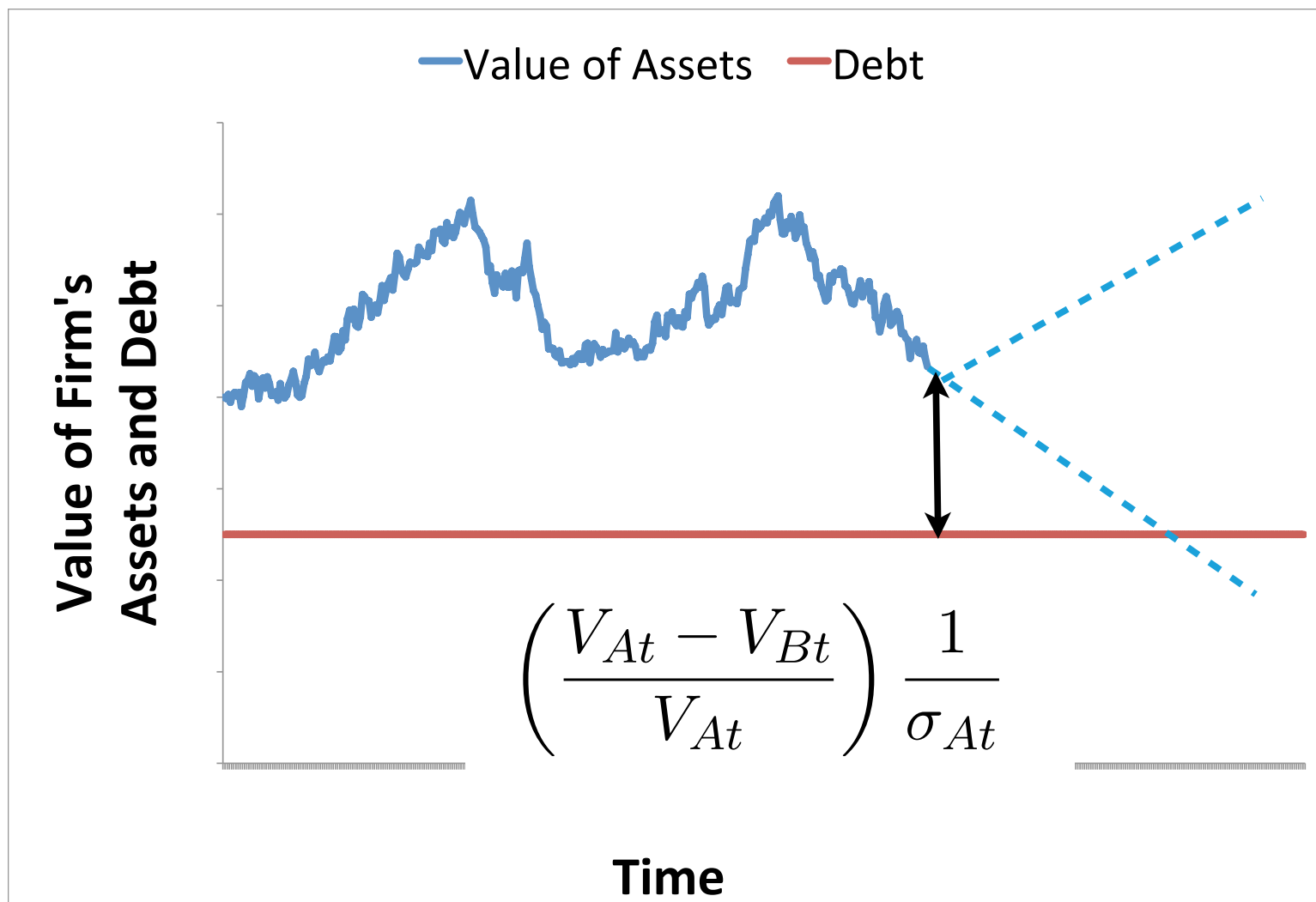


Figure 1: The value of equity as a function of the value of assets.

$$\left(\frac{V_A - V_B}{V_A} \right) \frac{1}{\sigma_A} \leq \frac{1}{\sigma_E} = \left(\frac{V_A - X}{V_A} \right) \frac{1}{\sigma_A} \leq \left(\frac{V_A - V_{A^*}}{V_A} \right) \frac{1}{\sigma_A}$$

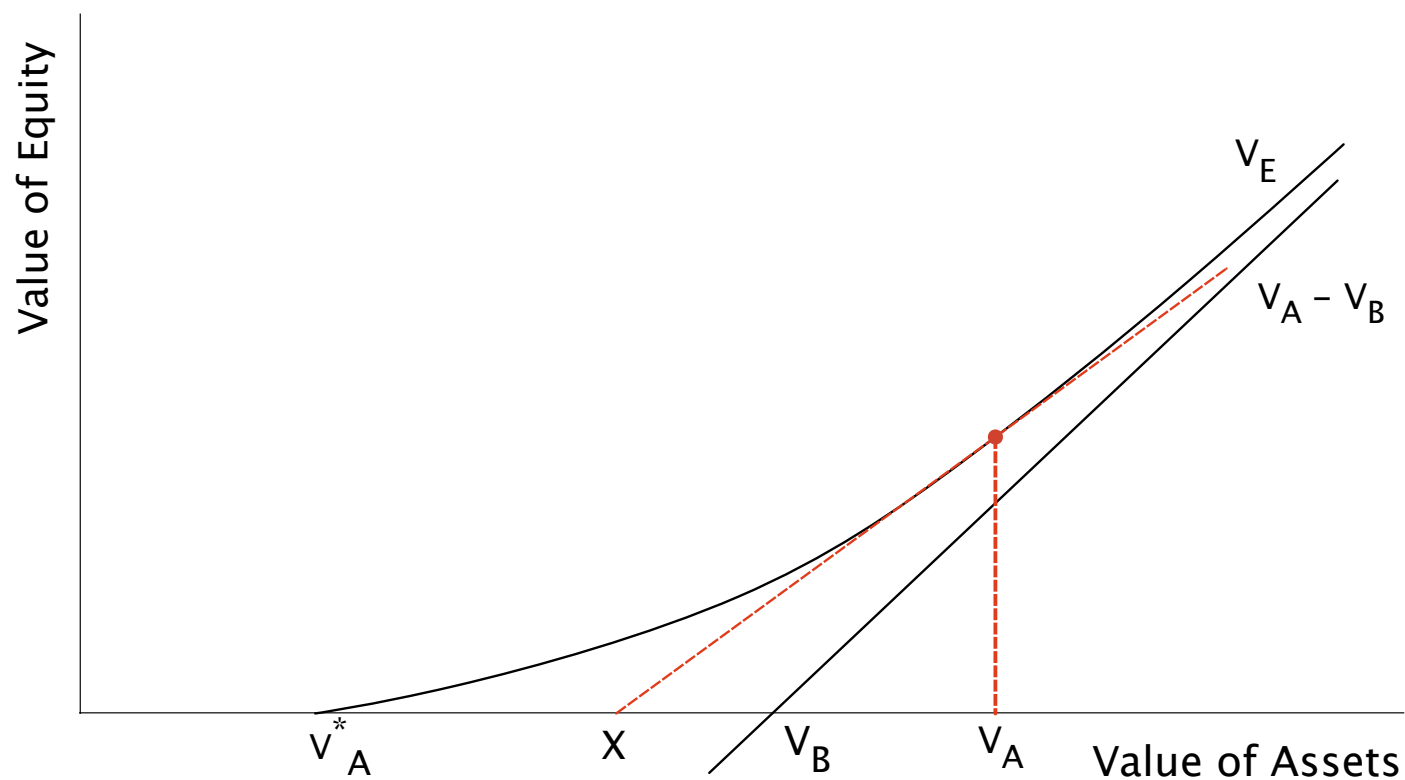


Figure 2: The value of equity as a function of the value of assets.

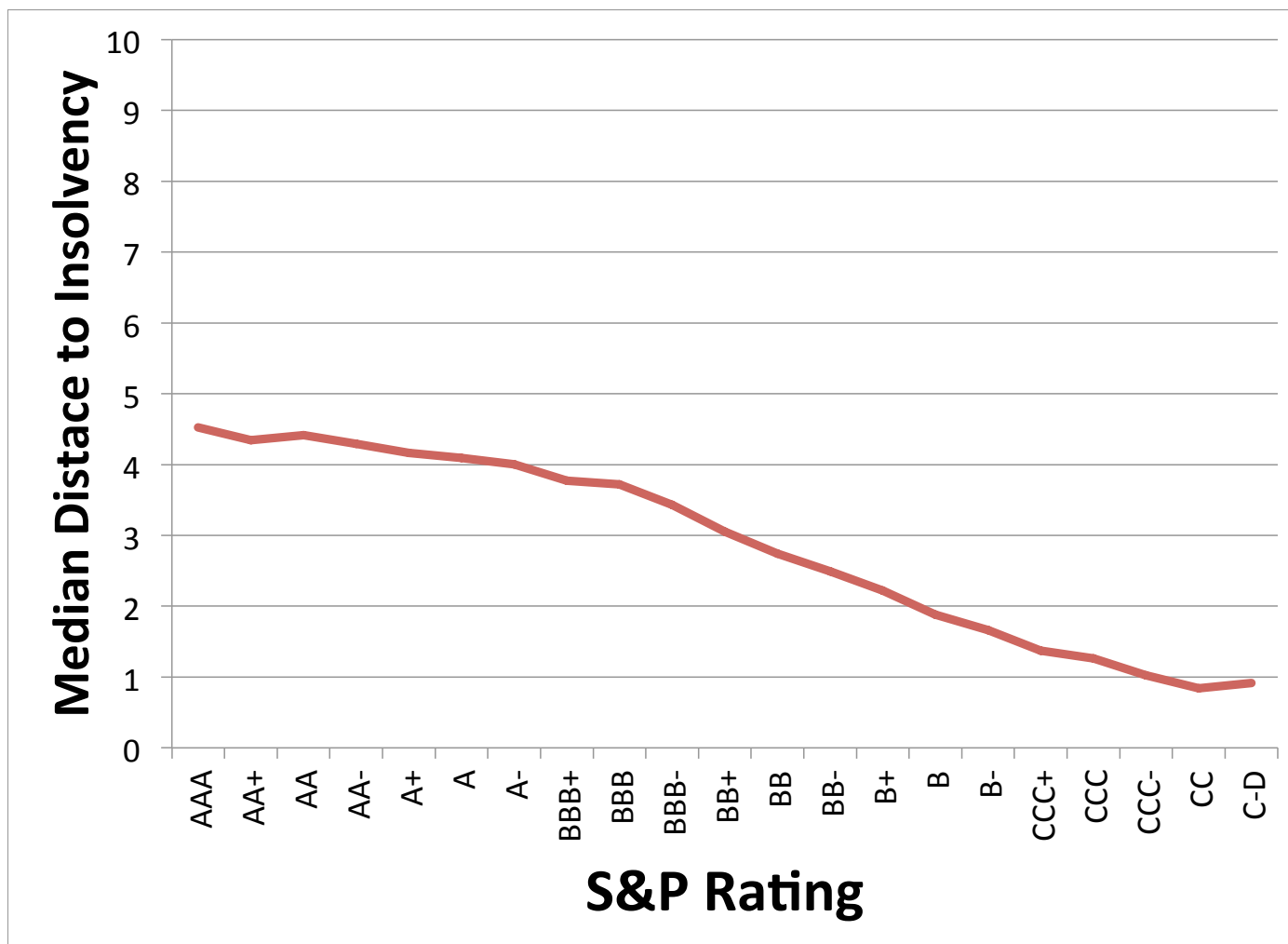


Figure 3: The empirical relationship between credit rating and Distance to Insolvency.

