TRAIN WRECKS:

ASSET PRICING AND THE VALUATION OF SEVERELY DISTRESSED ASSETS

Francis A. Longstaff*

Abstract. Motivated by the recent subprime credit crisis, we examine the asset-pricing implications of a market in which assets can become severely distressed as investors learn that an adverse event has occurred, but don't initially know the full extent of the damage. We show that the "train wreck" occurs in two stages. First, there is a major credit contraction as leveraged investors attempt to reduce their funding risk. As the debt sector shrinks, safe assets such as riskless bonds soar in value while the risk premium for risky assets increases. The price of the distressed asset falls, but is cushioned by the decline in the riskless interest rate. Risk sharing is affected as the most-risk-averse agents put more of their portfolio into risky assets. In the second stage, uncertainty is resolved, and market leverage, interest rates, and nondistressed asset values return to their previous levels. The resulting time variation in risk premium induces significant predictability into asset returns throughout the distress period. To examine the empirical implications of the model, we conduct the first large-scale empirical investigation into the pricing of subprime asset-backed CDOs using data for the ABX indexes. We find that negative shocks to the ABX index result in contractions in the size of the short-term credit market, increases in the value of both short-term and long-term Treasury bonds, and increases in the trading activity of financial stocks. We also find that ABX returns have significant forecast ability for Treasury bonds and the stock market as far as three weeks ahead, suggestive of a "deer-in-headlights" effect in the financial markets. Using fixed-income derivatives data, we show that similar effects were present in the market during the 1998 LTCM/hedge-fund crisis.

Current version: March 2008.

* UCLA Anderson School and NBER. I am very grateful for helpful discussions with Joshua Anderson, Vineer Bhansali, Bruce Carlin, Richard Clarida, Rajna Gibson, Robert Gingrich, Hanno Lustig, Alfred Murata, Steve Schulist, and Jiang Wang, and for the comments of seminar participants at UCLA and Pimco. All errors are my responsibility.

1. INTRODUCTION

The financial markets currently face a severe crisis as the threat of extensive defaults by subprime borrowers spills over into other credit sectors such as the asset-backed, mortgage-backed, municipal-bond, and corporate-bond markets. Concerns about the potential subprime loss exposure of major Wall Street firms and hedge funds have already led to a number of high-level dismissals among top executives, and many institutional players are scrambling for capital to bolster their balance sheets. The crisis has brought about an almost completely halt to the fledgling structured-credit market, a serious “credit crunch” for both individuals and financial institutions, and a major decline in the liquidity of debt securities in virtually every market.

Although previous literature has focused on the role that asymmetric information plays in these types of extreme shocks, the current crisis appears to be characterized more by “symmetric ignorance” on the part of market participants about the true value of their holdings of structured debt securities. This is due in large part to the heavy reliance many of these participants placed on the overly-optimistic credit ratings these securities had been assigned. As the crisis emerged, these optimistic credit ratings quickly evaporated, leaving investors holding illiquid positions in structured credit securities, each of which is associated with a highly complex and idiosyncratic stream of cash flows generated from hundreds or even thousands of difficult-to-analyze individual loans. This is a situation that Clarida (2007) relates to financial Knightian uncertainty.

Whatever the ultimate resolution of the current crisis, it represents an almost textbook example of a financial event in which an entire asset class becomes severely distressed. The subprime crisis, however, is far from unique in this respect and many other examples from the annals of finance could be cited including the tulip market in Holland in the 17th century, the crash of 1873 in which nearly 30 percent of all railroad bonds in the United States were in default, and the LTCM/hedge-fund crisis of 1998. Given the macro impact of these types of events on financial markets, it is of first-order importance to have a fundamental understanding of their asset-pricing implications.

In this paper, we study the valuation of distressed assets in a standard discrete-time exchange economy framework. In this setting, there are two classes of agents who differ in their degree of risk aversion. The agents can invest in a riskless asset and two classes of risky assets. The first risky asset can be viewed as the stock market. The second risky asset is initially similar to the first risky asset. Given an realization of a Poisson event at time t, however, the second asset becomes distressed. This means that at time t, it is revealed that the future dividends of the second asset will be permanently reduced by some potentially large fraction q beginning at $t+1$. The actual realization of q, however, will not be known until time $t+1$. Thus, if an event occurs at time t, the “passengers” on the train see the wreck coming, but don’t know how bad the crash will be; all that they can do is to "swap seats" with each other by trading shares of the assets.

The model provides a number of interesting insights into the economics of distressed assets. To make the intuition behind the results as clear as possible, we solve the model in a simple three-period setting in which the two classes of agents are initially endowed with equal wealth. In this setting, the agents make portfolio decisions in the first period, anticipating that financial distress could occur in the second period. As in Longstaff and Wang (2007), the less-risk-averse agent levers his portfolio by borrowing from the more-risk-averse agent. Thus, there is a significant debt sector in the economy. This aspect of the model is crucial in understanding the economics of distressed assets and is a key distinction between this paper and the standard representative-agent asset-pricing literature in which there is no debt sector in equilibrium.

We then consider what happens if a distress event occurs in the second period. We show that the imminent risk of a catastrophic decline in the distressed asset's dividend results in a substantial contraction in the size of the debt sector, producing something analogous to a credit crunch. Intuitively, this occurs as leveraged agents realize that they are now overextended in a distressed financial market and act to reduce their credit exposure. This credit contraction has important risk-sharing implications for the agents since it changes the investment opportunity set available in the market. For example, we show that a larger fraction of the more-risk-averse agents' portfolios is now allocated to risky assets, despite the fact that the volatility of these assets increases significantly

The credit contraction also has many consequences for asset prices. The tension between the desire of leveraged agents to reduce their debt and the demand by unleveraged agents to hold more riskless bonds in their portfolios results in a dramatic decline in the riskless interest rate. The resulting increase in the price of the "safe" riskless asset closely parallels the rally in the Treasury bond market often observed during financial crises. In some cases, the market price of the nondistressed risky asset (the stock market) may actually increase when the distress event occurs, although not by as much as the riskless asset. Intuitively, this is because the nondistressed risky asset becomes much safer relative to the distressed asset. Even in this situation, however, the premium for this asset increases significantly despite the fact that its cash flows are not affected by the distress event. Thus, there are major spillovers from the distressed asset market to the other financial markets.