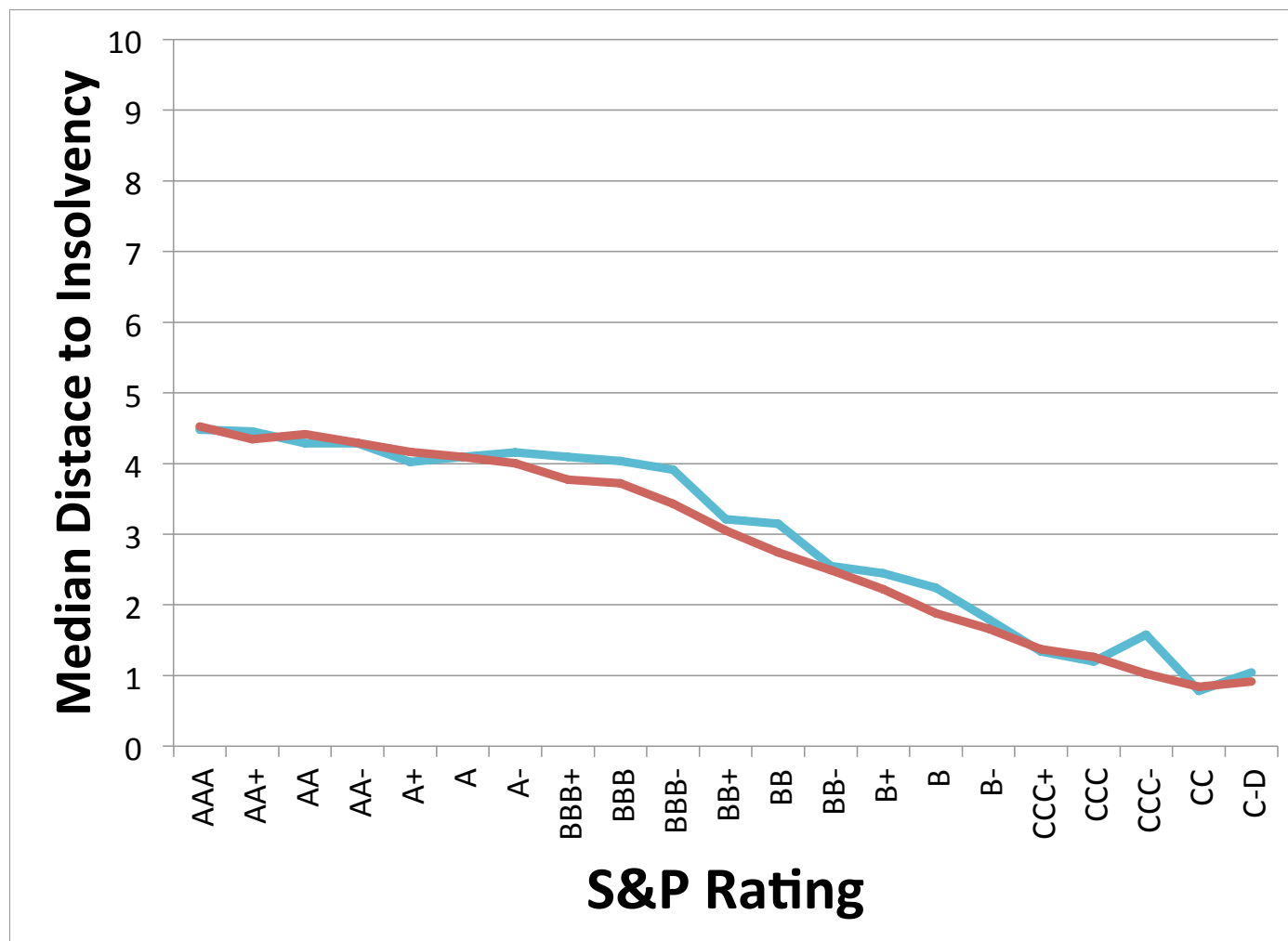


Figure 4: The empirical relationship between credit rating and Distance to Insolvency for Financial Firms and All Firms.

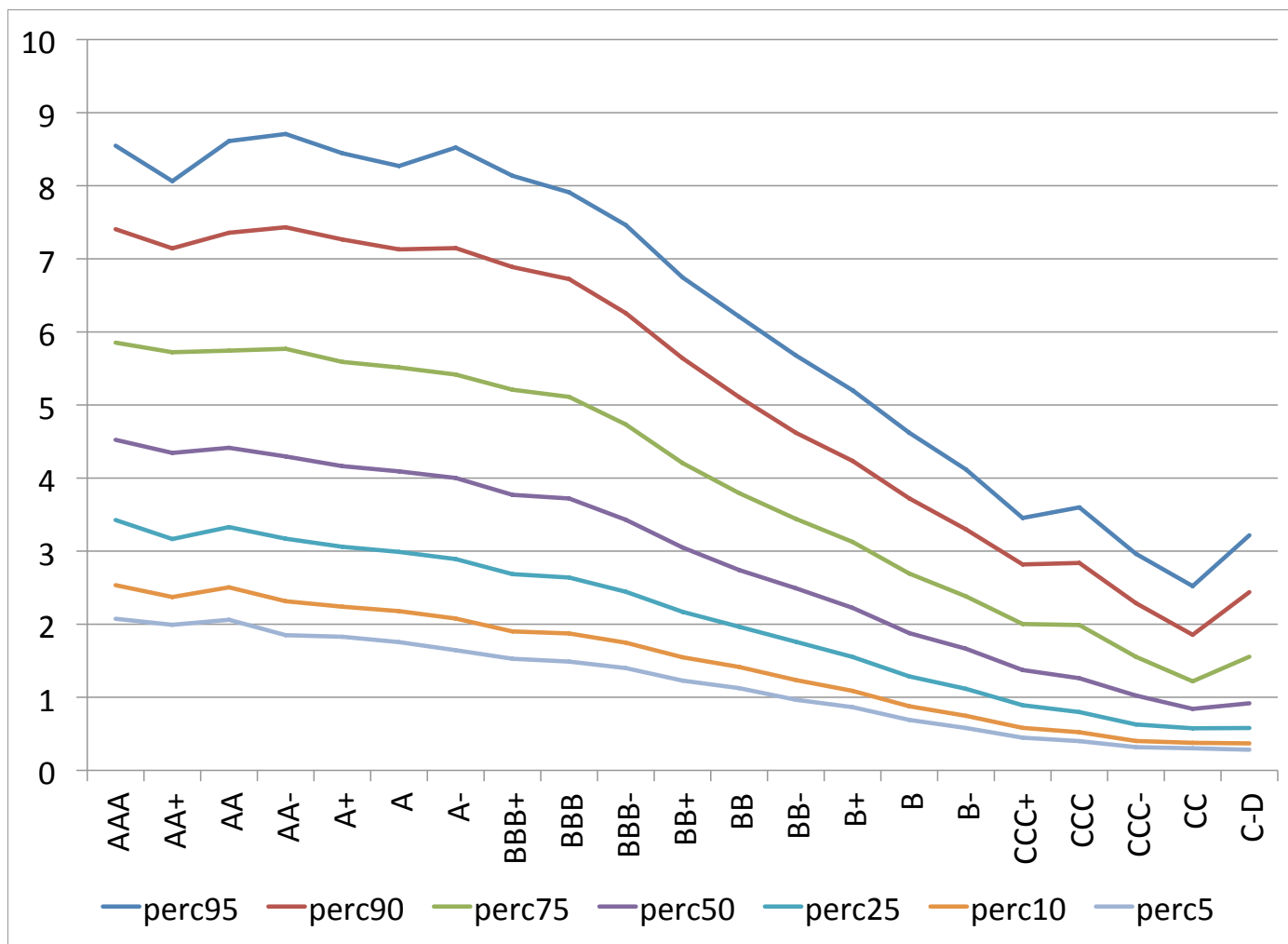


Figure 5: The distribution of Distance to Insolvency conditional on credit rating.

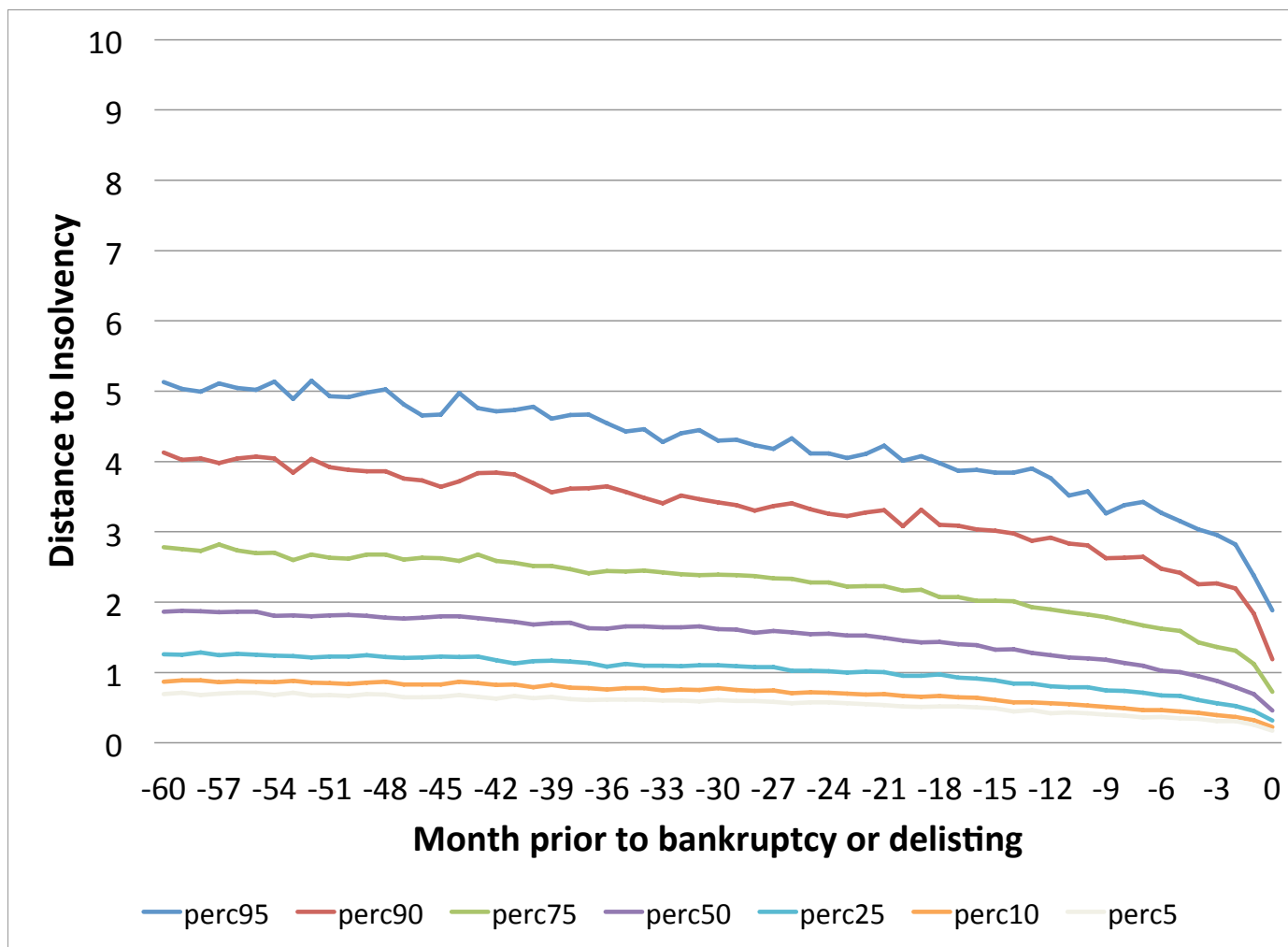


Figure 6: The distribution of Distance to Insolvency for firms that declare bankruptcy in the 60 months prior to bankruptcy or delisting.

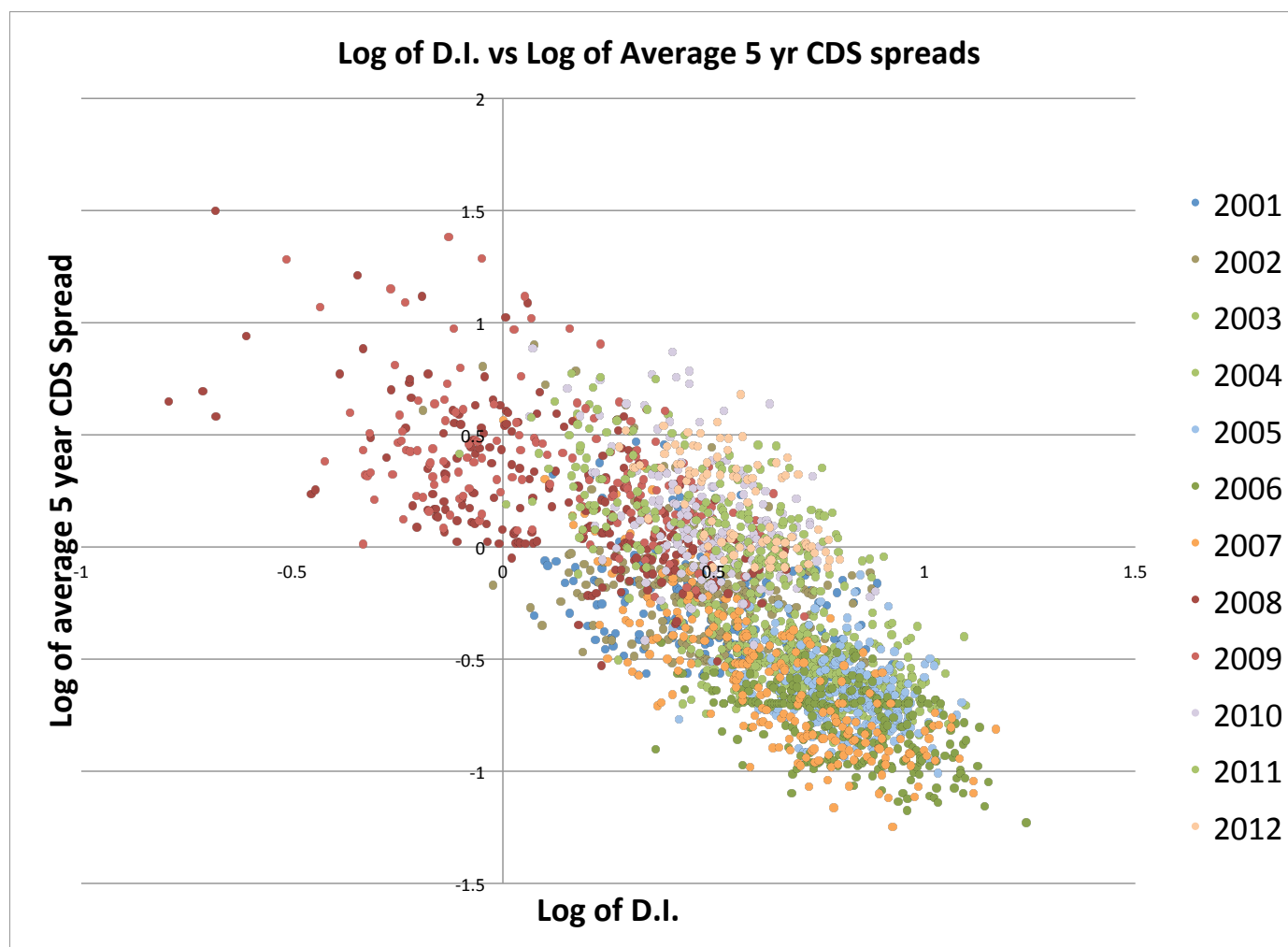


Figure 7: A scatter plot of the log of Distance to Insolvency versus the log of 5 year CDS swap rates for government backed large financial institutions 2001-2012. Data across firms for the 12 months in individual years is marked in different colors.