The distressed asset, of course, suffers a large decline in value. Curiously, however, the decline is substantially smaller than the expected decline in the distressed asset's dividend. The reason for this is that the decrease in the riskless rate more than offsets the large increase in the distressed asset's risk premium, resulting in an overall decline in the discount rate applied to its cash flows.

The final stage occurs when the actual decline in the distressed asset's dividend is revealed. As the uncertainty is resolved, the riskless rate, the value of the stock market, and the size of the debt market return to levels similar to their original values. The recovery, however, may not complete since the distribution of wealth and the overall risk-sharing capacity of the market may be profoundly effected by the distress event. The price of the distressed asset increases or decreases depending on the actual realization of the dividend and on the increase in the discount rate resulting from the return of the interest rate to pre-crisis levels.

To summarize, These results suggest that the train wreck occurs in two stages. First, uncertainty about the eventual outcome results in a credit contraction on the part of leveraged players. Safe assets rally significantly while the distressed asset drops precipitously in value (but not by as much as the expected decline in its dividend). Surprisingly, the overall capitalization of the market can increase through the discount effect, depending of the relative sizes of the two risky assets in the market. In the second stage, the resolution of uncertainty and the return to pre-crisis levels can result in further declines in the value of the distressed asset. This is particularly true if the risk-sharing ability of the market has been impaired through changes in the distribution of wealth among agents from the event. A key consequence of the two-stage nature of the distress event is that the time variation in distress-related risk premia induces additional predictability into asset returns.

To explore these asset-pricing implications, we examine the behavior of financial markets during two recent distress events. The first is the current subprime crisis in which structured-credit instruments such as mortgage-related asset-backed collateralized debt obligations (CDOs) are severely distressed. Using market prices for the ABX indexes of subprime mortgage-related asset-backed CDOs, we examine the extent to which large shocks in their values are related to changes in market leverage as well as Treasury bond and stock values. Using a VAR framework, we find that downward shocks in the CDO indexes map into significant declines in the size of the roughly $2 trillion commercial paper market over the next several weeks. Similarly, we find that CDO returns have strong predictive power for subsequent Treasury bond and S&P 500 index returns. In particular, Treasury bond prices increase in response to negative shocks to ABS CDO values, consistent with the model. Both financial stocks and the general stock market react negatively to declines in ABS CDO values. Furthermore, ABS CDO declines forecast large increases in the trading activity of financial stocks. These results support the empirical implications of the model.

These results, however, also raise the puzzling issue as to why the ABX index returns have significant forecasting power for prices in the stock and Treasury bond markets three to four weeks ahead. Is it that the ABX CDO markets are more liquid than the stock and bond markets? This possibility seems unlikely. Rather, it seems more plausible that extremely bad news is being incorporated more rapidly into the prices of the distressed assets than into the prices of nondistressed assets; that the stock and

Treasury bond markets possibly experienced something akin to a “deer-in-headlights” phenomenon. Our findings suggest that the nature of the price discovery process in financial markets could be state dependent.

The second distress event we consider is the hedge-fund crisis of 1998 in which the Russian default of its internal debt triggered a global credit event that eventually resulted in the demise of Long Term Capital Management (LTCM) and a number of other highly-leveraged hedge funds. Given the enormous size of LTCM’s interest-rate swap portfolio, many feared that the collapse of LTCM could easily send shock waves throughout the financial sector, toppling major Wall Street firms like dominoes. Without the timely intervention by the Federal Reserve Bank of New York in brokering a rescue plan, financial history might have been very different. To examine the asset-pricing effects, we use interest-rate swap rate data from the distressed fixed-income derivatives market and again study its relation to changes in Treasury bond and stock market values. The VAR results again show that shocks to the distressed asset class lead to subsequent valuation effects in the bond and stock markets.

There is an extensive literature on distressed assets, although typically in a corporate-finance or asset-sale context. Important examples include Shleifer and Vishny (1992), Asquith, Gertner, and Scharfstein (1994), Opler and Titman (1994), Clark and Ofek (1994), John and Ofek (1995), Andrade and Kaplan (1998), Pulvino (1998), Kahl (2002), Brunnermeier and Pedersen (2005), and Pritsker (2005). Another extensive branch of the literature focuses on the role of contagion in financial markets. Recent examples include Allen and Gale (2000), Kyle and Xiong (2001), and Kodres and Pritsker (2002), Several recent papers focus on asset pricing with distressed assets. Important examples include Longstaff (2004), Vayanos (2004), Acharya and Pedersen (2005), Brunnermeier and Pedersen (2007), and Carlin, Lobo, and Viswanathan (2007). This paper differs in a number of ways from the previous literature by introducing distress events into a standard asset-pricing framework and examining the effects on agents’ portfolio decisions and equilibrium security prices. Furthermore, this paper conducts the first major empirical investigation into the asset-pricing effects stemming from the distressed subprime asset-backed CDO market and the 1998 LTCM/hedge-fund crisis.

The remainder of this paper is organized as follows. Section 2 presents the distressed asset model. Section 3 discusses the asset-pricing implications of the model. Section 4 presents empirical results for the case of the 2007 subprime credit crisis. Section 5 reports the empirical results for the case of the 1998 LTCM/hedge-fund crisis. Section 6 summarizes the results and makes concluding remarks.

2. THE DISTRESSED ASSET MODEL

The basic framework of the model is a simple extension of the two-agent model of Wang (1996) and Longstaff and Wang (2007). Specifically, we consider a pure exchange economy (Lucas (1978)) in which there is a single perishable consumption good that serves as the numeraire.

In this discrete-time framework, there are three types of investments that can be traded by agents each period. The first is a riskless one-period zero-coupon bond which pays one unit of the consumption good at maturity (agents can borrow from or lend to each other without default). As is standard, we assume that this riskless asset is in zero net supply in the economy. Let D_t denote the price of this asset and r_t the riskless interest rate.

The second asset can be thought of as a "stock" that pays a dividend flow of X_t of the consumption good. The value of X_t is stochastic and follows a discrete-time lognormal random walk,

$$\ln X_t = \ln X_{t-1} \ + \ \alpha \ + \ \sigma \ Z_t, \tag{1}$$

where α and σ are constants and Z_t is a standard normal random variate. The expected (log) growth rate of X_t is α; the volatility of the growth rate of X_t is σ. The total number of shares of this stock in the economy equals one. Let P_t be the price of the stock (ex dividend).

The third asset is also a "stock." Initially, this asset pays a dividend of $Y_t = pX_t$, where p is a constant. Thus, the third asset begins as just a scaled version of the second asset. To capture the notion of a distress event in the model, we assume that distress is triggered by a jump in an independent Poisson process. Let λ be the intensity of this Poisson process and denote the first time that a jump occurs as τ. When a distress event occurs at time τ, the dividend of this asset is then scaled by a constant factor q beginning with the dividend at time $\tau + 1$. Thus, subsequent dividends for this asset become $Y_t = pqX_t$. For simplicity, we assume that q is uniformly distributed on [0, 1], and that the realization of q is independent of anything else in the economy. The value of q is not known at time τ, but is revealed at time $\tau + 1$. The use of the uniform distribution captures the intuitive notion of a distress event in which agents have almost no prior about what the ultimate value of the asset will be; the decline in the asset's value could be anywhere between 0 and 100 percent.[1] We likewise assume that the total

[1]Alternative specifications for the distribution of q could also be used and would have little effect on the basic qualitative results of the model.

number of shares of this stock in the economy equals one. Let Q_t denote the price of this asset (ex dividend).

Agents in this economy can trade competitively in the securities markets and consume the proceeds. Let C_t denote an agent's consumption, V_t his holdings of the riskless asset, N_t his holdings of the second asset, and M_t his holdings of the third asset. An agent's wealth process W_t (defined by $W_t = V_t D_t + N_t P_t + M_t Q_t$) must be positive with probability one. At time t, an agent's consumption C_t equals the value of his portfolio chosen at time $t-1$ plus dividends, minus the value of the portfolio he chooses at time t,

$$\begin{aligned} C_t = V_{t-1} + N_{t-1}(P_t + X_t) + M_{t-1}(Q_t + Y_t) \\ - V_t D_t - N_t P_t - M_t Q_t, \end{aligned} \tag{2}$$

where $Y_t = pX_t - (1-q)pI_tX_t$, and I_t is an indicator than takes value one if $\tau \leq t-1$, and zero otherwise.

There are two classes of identical investors in the economy, denoted as 1 and 2. Both classes are initially endowed with only shares of the two types of stocks. The initial endowments of shares for the first class of agents are w and v, respectively. The initial endowments of shares for the second class of agents are $1-w$ and $1-v$, respectively. The initial number of shares optimally chosen by each class at time zero, of course, need not equal their initial endowments. Investors in each class choose their consumption and investment strategies to maximize their expected lifetime utility. The preferences of the two classes of agents are

$$E_t \left[\sum_{i=0}^{\infty} \beta^i \frac{C_{1,t+i}^{1-\gamma}}{1-\gamma} \right], \tag{3}$$

$$E_t \left[\sum_{i=0}^{\infty} \beta^i \frac{C_{2,t+i}^{1-2\gamma}}{1-2\gamma} \right], \tag{4}$$

respectively, and where γ is a positive constant. The terms $C_{1,t}$ and $C_{2,t}$ denote the aggregate consumption of the first and second classes of agents, respectively. Thus, the first and second classes of agents have constant relative risk aversion (CRRA) of γ and 2γ, respectively. In addition, we impose the following growth condition on the parameter values,

$$\ln \beta < \max\{0, (1-\gamma)(\alpha + \tfrac{1}{2}(1-\gamma)\sigma^2), (1-2\gamma)(\alpha + \tfrac{1}{2}(1-2\gamma)\sigma^2)\}. \tag{5}$$

This growth condition guarantees that investors' expected utilities are bounded given the aggregate consumption process implied by the dividend processes.

We have assumed that there are only two classes of investors in the economy and that they behave competitively in the market. Since investors within each class have the same isoelastic preferences, we can represent each class with a single representative investor who has the same preferences as the individual investors and the total endowment of each class (for example, see Rubinstein (1974)). In deriving the equilibrium, we can then treat the economy as populated with the two representative investors who behave competitively. In the remainder of the paper, we treat the two representative investors generically and simply refer to them as the more-risk-averse and less-risk-averse agents.

Market equilibrium in this economy consists of a set of price processes $\{D_t, P_t, Q_t\}$ and the consumption-trading strategies $\{C_{i,t}, (V_{i,t}, N_{i,t}, M_{i,t}),\ i = 1, 2\}$ such that the asset markets clear:

$$N_{1,t} \ + \ N_{2,t} = 1, \tag{6}$$

$$M_{1,t} \ + \ M_{2,t} = 1. \tag{7}$$

$$V_{1,t} \ + \ V_{2,t} = 0. \tag{8}$$

and that the agents' expected lifetime utilities are maximized subject to the positive wealth constraint and the consumption budget constraint in Equation (2).