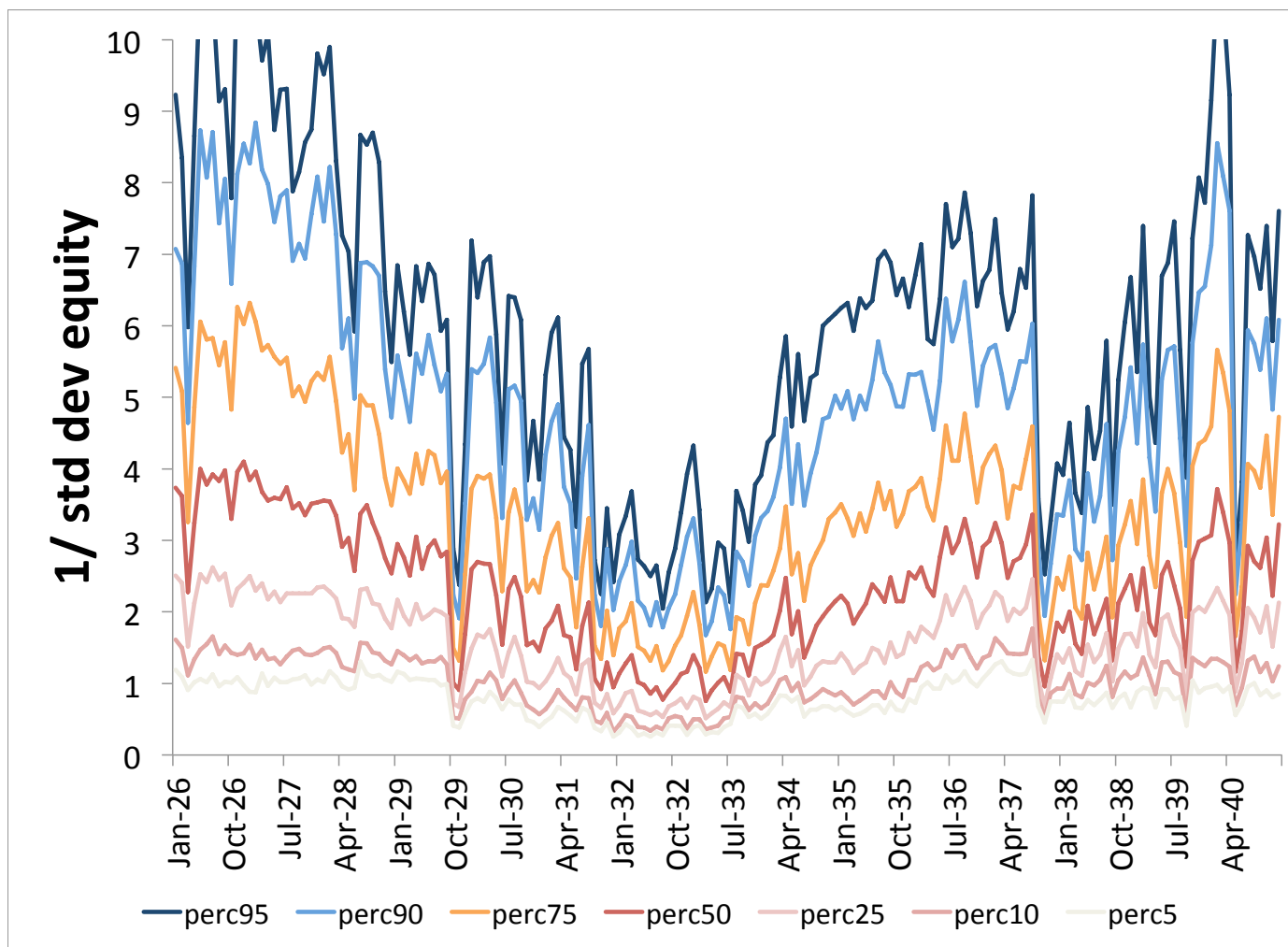


Figure 8: The distribution of Distance to Insolvency, 1926-1940.

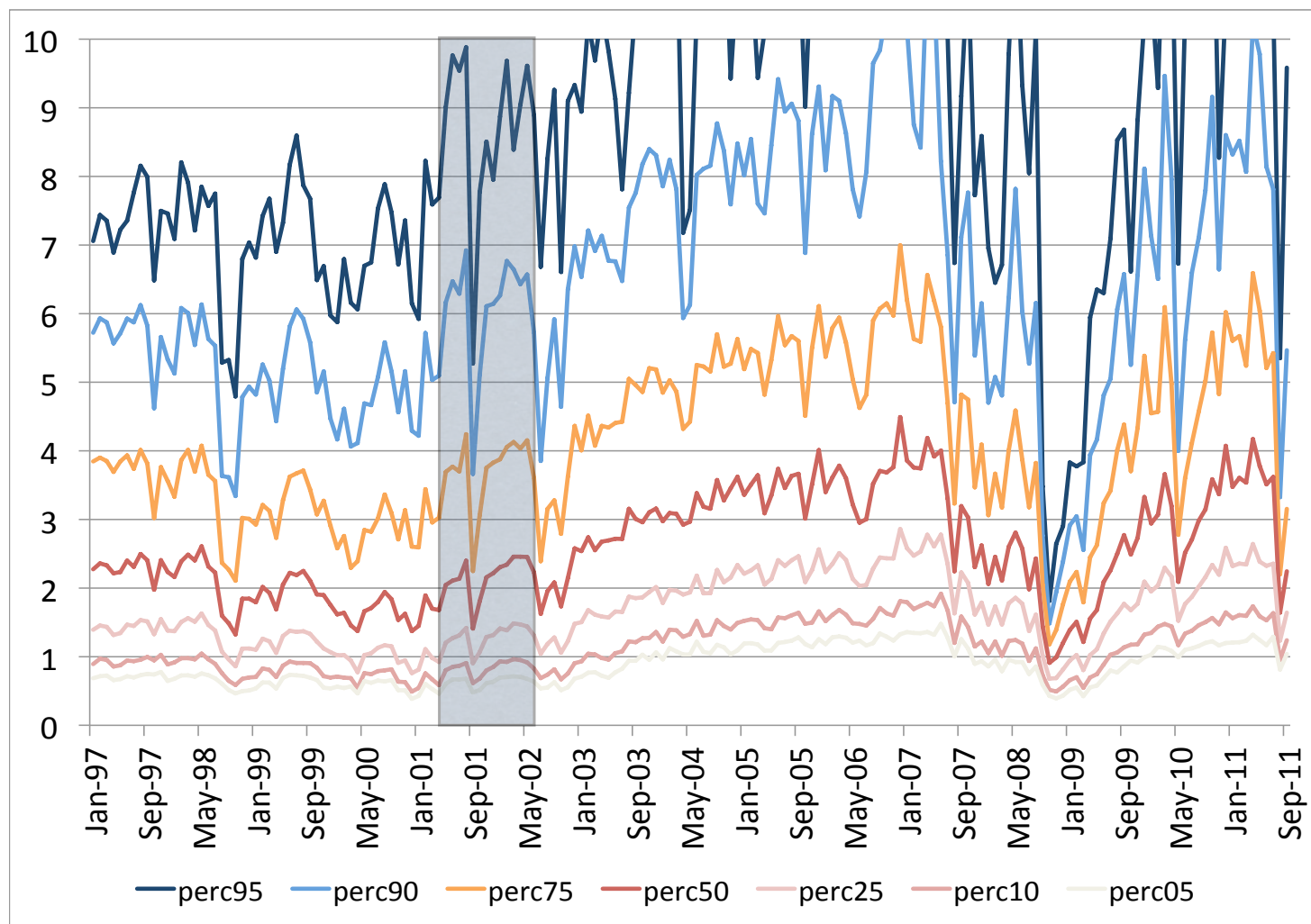


Figure 9: The distribution of Distance to Insolvency, 1997-2008.

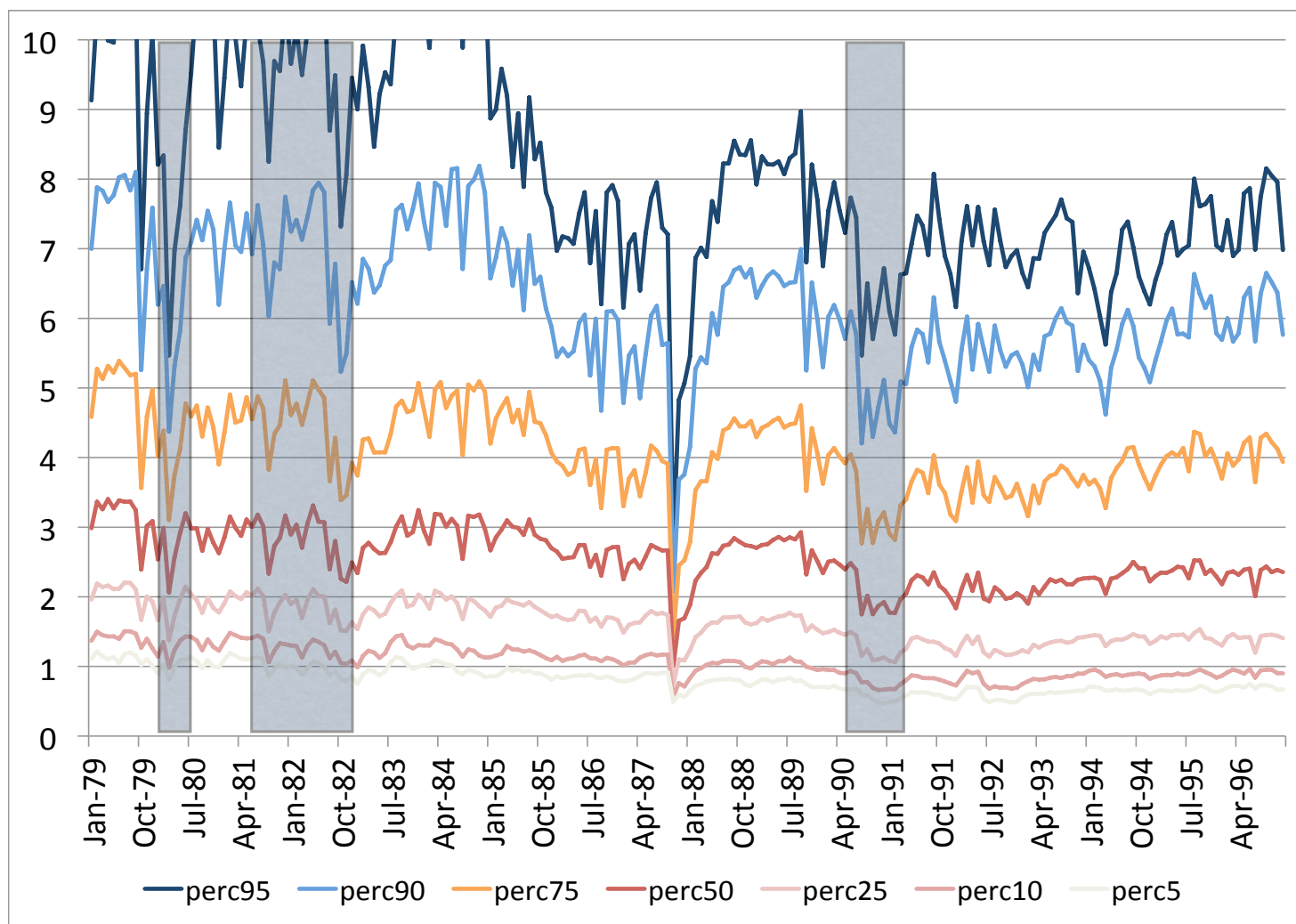


Figure 10: The distribution of Distance to Insolvency, 1979-1996.