3. ASSET-PRICING IMPLICATIONS

In this section, we illustrate the asset-pricing implications of the distressed asset model by solving for the equilibrium in a slightly simpler single-event setting in which the first agent has log utility.

3.1 The Single-Event Setting

As before, the two agents have an infinite horizon. At time zero, the agents are endowed with shares and make optimal consumption and portfolio decisions. In this setting, we assume that a distress event can only occur at time one. The probability that a distress event occurs at time one is λ. If there is no event at time one, then the agents make decisions on the basis that no future events will occur. If there is an event at time one, however, the agents make decisions in the face of extreme uncertainty about the ultimate value of the distressed asset. At time two, all uncertainty about the dividend of the second asset is resolved. Since no further distress event can occur after time one, the problem then reduces to a discrete-time version of the infinite-horizon Wang (1996) and Longstaff and Wang (2007) two-agent model, and we can use their closed-form solutions for asset prices to help solve the Euler equations for this model.

3.2 Solving for the Equilibrium

Given the discrete-time framework of the model and the continuum of possible realizations for the dividend processes, we cannot solve for the equilibrium using standard complete markets techniques (solving for the optimal consumption policy and then determining the trading strategy that generates that consumption). Rather, at each point of time, we need to solve for the optimal portfolio strategy that maximizes each agent's expected utility given the market prices of the assets, subject to the budget constraint.

For convenience, denote the first agent's consumption and portfolio choices as C_t, N_t, M_t, and V_t. After substituting in the market clearing conditions, solving the equilibrium at time t requires determining the values of C_t, N_t, M_t, V_t, P_t, Q_t, and D_t. Since there are two classes of agents and three assets, six Euler equations must be satisfied at each point in time. Furthermore, the present value of each agent's consumption stream must equal the value of his wealth at each point in time. These requirements provide us with the following seven equations from which we can solve for the equilibrium

$$P_t = E_t \left[\beta \left(\frac{C_t}{C_{t+1}} \right) (P_{t+1} + X_{t+1}) \right], \tag{9}$$

$$P_t = E_t \left[\beta \left(\frac{X_t + Y_t - C_t}{X_{t+1} + Y_{t+1} - C_{t+1}} \right)^2 (P_{t+1} + X_{t+1}) \right], \tag{10}$$

$$Q_t = E_t \left[\beta \left(\frac{C_t}{C_{t+1}} \right) (Q_{t+1} + Y_{t+1}) \right], \tag{11}$$

$$Q_t = E_t \left[\beta \left(\frac{X_t + Y_t - C_t}{X_{t+1} + Y_{t+1} - C_{t+1}} \right)^2 (Q_{t+1} + Y_{t+1}) \right], \tag{12}$$

$$D_t = E_t \left[\beta \left(\frac{C_t}{C_t} \right) \right], \tag{13}$$

$$D_t = E_t \left[\beta \left(\frac{X_t + Y_t - C_t}{X_{t+1} + Y_{t+1} - C_{t+1}} \right)^2 \right], \tag{14}$$

$$\theta(P_t + X_t) + \phi(Q_t + Y_t) + \xi = C_t \sum_{i=0}^{\infty} \beta^i = \frac{C_t}{1 - \beta}, \tag{15}$$

where θ, ϕ, and ξ denote the number of shares of the first, second, and riskless asset, respectively, with which the agent arrives at time t (either from his endowment or from his portfolio choice in the previous period).

The primary challenge in solving for the equilibrium is that the problem is both path dependent and backwards recursive. Specifically, the solution at time t is conditional on the portfolio choice made at time $t-1$ through the wealth constraint. However, solving the model at time $t-1$ requires evaluating the expectations in the Euler conditions over the distribution of consumption and asset prices at time t.

To tackle this difficult problem, we use a triple-nested solution approach. First, we solve the problem at time two for the entire grid of possible time-one portfolios. This is computationally feasible since we can use the closed-form solutions from Longstaff and Wang (2007) for consumption and asset prices at time two (rather than having to repeatedly solve the model at time three, time four, etc.).[2] Next, using this grid as a "look up" table, we step backwards and solve the problem at time one for the entire grid of possible time-zero portfolios. Finally, we solve the problem at time zero by using the look up table of time-one solutions. Thus, while numerically intensive, this approach has the advantage of being conceptually straightforward.

3.3 Model Calibration

Since our objective is to illustrate the asset-pricing implications of the model in the most intuitive way possible, we will use a simple yet realistic calibration for the model. First, we assume that the two classes of agents are endowed with equal amounts of the two risky assets at time zero. This assumption is consistent with Longstaff and Wang (2007) who show that it implies a size for the debt sector on the order of 20 percent of the aggregate value of all assets. They also show that this value agrees closely with the 19.3 percent ratio of aggregate household debt to aggregate household assets based on 2007 Federal Reserve Board Flow of Funds Accounts data.

We also assume that the expected growth rate α in dividends is 2 percent and that the volatility of dividend growth σ is 20 percent. These parameter values are very consistent with the empirical properties of dividends as imputed from corporate earnings reported by Longstaff and Piazzesi (2004). For example, the annualized volatility of dividends imputed from aggregate corporate profits (with inventory valuation and capital consumption allowances) is 23.08 percent for the 1946 to 2007 period based on National Income and Product Accounts (NIPA) provided by the Bureau of Economic Analysis. The subjective discount rate parameter is assumed to be $\beta = .96$.

[2]In using the Longstaff and Wang (2007) closed-form solutions, we note that at time two, the two risky assets can be treated as a single risky asset with a dividend of $X_t + Y_t$, since further jumps do not occur. Thus, the single-risky-asset solutions provided by Longstaff and Wang can be applied as approximations of the time-two value of the risky assets in numerically evaluating the Euler equations.

Consistent with Liu, Longstaff, and Pan (2003), Longstaff and Piazzesi (2004), and others, we assume that there is a one-percent chance that a distress event occurs at time one. In actuality, this value is probably on the conservative side since major distress events such as the current subprime crisis appear to happen with some frequency. This parameter, however, has only a minor effect on the results for time zero. Thus, we will adopt this more-conservative specification.

Finally, we specify the initial dividend for the distressed asset to be 10 percent as large as that for the stock (the market). This assumption is roughly consistent with the current relative sizes of the subprime mortgage market (estimated by industry sources to be currently on the order of \$1.5 trillion) and the total market capitalization of corporate equities and shares of mutual funds held by households (estimated to be about \$10.5 trillion at the end of 2007).[3]

3.4 The Results

To illustrate more clearly the asset-pricing effects as a distress event unfolds, we follow a specific sample path for the economy over time in which the dividend realization ends up having the same value each period, $X_0 = X_1 = X_2 = 1$. This scenario, of course, is just one of an infinite number of possible sample paths. Adopting this approach, however, has the important advantage of allowing us to identify the direct effects of a distress event while holding fixed the dividend levels. Table 1 reports the optimal consumption and portfolio choices of the two agents. Table 2 reports the equilibrium prices for the stock, distressed asset, and the riskless bond, as well as the risk premium for the stock and the distressed asset.

3.4.1 Pre-distress results

At time zero, the agents know that there is a chance that there will be a distress event at time one. As shown, each agent holds the same number of shares of the stock and the distressed asset. Since there are an equal number of shares of the two assets in the market, this means that each agent chooses to hold the market portfolio (consisting of the stock and the distressed asset), levered up or down. Thus, we obtain the usual one-fund separation result.

Consistent with the results in Longstaff and Wang (2007), the less-risk-averse agent levers his portfolio holdings by borrowing from the more-risk-averse agent. In terms of portfolio weights, the less-risk-averse agent invests 126.8 percent of his wealth in the stock, 12.6 percent in the distressed asset, and borrows an amount equal to −39.4

[3]The estimated size of the subprime mortgage market is from Reuters. The market value of corporate equities and shares of mutual funds held by households is from the Federal Reserve Board Flow of Funds Accounts, Release Z.1 for the third quarter of 2007.

percent of his wealth. In contrast, the more-risk-averse agent holds a portfolio consisting of 55.6 percent in the stock, 5.5 percent in the riskless asset, and lends 38.8 percent of his wealth.

The results also indicate that there is substantial leverage in the economy. Dividing the notional amount of debt by the aggregate valuation of the market implies a leverage ratio of 19.57 percent. This value compares well with current aggregate leverage ratios for U.S. households computed from Federal Reserve Flow of Funds data (see Longstaff and Wang (2007)).

Turning to asset prices, Table 2 shows that while the dividend for the distressed asset is 10 percent that of the stock, its market value is only 9.946 percent that of the stock. There are two reasons for this discount. First, there is a one-percent chance that the asset will become distressed. If this occurs, then the expected decline in the distressed asset's dividend is 50 percent. Thus, the time-zero price of the distressed asset reflects the potential loss. Second, the higher risk of the dividends from the distressed asset also maps into a slightly higher risk premium for the distressed asset. In particular, the expected return of the distressed asset is about one basis point higher than that of the stock.

3.4.2 Distress-event results

At time one, the market is now confronted with the realization that the dividend for the second risky asset will be reduced via an unknown factor q starting at time two. The expected value of q is 50 percent. Since q is uniformly distributed, however, the actual amount of the decline can be anything between 0 to 100 percent.

With the onset of distress at time one, the agents need to revisit their original portfolio decisions. Although the distressed asset is now much riskier than the stock while the market waits for q to be revealed, there is surprisingly little trade in either the stock or the distressed asset. In fact, the agents continue to hold the market portfolio and the number of shares of the stock and the distressed asset held by each agent is the same as before to four decimal places.

In contrast, the distress event has a significant effect on the size of the debt sector in the economy. In particular, the amount of debt in the market declines by roughly 7 percent, and the leverage ratio for the market declines from 19.6 percent to 16.8 percent. At the margin, a decline in the amount of credit in the financial markets of this magnitude would immediately be termed a major "credit crunch" or "liquidity squeeze" in the financial press.

These results illustrate several of the key empirical implications of the model. The arrival of a distress event triggers a significant credit contraction in the economy, but does not lead to a major flight to quality. In this context, a flight to quality would occur if one of the agents were to unwind some of his holdings of the now much-riskier distressed asset and increase his holdings of the relatively-safer riskless bond and stock market. In this example, the more-risk-averse agent chooses a portfolio in which the fraction of his wealth invested in risky assets actually increases. Thus, the results almost seem to imply perverse risk-sharing characteristics. Furthermore, both agents continue to hold the market portfolio; neither agent tilts his portfolio away from the distressed asset.

Why is there no flight to liquidity when the asset becomes distressed? Given the prominent role that the notion of a flight to quality plays in both the academic and practitioner literature, the absence of a flight to quality may seem counterintuitive at first. Intuitively, however, it is important to recognize that the notion of a flight to quality is inherently a partial equilibrium concept. At the level of a price-taking individual investor, it may be possible to sell risky assets and buy safer ones when a crisis occurs. What is true at the individual level, however, cannot be true at the market level. Even when an asset becomes distressed, the asset must still be held by someone. As shown by Cochrane, Longstaff, and Santa-Clara (2007), market-clearing logic requires that prices and expected returns must adjust so that agents collectively are willing to own all of the assets in the market. In our model, equilibrium market prices and risk premia change in a way that makes each agent willing to continue holding the two risky assets in the same proportion that they appear in the market. Thus, no flight to quality in the traditional sense occurs since both agents find it optimal to hold the market portfolio, consistent with classical equilibrium portfolio choice and risk-sharing theory.