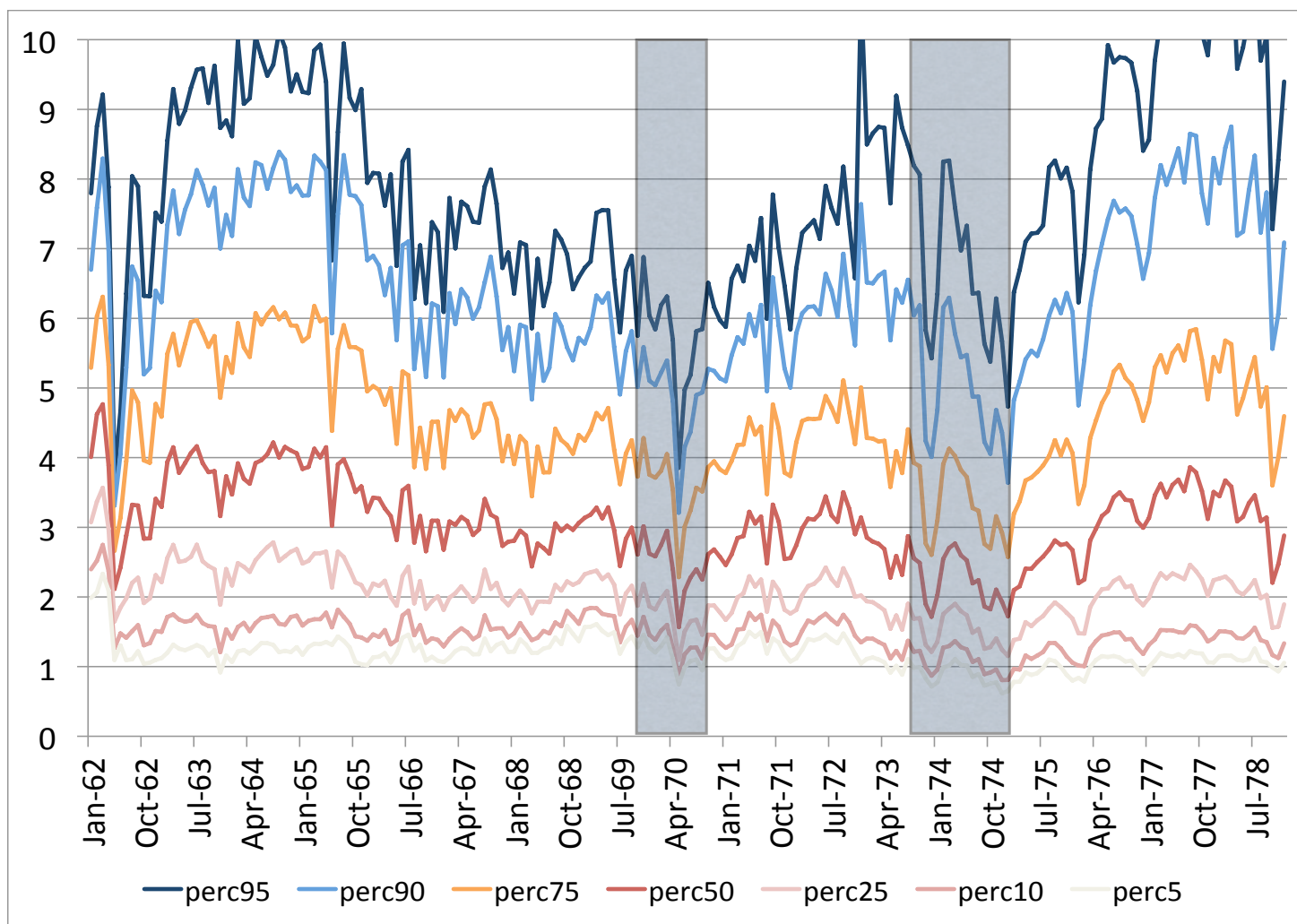


Figure 11: The distribution of Distance to Insolvency, 1962-1978.

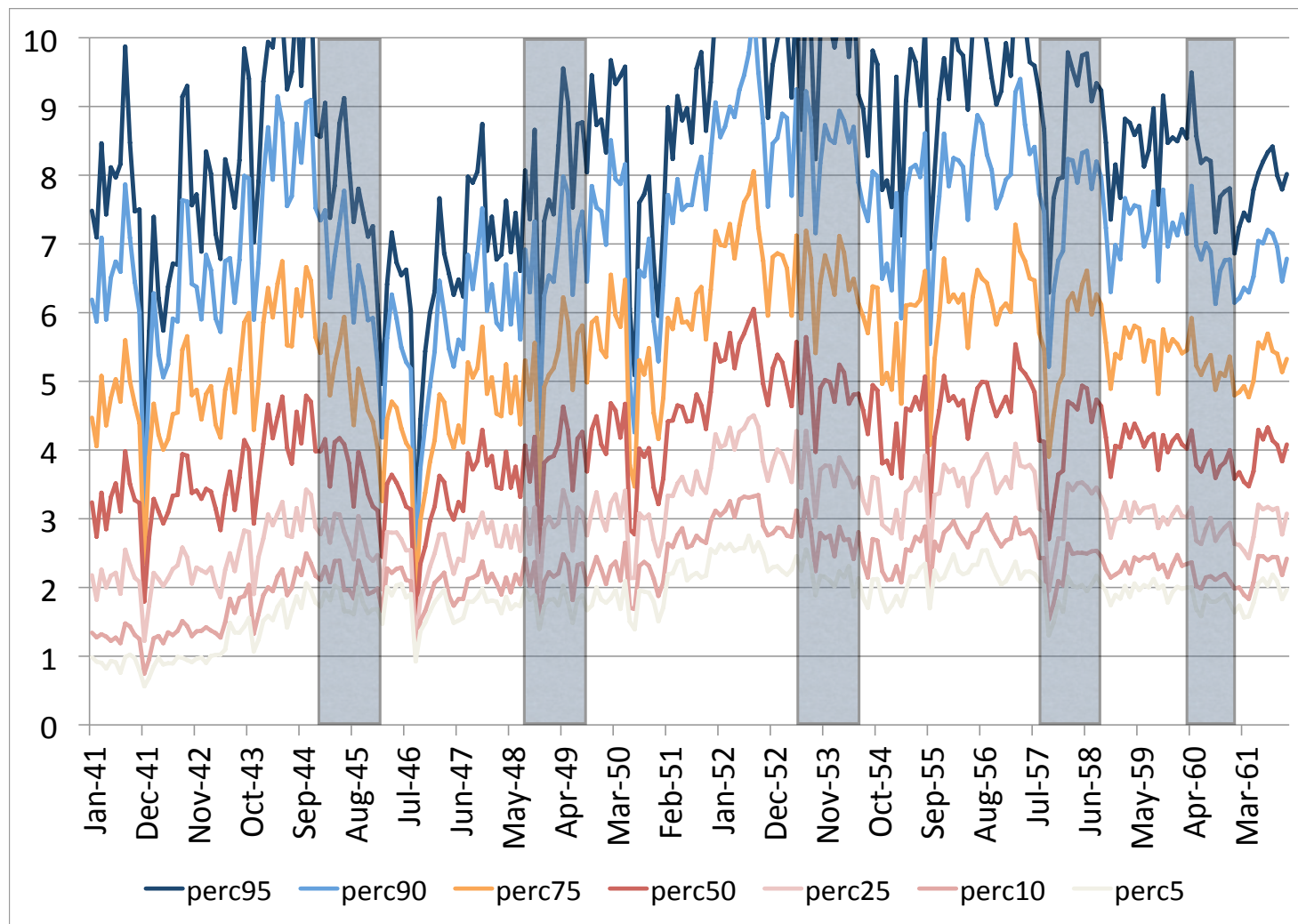


Figure 12: The distribution of Distance to Insolvency, 1941-1961.

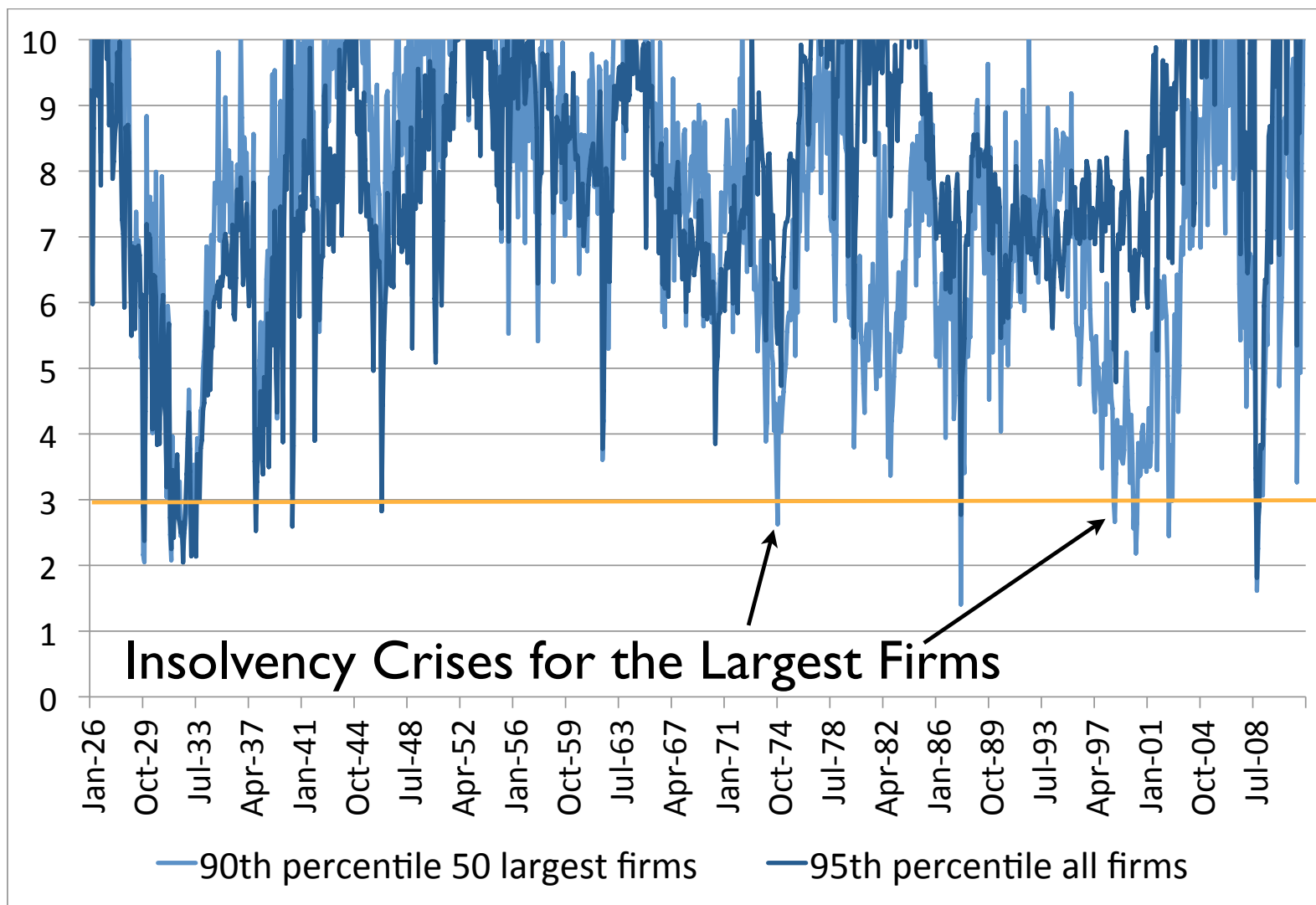


Figure 13: The 90th percentile of Distance to Insolvency for the largest 50 firms by market capitalization and the 95th percentile of the distribution of Distance to Insolvency for all firms 1926-2011. The horizontal yellow line at 3 marks the boundary which we use to define an *insolvency crisis*. The distinctive crisis episodes for large firms are marked with black arrows.

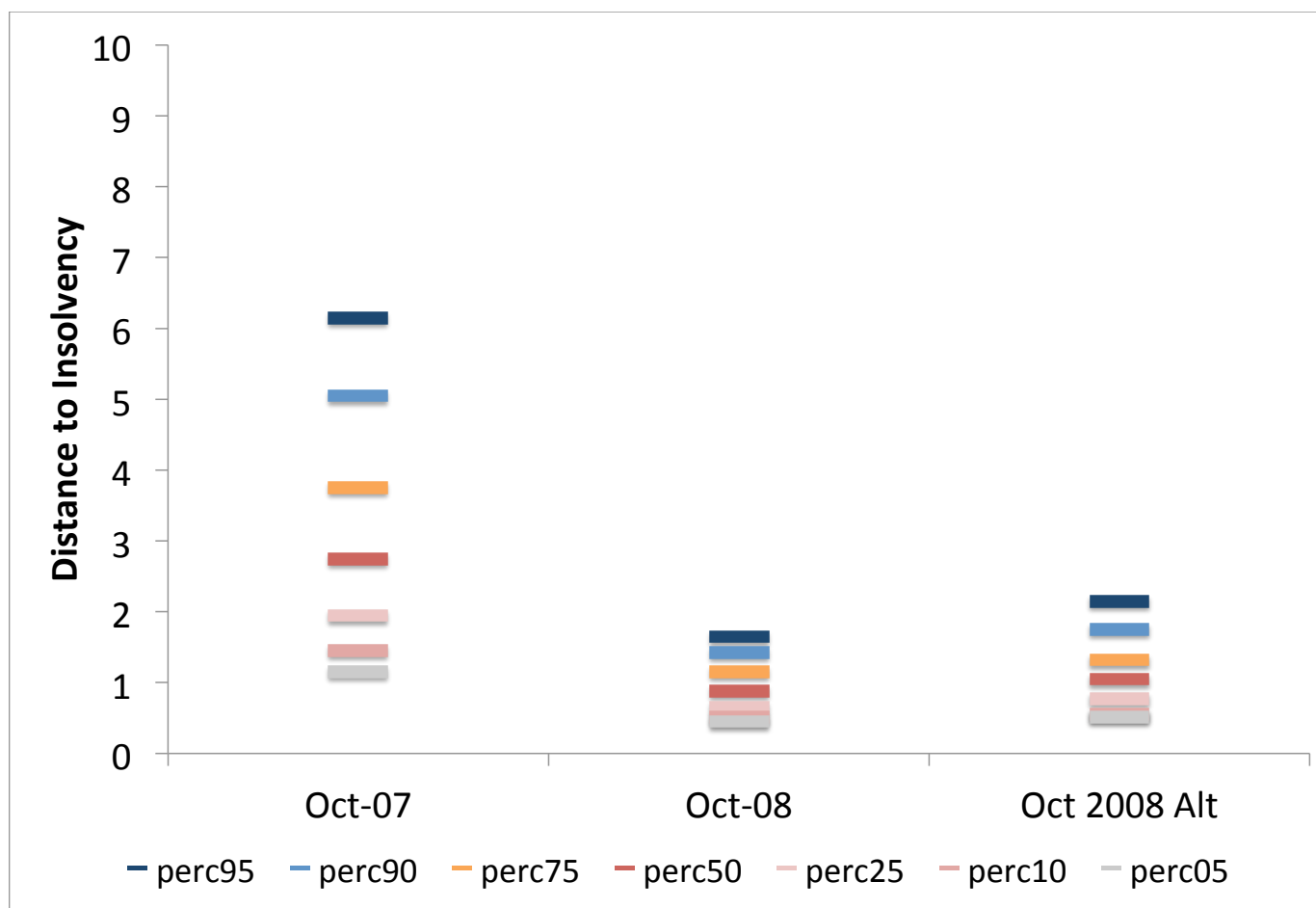


Figure 14: The percentiles of Distance to Insolvency for all firms in October 2007 and October 2008 together with the counterfactual alternative percentiles of Distance to Insolvency that would have arisen from October 2007 leverage and October 2008 asset volatility.