Why do previous papers find that flights to quality may occur? The primary reason may be that most of these papers focus on the standard single risky asset economy in which there is only riskless debt and a stock. In this setting, the credit contraction we identify may be mistakenly termed a flight to quality. In reality, a flight to quality could only be observed in a market with multiple risky assets. By being one of the first papers to allow for both a significant debt sector and multiple risky assets, we are able to illustrate that a credit contraction is a fundamentally different phenomenon from a flight to quality. While our results are limited to the model we present, we conjecture that flights to quality would be difficult to support in any general equilibrium model in which prices adjust to allow for market clearing.

One major consequence of the credit contraction is that the market value of the safe riskless asset increases dramatically. Table 2 shows that the value of a riskless bond rallies by more than 6 percent when the distress event occurs. In this simple example, the riskless rate actually becomes negative as riskless bonds become scarcer in the market.[4] Intuitively, this reflects a tension between the two classes of agents. When the distress event occurs, the leveraged less-risk-averse agents need to strengthen

[4]This aspect of the model is consistent with the behavior of interest rates in the financial markets. For example, the yield to maturity on the current five-year inflation indexed

their balance sheet by reducing debt. In contrast, the unlevered more-risk-averse agents would prefer to hold more of their portfolio in the form of riskless bonds. In equilibrium, the decline in the borrowing costs for the leveraged agents induces them to supply more bonds to the market that they otherwise would. Despite the large decline in their cost of debt capital, however, the net effect on the market is a severe credit contraction.

The distress event also has a number of surprising effects on the prices of the risky assets. Given that the expected value of q is 50 percent, one might expect that the value of the distressed asset would decline by 50 percent (or even more if the associated risk premium increased). In actuality, however, the value of the distressed asset only declines by about 48 percent. Intuitively, the reason for this is twofold. First, there is in fact a large increase in the risk premium for the distressed asset at time one; the risk premium for the distressed asset increases by 329 basis points if a distress event occurs at time one. Secondly, however, the increase in the risk premium for the distressed asset is more than offset by the decline in the riskless rate by 586 basis points. The net effect is that the overall discount rate applied to the distressed asset's cash flows actually declines by about 257 basis points. Thus, the value of distressed asset only declines by about $50 - 2 = 48$ percent. This discount rate effect has the result of softening the initial impact of a distress event on the value of the distressed asset.

Finally, as with the riskless asset, the distress event also results in a substantial increase in the value of the risky stock. In fact, the increase in the value of the stock is actually slightly larger than the increase in the value of the riskless bond. Surprisingly, the overall effect on the price of the stock is so large that it actually results in an increase in the total valuation of the market. This is true even after taking into account the large decline in the value of the distressed asset. Specifically, the total value of the market is 32.46 at time zero, but increases by about 1.3 percent to 32.88 when the distress event occurs at time one. Thus, we get the seemingly paradoxical result that the demand for safe assets is so urgent during a distress event that the increase in their value exceeds the actual initial decline in the value of the compromised or distressed assets. We note, however, that this result depends on the relative size of the distressed asset to the nondistressed asset; for other parameter values, the total value of the market may in fact decline when distress occurs.

3.4.3 Post-distress results

At time two, the size of the dividend decline for the distressed asset is revealed, prices adjust, and things go back to normal. For the purposes of this example, we assume that the realized value of q equals its expected value of 50 percent.

Table 1 shows that the consumption and portfolio decisions of the agents at time two are essentially identical to those they made at time zero previous to the distress

---

TIPS bond is -0.04 (a negative yield to maturity of four basis points).

event. In particular, the agents continue to hold the market portfolio. With the resolution of uncertainty about the decline in the distressed asset's value, the credit crunch disappears, the size of the debt sector essentially returns to its previous level, and the leverage ratio for the economy actually attains a slightly higher value than before the distress event. Specifically, the less-risk-averse agent borrows 6.3005 from the more-risk-averse agent, implying a market leverage ratio of 20.3 percent. Furthermore, the portfolio weights for the less-risk-averse agent show that he takes a slightly more leveraged position in the risky asset than before. Intuitively, this latter behavior makes sense since we are focusing on a single-event case in this section. Thus, after the distress event at time one, the agents know that future distress events will not occur and can take slightly more aggressive investment position. In a more general multi-event setting, the agents behavior at time two would likely more closely resemble their behavior at time zero.

The resolution of uncertainty also affects the values of the assets. The distress premium disappears, and the price of the stock and the riskless bond return to their pre-distress levels. From the perspective of the agents, however, the end of the crisis results in a substantial negative return in the value of these "safe assets;" the liquidity premium tends to be very ephemeral.

The results also show that even though the realized value of q equals its expected value, there is also a substantial additional decline in the value of the distressed asset by about 2.6 percent. The rationale for this second decline is that the return of the riskless rate to its pre-distress levels results in a higher discount rate for the distressed asset. This is true even though the risk premium for the distressed asset also declines and now equals that of the stock; the increase in the riskless rate is larger than the decline in the risk premium for the distressed asset.

3.5 Discussion

Admittedly, the results presented in this section are based on a simply-calibrated stylized model of asset distress. Despite this, however, we believe that these results provide a number of key economic insights about markets with distressed assets and illustrate asset-pricing effects that would be present in more general economic setting.

Specifically, the results suggest that a major distress event might be associated with the following types of market effects:

- A contraction in the size of the debt sector.
- A decline in the riskless interest rate.
- An increase in the value of risky nondistressed assets.
- Predictability in the returns of assets through time-varying distress-related risk

premia.

The contraction in the debt sector arises through the actions of leveraged agents who now recognize that they are exposed to the risk of further catastrophic declines in the value of the distressed asset. This deleveraging is consistent the results in Longstaff (2001), Liu, Longstaff, and Pan (2003), and others who find that agents endogenously choose to curtail their leverage in the face of event risk or the risk of large downward jumps in asset prices.

As the size of the credit market contracts, the model also implies a significant increase in the value of riskless bonds, producing a decline in the riskless interest rate. Thus, this implication of the model is directly testable using Treasury bond yields.

The model also implies that the value of risky assets with cash flows that are not affected by the distress event could also increase. The intuition for this effect stems from the decline in the discount rate applied the asset's cash flows; although the risk premium for the asset increases, the model suggests that this increase may be more than offset by the decline in the riskless rate.

Finally, as the distress event unfolds, the risk premia for assets first increase, but then decrease as the cash-flow uncertainty is resolved. Thus, the risk premia display a pattern akin to mean reversion. In turn, the time variation in risk premia can induce predictability in asset returns. Again, this implication of the model is directly testable.

To summarize, these results suggest that financial train wrecks may occur in two stages. The first stage is characterized by a credit crunch as the size of the debt sector contracts, and large asset valuation effects. In the second stage, uncertainty about the true value of the distressed asset is resolved and asset valuations return to pre-distress levels. Thus, the end of the distress event may be associated with a sharp decline in the value of the non-distressed asset as the temporary liquidity premium applied to these assets during the crisis disappears. Even if the realized decline in the distressed asset's cash flows equals the market expectations, the value of the distressed asset can fall even further as the discount rate effect is reversed. Thus, from an investor's perspective, the end of a crisis is not necessarily good news; the end of the crisis may be when "the other shoe drops."

Almost by definition, distress events are (hopefully) infrequent occurrences in financial markets. As a result, sample sizes are likely to be too small to allow formal empirical tests of the model. On the other hand, it would be useful to have some evidence about whether these empirical implications map into real world events. In this spirit, our approach will be to focus on several case studies for which data are available and examine whether the empirical implications of the model summarized above receive support from the data.

4. THE SUBPRIME ASSET-BACKED CDO CRISIS

As the first case study, we consider the current subprime mortgage crisis and its effects on the financial markets. In doing this, we begin with a brief review of the asset-backed securities (ABS) CDO market. To measure the effects of the crisis on the market values of distressed mortgage-related ABS CDOs, we use an extensive data set for the ABX indexes of CDO prices covering the 2006-2007 period. We then examine the relation between events in the stock, debt, and distressed asset-backed CDO markets.

4.1 The ABS CDO Market and the ABX Index.

In the current crisis, tranches or CDOs based on the cash flows of portfolios of subprime home-equity loans are the primary distressed asset class in the market. These subprime CDOs were aggressively sold to investors during the past several years and were widely viewed as one of the most important financial innovations of the past decade. According to the Securities Industry and Financial Markets Association, the total U.S. issuance of asset-backed securities (ABS) during the 2005-2007 period was $3.289 trillion, and the total U.S. issuance of CDOs during the same period was $965 billion. Because news about the subprime crisis appears daily in the financial press, we avoid telling a twice-told tale by simply providing in Table 3 a chronology of the major crisis events during 2007. This chronology is taken from an extensive timeline reported by Reuters.

4.1.1 Asset-Backed CDOs

Asset-backed tranches or CDOs share many features in common with CDOs for corporate bonds. As described in Longstaff and Rajan (2008), a CDO is created by an issuer first forming a portfolio of loans, either by lending money directly, or by buying debt securities in the marketplace.[5] In the ABS market, these loans could consist of first mortgages, second mortgages, loans on manufactured homes, credit card receivables, auto loans, student loans, and even account receivables.[6] Once the portfolio is formed, the CDO issuer sells tranches based on the cash flows scheduled to be generated by the underlying loans. Typically, the tranches vary in terms of their subordination. For example, the equity or residual tranche receives a high coupon on its principal amount, but is first in line to absorb any credit losses suffered by the underlying portfolio. On the other hand, a supersenior tranche might only receive a coupon of Libor plus 20 basis points, but would not suffer any credit losses until after the total credit losses for the portfolio exceeded 15 percent.

[5]Alternatively, a synthetic CDO could be constructed through the use of credit default swaps.

[6]For an excellent review of the ABS market, see Rajan, McDermott, and Roy (2007).

In effect, a ABS CDO structure could be viewed as a synthetic lender where the assets consist of, say, subprime home equity loans and where the capital structure consists of equity, subordinated debt, and senior debt (all often in the form of floating-rate notes). From a CDO issuer's perspective, the advantages of issuing CDOs is that it allows the issuer to make loans, repackage them, and then sell them to third parties, thereby allowing the issuer to earn fees from originating and then servicing the loans without having to commit their capital permanently. Of course, this mechanism creates a number of moral hazard risks since the issuer is aware that he will not suffer the credit losses on the loans he makes since they will be sold as repackaged CDOs.