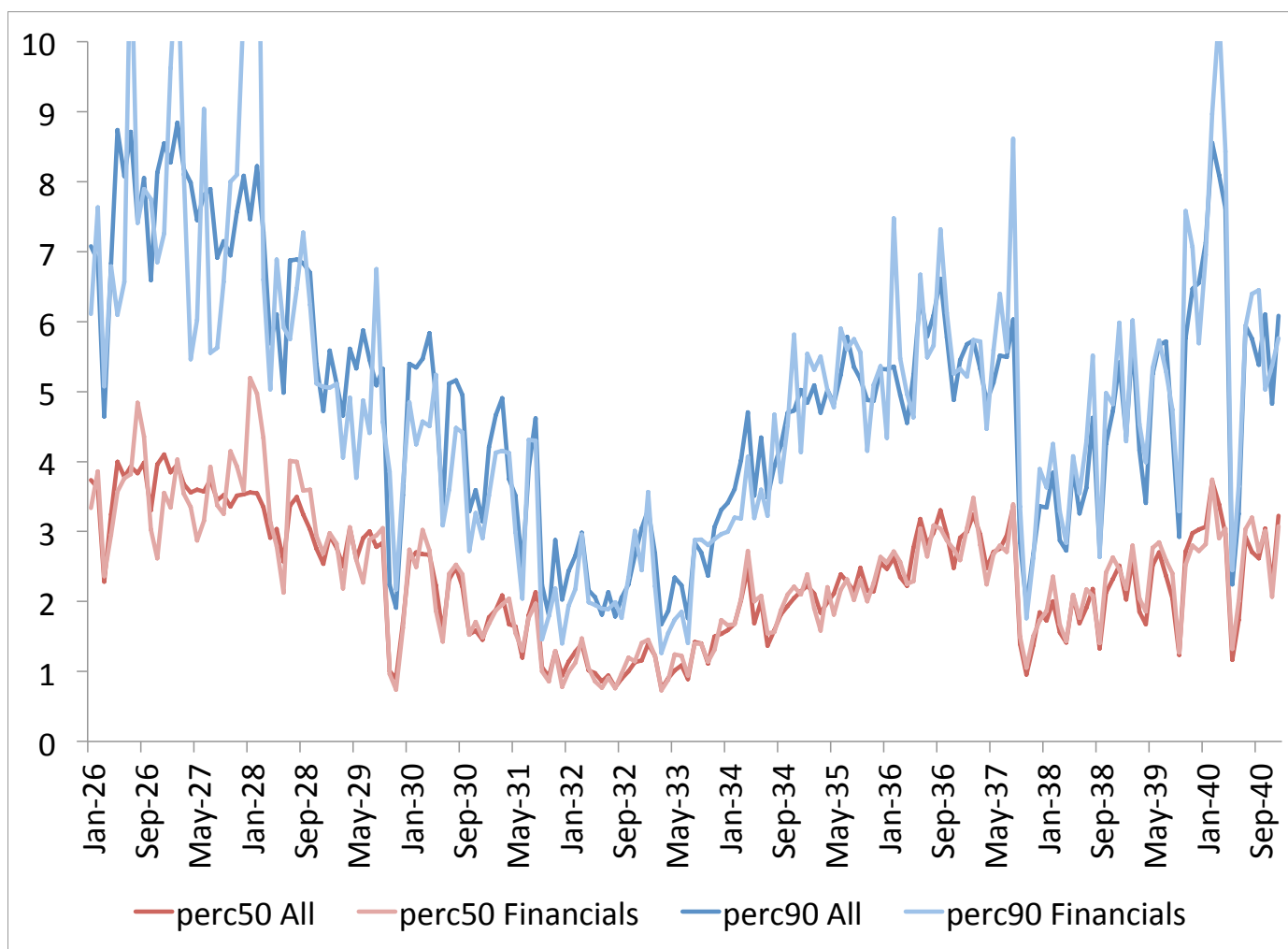


Figure 15: The 50th and 90th percentile Distance to Insolvency for Financial Firms and All Firms 1926-1940

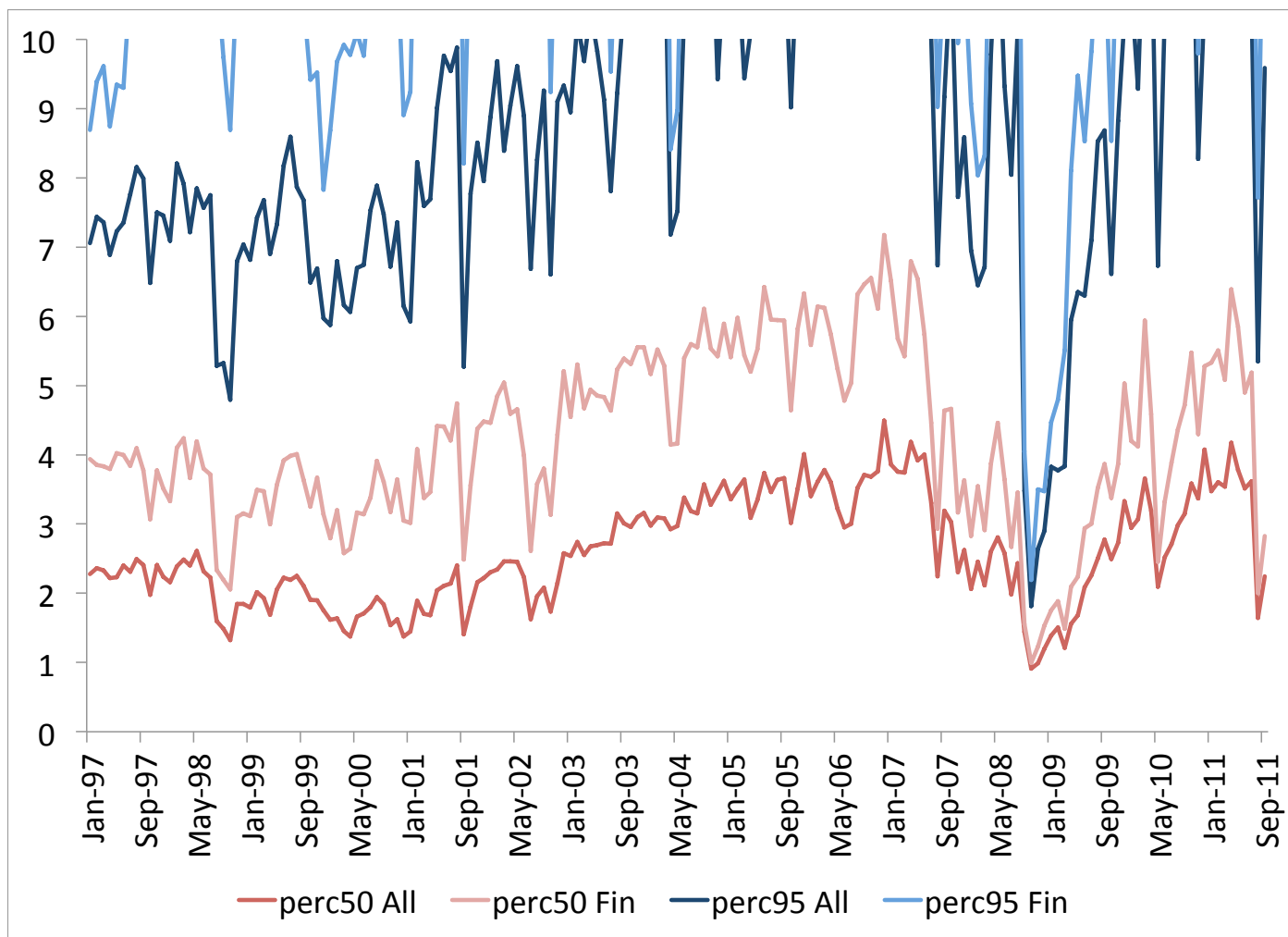


Figure 16: The 50th and 95th percentile Distance to Insolvency for Financial Firms and All Firms 1997-2011

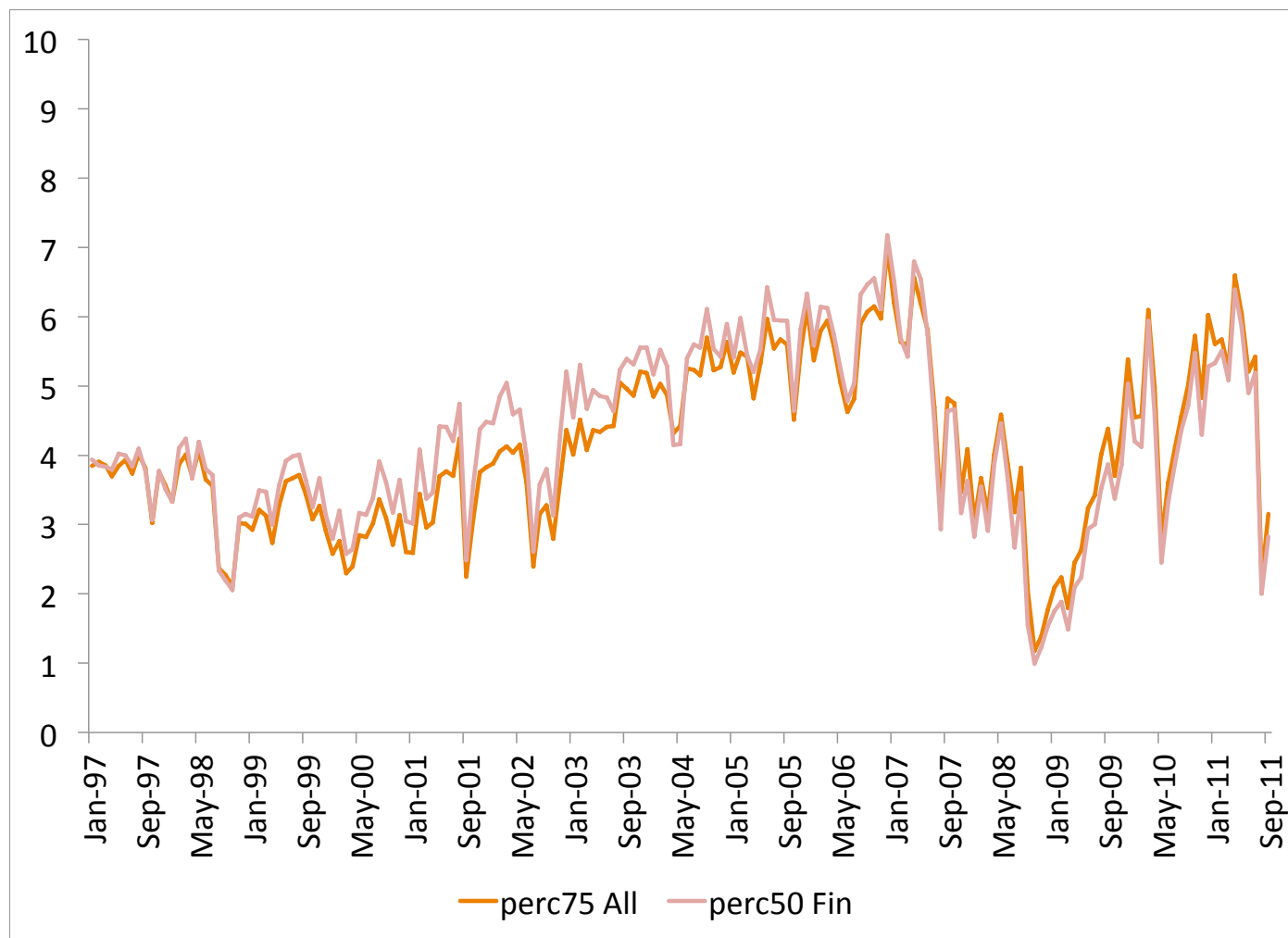


Figure 17: The 50th percentile Distance to Insolvency for Financial Firms and the 75th percentile for All Firms 1997-2011

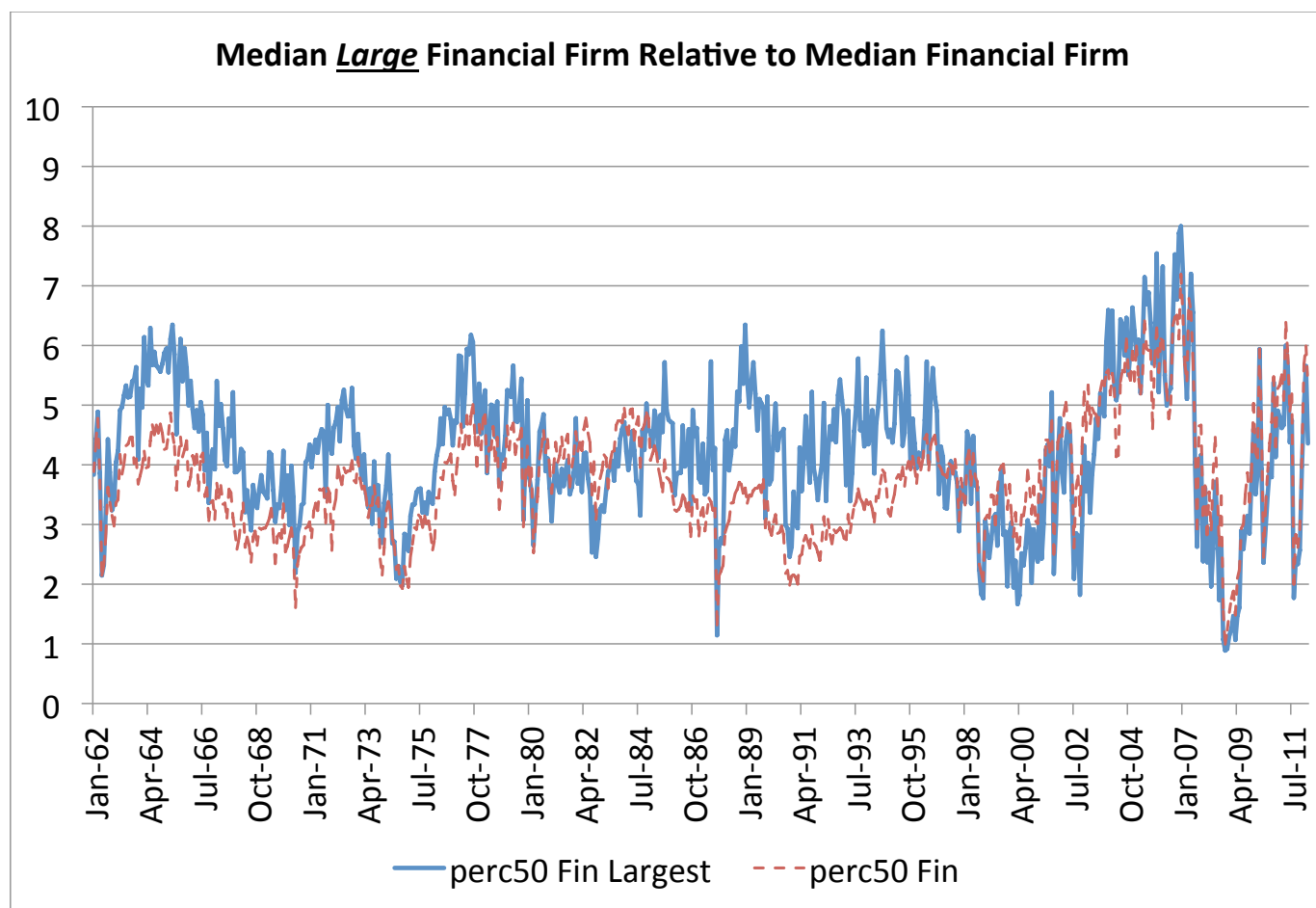


Figure 18: The median Distance to Insolvency for the median of the top 50 financial firms, by market capitalization, versus for the median of all financial firms.

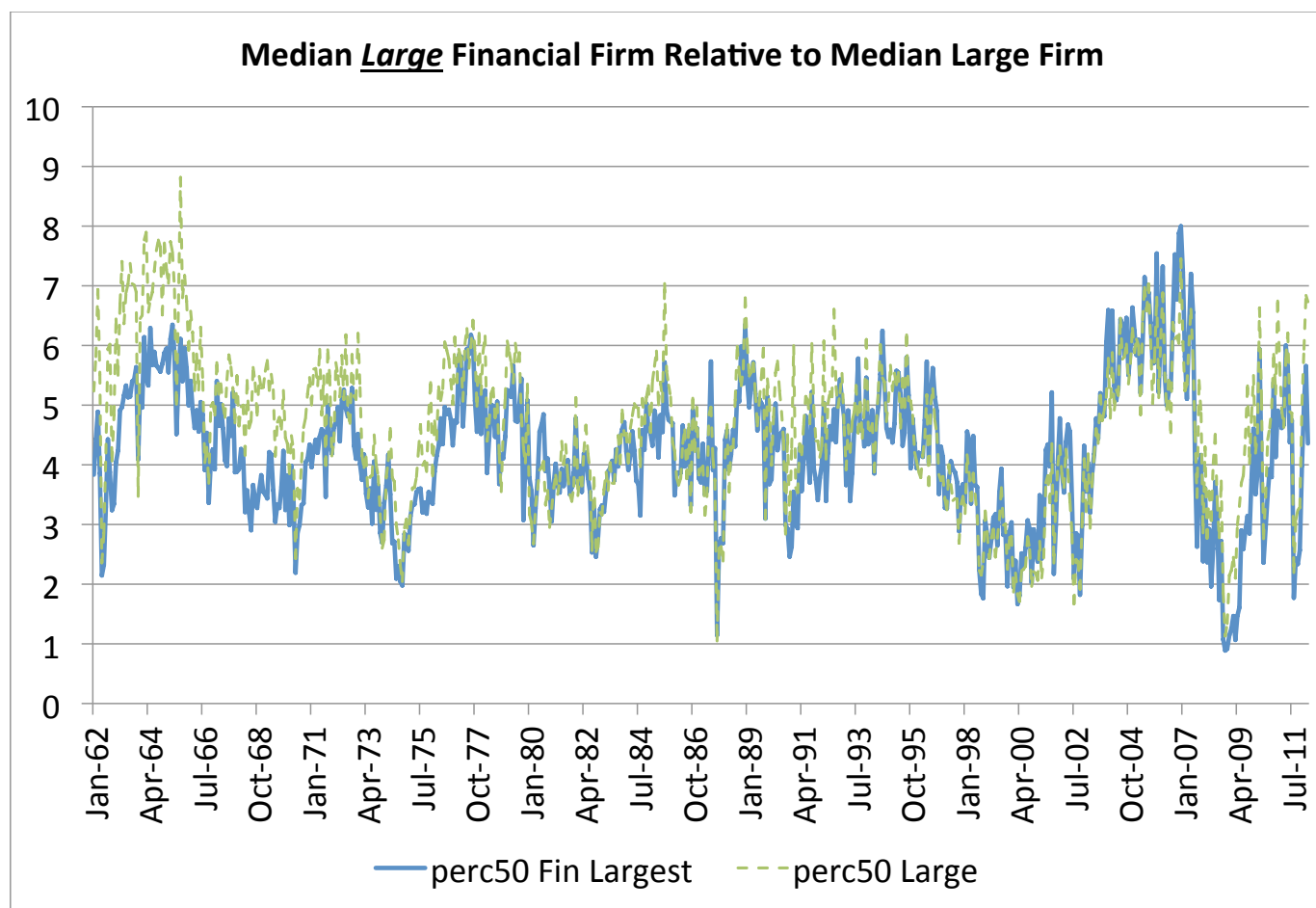


Figure 19: The median Distance to Insolvency for the median of the top 50 financial firms, by market capitalization, versus for the median of the top 50 of all firms.

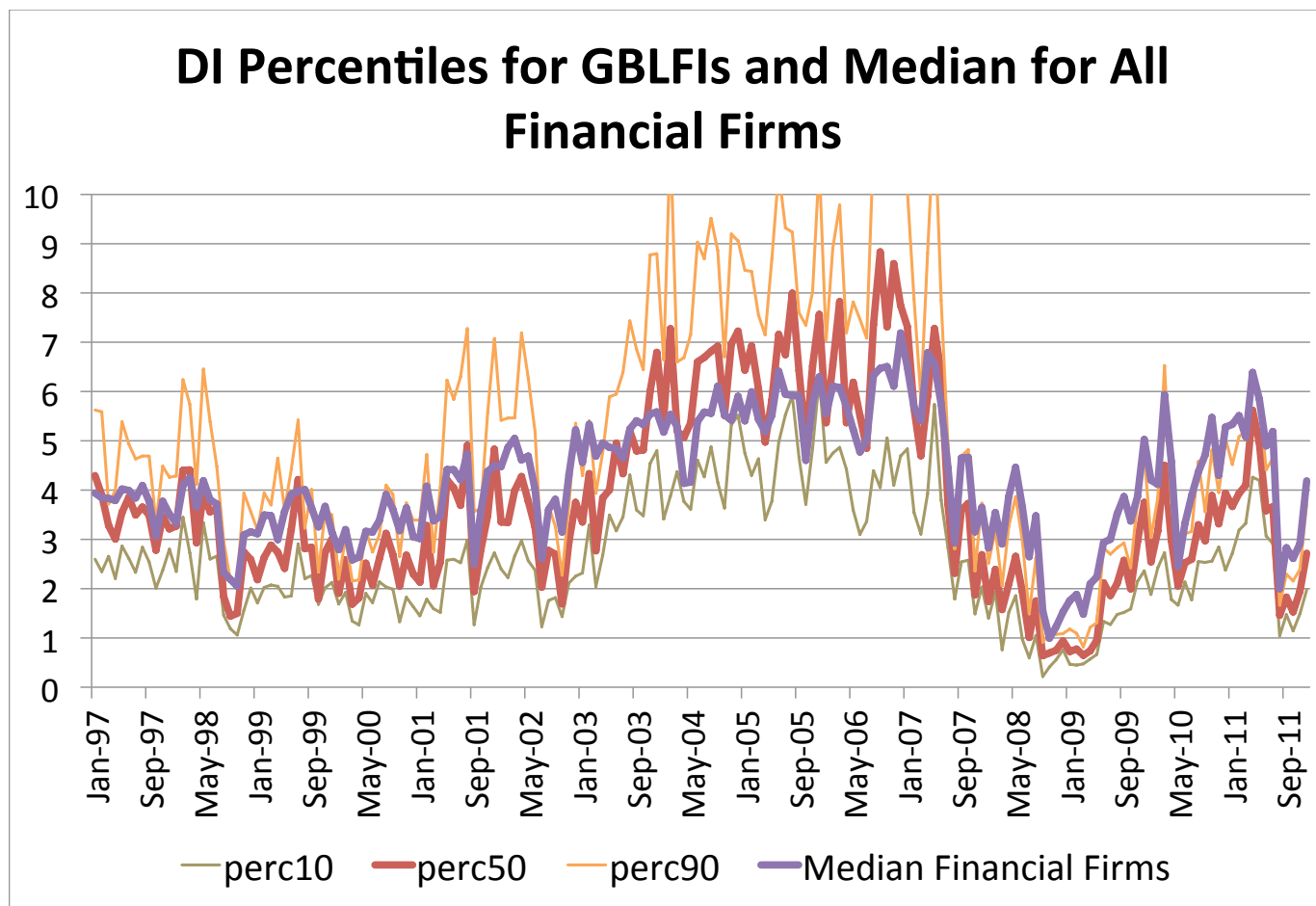


Figure 20: Distance to Insolvency for government-backed large financial institutions (GBLFIs), versus for the median of all financial firms.

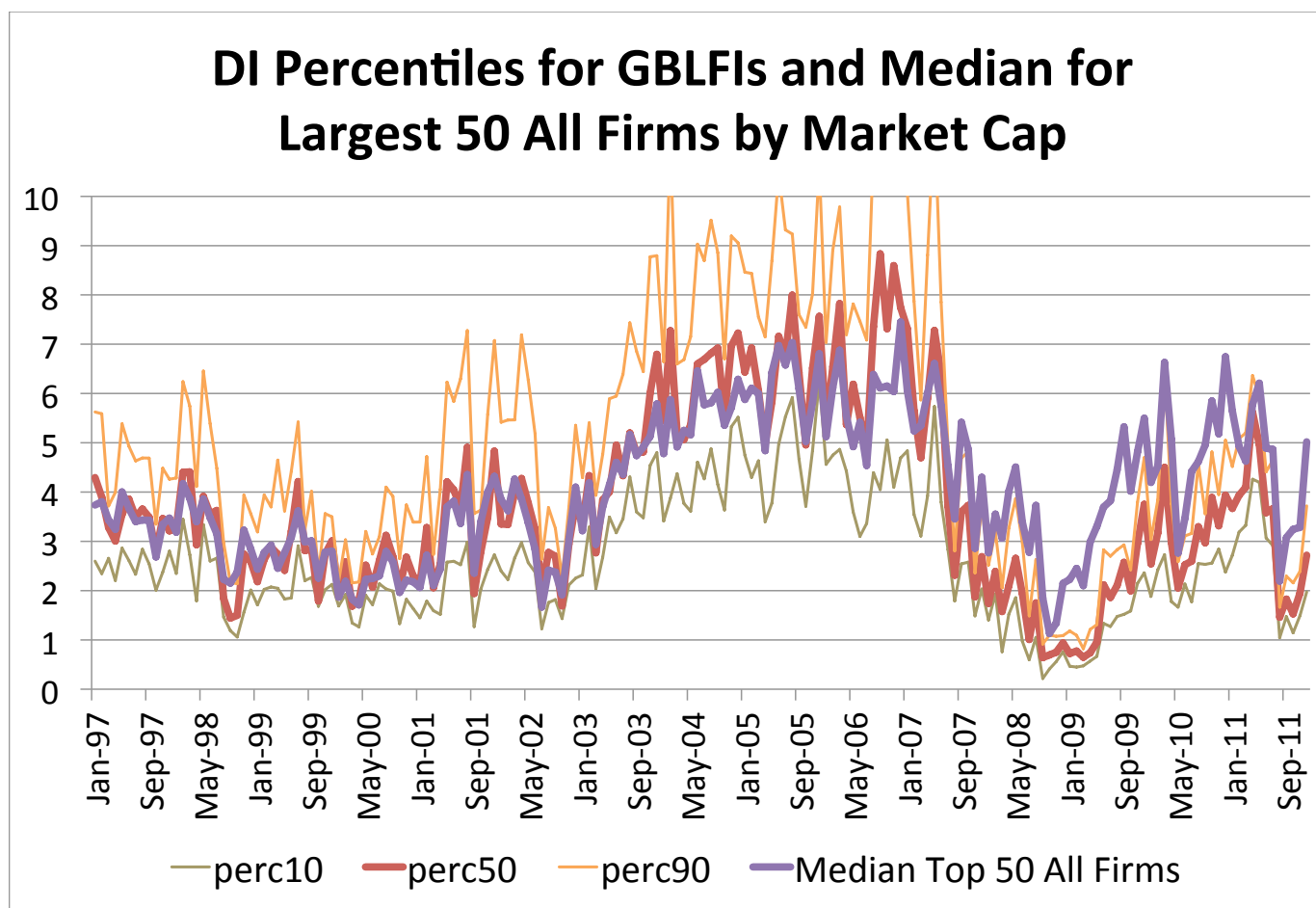


Figure 21: Distance to Insolvency for government-backed large financial institutions (GBLFIs), versus for the median of the largest 50 of all firms by market capitalization.

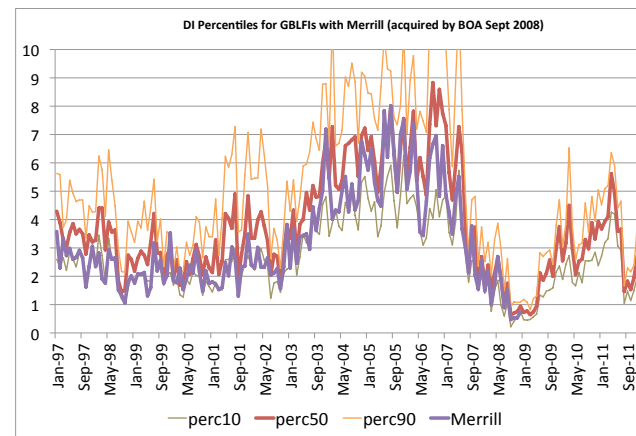
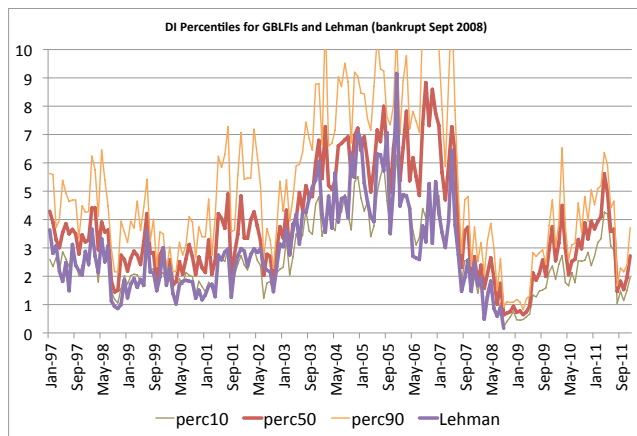
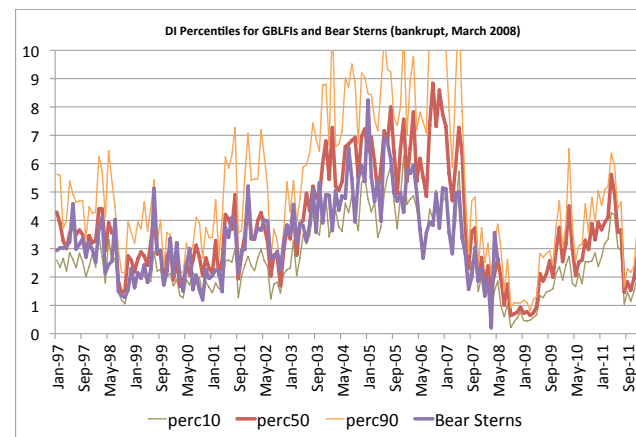
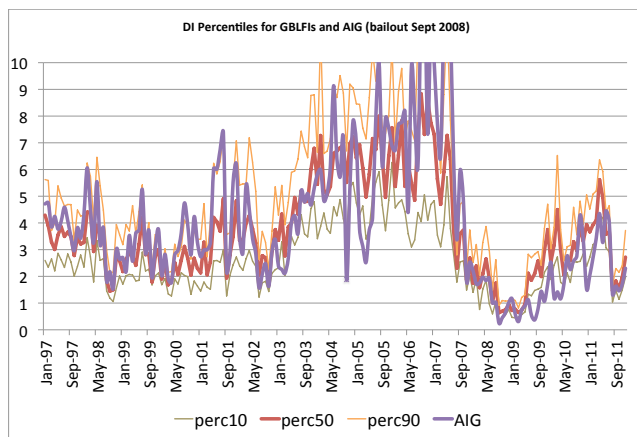


Figure 22: Distance to Insolvency for government-backed large financial institutions (GBLFIs) that failed during the crisis.

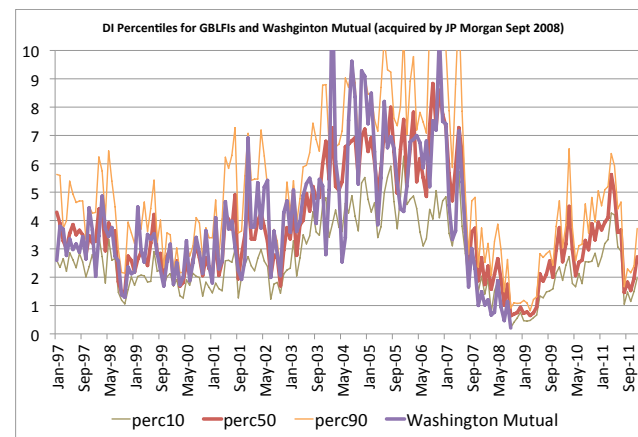
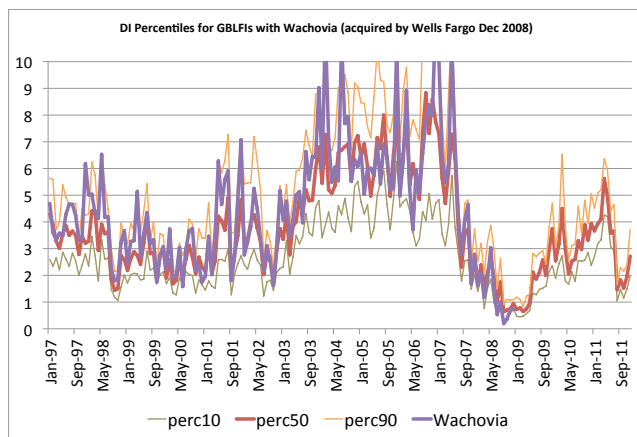


Figure 23: Distance to Insolvency for government-backed large financial institutions (GBLFIs) that failed during the crisis (ct'd).

Rank	1962	1972	1982
1	C I T FINANCIAL CORP	FIRST NATIONAL CITY CORP	AMERICAN EXPRESS CO
2	CONTINENTAL INSURANCE CO	TRAVELERS CORP	AETNA LIFE & CASUALTY CO
3	BENEFICIAL FIN CO	CHASE MANHATTAN CORP	UNION PACIFIC CORP
4	WESTERN BANCORPORATION	AETNA LIFE & CASUALTY CO	CITICORP
5	TRANSAMERICA CORP	ROYAL DUTCH PETROLEUM CO	ROYAL DUTCH PETROLEUM CO
6	COMMERCIAL CR CO	MORGAN J P & CO INC	DART & KRAFT INC
7	HOUSEHOLD FINANCE CORP	MERRILL LYNCH PIERCE FENNER	BANKAMERICA CORP
8	TRI CONTINENTAL CORP	TRANSAMERICA CORP	TRAVELERS CORP
9	LEHMAN CORP	UNION PACIFIC CORP	MORGAN J P & CO INC
10	MARINE MIDLAND CORP	M G I C INVESTMENT CORP	CONNECTICUT GENERAL CORP
11	GREAT WESTERN FINANCIAL CORP	I N A CORP	I N A CORP
12	FIRST CHARTER FINL CORP	HOUSEHOLD FINANCE CORP	C S X CORP
13	ASSOCIATES INVESTMENT CO	MANUFACTURERS HANOVER CORP	CHASE MANHATTAN CORP
14	NEWMONT MINING CORP	CONTINENTAL CORP	GENERAL RE CORP
15	MADISON FD INC	C I T FINANCIAL CORP	UNITED TELECOMMUNICATIONS INC
16	FINANCIAL FEDERATION INC	FEDERAL NATIONAL MORTGAGE ASSN	CONTINENTAL CORP
17	MESABI TRUST	SEABOARD COAST LINE INDS INC	U S F & G CORP
18	ELECTRIC BOND & SHARE CO	SANTA FE INDS INC	SANTA FE INDS INC
19	MISSION CORP	LINCOLN NATIONAL CORP IN	MARSH & MCLENNAN COS INC
20	TALCOTT JAMES INC	FIRST CHICAGO CORP	TRANSAMERICA CORP
21	FAMILY FIN CORP	MARLENNAN CORP	CONTINENTAL ILL CORP
22	MISSION DEV CO	BENEFICIAL CORP	FIRST INTERSTATE BANCORP
23	SEABOARD FINANCE CO	WESTERN BANCORPORATION	TEXAS EASTERN CORP
24	ALLEGHANY CORP MD	CHEMICAL NEW YORK CORP	MANUFACTURERS HANOVER CORP
25	UNITED CORP	C N A FINANCIAL CORP	INTERFIRST CORP
26	AMERICAN INVESTMENT CO IL	UNITED STATES FID & GTY CO	TEXAS COMMERCE BANCSHARES INC
27	UNITED STATES & FGN SECS CORP	INTERNATIONAL UTILITIES CORP	AMERICAN GENERAL CORP
28	ADAMS EXPRESS CO	BANKERS TRUST NY CORP	MERRILL LYNCH & CO INC
29	GENERAL PUBLIC SERVICE CORP	FIRST CHARTER FINL CORP	SONAT INC
30	NIAGARA SHARE CORP	FIRST PENNSYLVANIA CORP	MISSOURI PACIFIC CORP
31	SAN DIEGO IMPERIAL CORP	UNITED UTILITIES INC	CRUM & FORSTER
32	UNITED FINANCIAL CORP CA	KAUFMAN & BROAD INC	SOUTHLAND ROYALTY CO
33	GENERAL PRECISION EQUIP CORP	AMERICAN GENERAL INS CO	SECURITY PACIFIC CORP
34	GENERAL AMERICAN INVESTORS INC	TRI CONTINENTAL CORP	BANKERS TRUST NY CORP
35	TISHMAN REALTY & CNSTRUCTION INC	JEFFERSON PILOT CORP	FIRST CITY BANCORPORATION TX
36	RHODESIAN SELECTION TR LTD	NORTHWEST BANCORPORATION	CHEMICAL NEW YORK CORP
37	HELLER WALTER E & CO	CAPITAL HOLDING CORP	LINCOLN NATIONAL CORP IN
38	GIBRALTAR FINANCIAL CORP CA	LEHMAN CORP	TOYS R US INC
39	AMERICAN INTERNATIONAL CORP	FIRST NATIONAL BOSTON CORP	N L T CORP
40	DOMINICK FUND INC	AMERICAN RESEARCH & DEV CORP	CITY INVESTING CO
41	AMERICAN RESEARCH & DEV CORP	WELLS FARGO & CO	HOUSEHOLD INTERNATIONAL INC
42	CITY INVESTING CO	MARINE MIDLAND BKS INC	FIRST CHICAGO CORP
43	TEXAS PACIFIC LAND TRUST	USLIFE CORP	C N A FINANCIAL CORP
44	PETROLEUM CORP AMER	CITY INVESTING CO	MIDCON CORP
45	GREAT NORTHERN IRON ORE PPTYS	GREAT WESTERN FINANCIAL CORP	CAPITAL HOLDING CORP
46	STANDARD FINANCIAL CORP	CROCKER NATIONAL CORP	MELLON NATIONAL CORP
47	EUROFUND INC	RYDER SYSTEMS INC	REPUBLIC TEXAS CORP
48	NATIONAL AVIATION CORP	WACHOVIA CORP	COMBINED INTL CORP
49	DINERS CLUB INC	ILLINOIS CENT INDUSTRIES INC	ESMARK INC
50	GENERAL ACCEPTANCE CORP	UNIONAMERICA INC CALIF	ALEXANDER & ALEXANDER SVCS INC

Table 1: Top financial companies by market capitalization, in March 1962, 1972, 1982

Rank	1992	2002	2012
1	AMERICAN INTERNATIONAL GROUP INC	CITIGROUP INC	WELLS FARGO & CO NEW
2	FEDERAL NATIONAL MORTGAGE ASSN	AMERICAN INTERNATIONAL GROUP INC	JPMORGAN CHASE & CO
3	BELL ATLANTIC CORP	BANK OF AMERICA CORP	BERKSHIRE HATHAWAY INC DEL
4	B C E INC	BERKSHIRE HATHAWAY INC DEL	CITIGROUP INC
5	MORGAN J P & CO INC	WELLS FARGO & CO NEW	BANK OF AMERICA CORP
6	NATIONSBANK CORP	FEDERAL NATIONAL MORTGAGE ASSN	SPDR S & P 500 E T F TRUST
7	AMERICAN EXPRESS CO	J P MORGAN CHASE & CO	BERKSHIRE HATHAWAY INC DEL
8	BERKSHIRE HATHAWAY INC DEL	MORGAN STANLEY DEAN WITTER & CO	ROYAL BANK CANADA MONTREAL QUE
9	BANKAMERICA CORP	U B S AG	TORONTO DOMINION BANK ONT
10	TOYS R US INC	AMERICAN EXPRESS CO	SPDR GOLD TRUST
11	BANC ONE CORP	WACHOVIA CORP 2ND NEW	AMERICAN EXPRESS CO
12	NORFOLK SOUTHERN CORP	BANK ONE CORP	BANK OF NOVA SCOTIA
13	GENERAL RE CORP	MERRILL LYNCH & CO INC	UNITEDHEALTH GROUP INC
14	CHEMICAL BANKING CORP	FEDERAL HOME LOAN MORTGAGE CORP	GOLDMAN SACHS GROUP INC
15	FEDERAL HOME LOAN MORTGAGE CORP	U S BANCORP DEL	U S BANCORP DEL
16	STUDENT LOAN MARKETING ASSN	GOLDMAN SACHS GROUP INC	AMERICAN INTERNATIONAL GROUP INC
17	C S X CORP	FIFTH THIRD BANCORP	VANGUARD INTL EQUITY INDEX FUNDS
18	CHUBB CORP	FLEETBOSTON FINANCIAL CORP	U B S AG
19	CITICORP	M B N A CORP	DEUTSCHE BANK A G
20	MERRILL LYNCH & CO INC	WASHINGTON MUTUAL INC	SIMON PROPERTY GROUP INC NEW
21	MARSH & MCLENNAN COS INC	MARSH & MCLENNAN COS INC	BARRICK GOLD CORP
22	P N C FINANCIAL CORP	BANK NEW YORK INC	METLIFE INC
23	NORWEST CORP	SPDR TRUST	ISHARES TRUST
24	C N A FINANCIAL CORP	ALLSTATE CORP	MORGAN STANLEY DEAN WITTER & CO
25	WACHOVIA CORP NEW	HOUSEHOLD INTERNATIONAL INC	ISHARES TRUST
26	BURLINGTON RESOURCES INC	UNITEDHEALTH GROUP INC	BANK MONTREAL QUE
27	AETNA LIFE & CASUALTY CO	ROYAL BANK CANADA MONTREAL QUE	POWERSHARES QQQ TRUST
28	SUNTRUST BANKS INC	METLIFE INC	P N C FINANCIAL SERVICES GRP INC
29	AMERICAN GENERAL CORP	NASDAQ 100 TRUST SERIES I	CAPITAL ONE FINANCIAL CORP
30	BANKERS TRUST NY CORP	SUNTRUST BANKS INC	CANADIAN IMPERIAL BANK COMMERCE
31	FIRST UNION CORP	NATIONAL CITY CORP	ISHARES TRUST
32	MORGAN STANLEY GROUP INC	PRUDENTIAL FINANCIAL INC	PRUDENTIAL FINANCIAL INC
33	C I G N A CORP	STATE STREET CORP	BANK OF NEW YORK MELLON CORP
34	WELLS FARGO & CO	B B & T CORP	BLACKROCK INC
35	N B D BANCORP INC	SCHWAB CHARLES CORP NEW	BANCO BRADESCO S A
36	G E I C O CORP	TORONTO DOMINION BANK ONT	FRANKLIN RESOURCES INC
37	ALLTEL CORP	P N C FINANCIAL SERVICES GRP INC	WELLPOINT INC
38	FLEET NORSTAR FINANCIAL GRP INC	MELLON FINANCIAL CORP	ACE LTD NEW
39	CHASE MANHATTAN CORP	HARTFORD FINANCIAL SVCS GRP INC	MANULIFE FINANCIAL CORP
40	TRANSAMERICA CORP	LEHMAN BROTHERS HOLDINGS INC	PUBLIC STORAGE
41	SOCIETY CORP	U S A EDUCATION INC	TRAVELERS COMPANIES INC
42	HANSON PLC	A F L A C INC	ISHARES TRUST
43	ST PAUL COS INC	BERKSHIRE HATHAWAY INC DEL	STATE STREET CORP
44	SAFECO CORP	C I G N A CORP	B B & T CORP
45	BANK NEW YORK INC	CAPITAL ONE FINANCIAL CORP	A F L A C INC
46	TORCHMARK CORP	NORTHERN TRUST CORP	VANGUARD INDEX TRUST
47	FIFTH THIRD BANCORP	MANULIFE FINANCIAL CORP	ISHARES TRUST
48	AON CORP	CANADIAN IMPERIAL BANK COMMERCE	BROOKFIELD ASSET MANAGEMENT INC
49	CAPITAL HOLDING CORP	X L CAPITAL LTD	C M E GROUP INC
50	NATIONAL CITY CORP	CHUBB CORP	EQUITY RESIDENTIAL

Table 2: Top financial companies by market capitalization, in March 1992, 2002, 2012

Number	Name
1	AMERICAN EXPRESS CO
2	AMERICAN INTERNATIONAL GROUP INC
3	B B & T CORP
4	BANK OF AMERICA CORP
5	BANK OF NEW YORK MELLON CORP
6	BEAR STEARNS COMPANIES INC
7	CAPITAL ONE FINANCIAL CORP
8	CITIGROUP INC
9	FIFTH THIRD BANCORP
10	GOLDMAN SACHS GROUP INC
11	J P MORGAN CHASE & CO
12	KEYCORP NEW
13	LEHMAN BROTHERS HOLDINGS INC
14	MERRILL LYNCH & CO INC
15	METLIFE INC
16	MORGAN STANLEY GROUP INC
17	P N C BANK CORP
18	REGIONS FINANCIAL CORP
19	STATE STREET CORP
20	SUNTRUST BANKS INC
21	U S BANCORP DEL
22	WACHOVIA CORP 2ND NEW
23	WASHINGTON MUTUAL INC
24	WELLS FARGO & CO NEW

Table 3: Government-Backed Large Financial Institutions

References

- Anat Admati, Peter DeMarzo, Martin Hellwig, and Paul Pfleiderer. Debt overhang and capital regulation. March 2012. [7](#)
- Cristina Arellano, Yan Bai, and Patrick Kehoe. Financial markets and fluctuations in uncertainty. Working paper, March 2011. [3](#)
- Ben Bernanke. Nonmonetary effects of the financial crisis in the propagation of the great depression. *The American Economic Review*, 73(3):257–276, 1983. [4](#)
- Ben Bernanke and Mark Gertler. Agency costs, net worth, and business fluctuations. *The American Economic Review*, 1:14–31, 1989. [1](#)
- Ben Bernanke, Mark Gertler, and Simon Gilchrist. The financial accelerator in a quantitative business cycle framework. In John Taylor and Michael Woodford, editors, *Handbook of Macroeconomics*, chapter 21, pages 1341–1392. Elsevier, 1999. [1](#)
- Sreedhar Bharath and Tyler Shumway. Forecasting default with the merton distance to default model. *Review of Financial Studies*, 21(3):1339–1369, May 2008. [15](#)
- Fischer Black and John C. Cox. Valuing corporate securities: Some effects of bond indenture provisions. *Journal of Finance*, 31(2):351–367, May 1976. [9](#)
- Nicholas Bloom. The impact of uncertainty shocks. *Econometrica*, 77(3):623–685, May 2009. [3](#)
- Markus K. Brunnermeier and Yuliy Sannikov. A macroeconomic model with a financial sector. Working paper, Princeton University, 2012. [4](#)
- Charles T. Carlstrom and Timothy S. Fuerst. Agency costs, net worth, and business fluctuations: A computable general equilibrium analysis. *The American Economic Review*, 87:893–910, 1997. [1](#)
- Sudheer Chava and Robert A. Jarrow. Bankruptcy prediction with industry effects. *Review of Finance*, 8(4):537–569, 2004. [14](#)
- Lawrence Christiano, Roberto Motto, and Massimo Rostagno. Financial factors in economic fluctuations. Working paper, May 2010. [3](#)
- Thomas Cooley and Vincenzo Quadrini. Financial markets and firm dynamics. *The American Economic Review*, 91(5):1286–1310, 2001. [1](#)
- Thomas Cooley, Ramon Marimon, and Vincenzo Quadrini. Aggregate consequences of limited contract enforceability. *Journal of Political Economy*, 112(4):817–847, 2004. [1](#)
- E. Gerald Corrigan. Are banks special?, 1983. [5](#)
- Douglas Diamond and Rachuram Rajan. Fear of fire sales, illiquidity seeking, and credit freezes, 2011. [7](#)

- Darrell Duffie. *Measuring Corporate Default Risk*. Oxford University Press, 2011. 1, 14
- Darrell Duffie, Leandro Saita, and Ke Wang. Multi-period corporate default prediction with stochastic covariates. *Journal of Financial Economics*, 83:635–665, 2007. 14, 15
- Darrell Duffie, Andreas Eckner, Guillaume Horel, and Leandro Saita. Frailty correlated default. *Journal of Finance*, 64(5):2089–2123, October 2009. 14
- Financial Crisis Inquiry Commission. *Financial Crisis Inquiry Report*. Government Printing Office, <http://fcic.law.stanford.edu/>, 2011. 5
- Xavier Gabaix. Variable rare disasters: An exactly solved framework for ten puzzles in macro-finance. *Quarterly Journal of Economics*, 127(2):645–700, 2012. 4
- Mark Gertler and Nobuhiro Kiyotaki. Financial intermediation and credit policy in business cycle analysis. In *Handbook of Monetary Economics*, volume 3, chapter 11, pages 547–599. Elsevier, 2010. 4
- Kay Giesecke, Francis A. Longstaff, Stephen Schaefer, and Ilya Strebulaev. Corporate default risk: A 150 year perspective. *Journal of Financial Economics*, 102:233–250, 2011. 2, 18
- Kay Giesecke, Francis A. Longstaff, Stephen Schaefer, and Ilya Strebulaev. Macroeconomic effects of corporate default crises: A long term perspective. February 2012. 2, 18
- Simon Gilchrist, Jae W. Sim, and Egon Zakrajsek. Uncertainty, financial frictions, and investment dynamics. Working paper, 2010. 3
- Gary Gorton. Some reflections on the recent financial crisis. July 2012. 5
- Francois Gourio. Disaster risk and business cycles. *American Economic Review*, Forthcoming. 4
- Oliver Hart and Luigi Zingales. Curbing risk on wall street. *National Affairs*, Spring 2010. 15
- Zhiguo He and Arvind Krishnamurthy. A model of capital and crises. *Review of Economic Studies*, 79:735–777, 2012. 4
- Charles P. Kindleberger and Robert Aliber. *Manias, Panics, and Crashes: A History of Financial Crises*. Number 39 in Wiley Investment Classics. John Wiley and Sons, fifth edition, 2005. 3
- Nobuhiro Kiyotaki and John Moore. Credit cycles. *Journal of Political Economy*, 105: 211–248, 1997. 1
- Hayne E. Leland. Corporate debt value, bond covenants, and optimal capital structure. *Journal of Finance*, 49(4):1213–1252, September 1994. 1, 2, 7, 9, 10, 11, 26

- Francis Longstaff and Eduardo Schwartz. A simple approach to valuing risky fixed and floating rate debt. *Journal of Finance*, 50(3):789–819, July 1995. 9
- Robert C. Merton. On the pricing of corporate debt: The risk structure of interest rates. *Journal of Finance*, 29(2):449–470, May 1974. 1, 2, 7, 10
- Adriano Rampini and S. Viswanathan. Collateral, risk management, and the distribution of debt capacity. *Journal of Finance*, 65(6):2293–2322, December 2010. 3
- Adriano Rampini and S. Viswanathan. Financial intermediary capital. Working paper, March 2012. 4
- Carmen Reinhart and Kenneth Rogoff. *This Time Is Different: Eight Centuries of Financial Folly*. Princeton University Press, 2009. 3, 4
- Gary Stern and Ron Feldman. *Too Big to Fail: The Hazards of Bank Bailouts*. Brookings Institution Press, 2004. 5
- Zhao Sun, David Munves, and David Hamilton. Public firm expected default frequency (edf) credit measures: Methodology, performance, and model extensions. Moody’s Analytics Modeling Methodology, June 2012. 1, 10, 15