To provide an illustration of a typical subprime ABS CDO, Table 4 gives the details of a \$900 million CDO sponsored by Countrywide Home Loans, Inc. and issued through Lehman Brothers in February 2006. The issuing entity is designed as CWABS Asset-Backed Certificates Trust 2006-1. Of the total notional amount underlying the CDO, about \$500 million is based on subprime fixed-rate mortgages, while \$400 million is based on subprime floating-rate mortgages. On the fixed-rate side, the CDO consists of 12 separate tranches. The first six are equal in seniority but differ in terms of their coupon rates and collateral. The other six tranches are subordinated sequentially, with the MF-6 tranche absorbing the first \$5.525 million in losses, the MF-5 tranche absorbing the next \$6.188 million in losses, etc. A similar structure applies on the floating-rate side of the portfolio with the MV-7 tranche absorbing the first \$5.549 million of losses, the MV-6 tranche absorbing the next \$5.907 million of losses, etc. The average FICO score for the fixed-rate and floating-rate loans is 611 and 618, respectively, placing these loans squarely in the subprime category. Interestingly, while some of the underlying mortgages bear low "teaser" rates, many carry very high mortgage rates; the mortgage rates for the loans in the underlying portfolio vary from 4.95 to 12.00 percent. Given the different positions of the tranches in the capital structure "pecking order," it is not surprising that the tranches can have different credit ratings. Table 4 shows that the initial credit ratings for the tranches offered range from Aaa/AAA to Baa1/A.

Since each of these CDO tranches can be viewed as either a fixed-rate bond or a floating-rate note, the prices of these securities are generally quoted per \$100 notional. To illustrate, the MF-1 tranche in the CWABS 2006-1 example has a Bloomberg quoted price of 65.00 on December 4, 2007. Thus, an investor who acquired this tranche at the issue price of 99.99814 on February 8, 2006 would have mark-to-market loss of nearly 35 percent. Given that this tranche initially had a credit rating of AA1/AA+, the subsequent large decline in the value of the tranche argues that the initial credit rating may have been overly optimistic.

From the perspective of the ABS CDO markets, there are several key events or threads that underlie the current distressed state of the market. First, the unexpected wave of subprime defaults and declines in housing values has created severe uncertainty about what the ultimate magnitude of credit losses will be. Second, given the inherent complexity of the underlying loan portfolios on which asset-backed CDOs are based (as evidenced from the Countrywide example in Table 4), many participants in the financial markets appear to have placed a high degree of reliance on the credit ratings provided by the ratings agencies in making investment and pricing decisions. When the rating agencies began to backtrack from their previous optimistic ratings in mid-2007 and the liquidity in secondary CDO markets dried up, many investors were left completely in the dark as to what their asset-backed CDO positions were actually worth. In this sense, the assumption that the decline in the value of a distressed security is uniformly distributed between zero and 100 percent could actually be a realistic one in the context of this crisis.

4.1.2 The ABX Index.

To measure the valuation effects on distressed subprime CDOs as the credit crisis unfolds, we use market quotations for the widely-known ABX indexes maintained by Markit Group Ltd. These indexes consist of daily closing values obtained from market dealers for subprime home-equity-related CDOs of various credit ratings.[7] In particular, the ABX indexes consist of five separate indexes, where each of these indexes is based on the market quotations of a specific basket of distinct subprime CDOs.

The AAA index is based on a portfolio of 20 subprime home-equity CDOs with initial credit ratings of AAA. The AA index is based on a portfolio of 20 subprime home-equity CDOs with initial credit ratings of AA. Similarly, the other three indexes are based on portfolios of subprime home-equity CDOs with credit ratings of A, BBB, and BBB−, respectively. Each index is a simple average of the prices for the 20 CDOs or tranches in the basket, where prices are quoted relative to a $100 notional position.

The 20 subprime deals that appear in each basket are chosen from among the qualifying deals of the largest subprime home equity asset-backed security (ABS) shelf programs during the six-month period preceeding the formation of the indexes. The algorithm for choosing the 20 subprime CDOs to be included in each index limits the same loan originator to four deals and the same master servicer to six deals. The minimum deal size is $500 million. Each CDO (tranche) must have a weighted average life between four to six years as of the issuance date (except the AAA tranche which must be greater than five years). The tranches must be rated by Moody's and Standard and Poors; the lesser of the ratings applies. At least 90 percent of a deal's assets must be first lien mortgages, and the weighted average FICO credit score for loans underlying the tranche must be less than 620. Deals must pay on the 25th of each month and referenced tranches must bear interest at a floating-rate benchmark of one-month Libor. The five

[7]Market makers for the ABX indexes include Bank of America, BNP Paribas, Deutsche Bank, Lehman Brothers, Morgan Stanley, Barclays Capital, Citigroup, Goldman Sachs, RBS Greenwich Capital, UBS, Bear Stearns, Credit Suisse, JP Morgan, Merrill Lynch, and Wachovia.

ABX indexes are reconstituted every six months. The first series of ABX indexes were formed in January 2006 and are designated the ABX.HE 1 AAA, AA, A, BBB, and BBB− indexes. The second series of ABX indexes were formed in July 2006 and are designated the ABX.HE 2 AAA, AA, A, BBB, and BBB− indexes. Similarly for the ABX.HE 3 and ABX.HE 4 indexes which were formed in January 2007 and July 2007, respectively.

Market quotations for the ABX indexes can be difficult to obtain. Fortunately, we were given access to a proprietary data set by a major fixed income asset management firm that includes daily closing values for all of the ABX.HE 1, 2, 3, and 4 indexes for the two-year period from the inception of the ABX index in January 19, 2006 to December 26, 2007. Table 5 presents summary statistics for the ABX indexes. Figure 1 plots the time series of ABX.HE 1 AAA, AA, A, BBB, and BBB− indexes during the sample period.

Table 5 and Figure 1 illustrate the wide variation in the market valuations of subprime ABS tranches during the sample period. At the beginning of 2006, the market values of the tranches ranged from 99.18 to 100.28. There is only minor variation in these prices until the beginning of 2007. By the end of February 2007, the BBB− index had declined to about 80. This coincides with the February 2007 evidence of subprime losses and profit warnings by subprime lenders (see the chronology in Table 3). After February, the indexes recovered partially. By mid 2007, however, the indexes began to decline precipitously. Similar patterns are observed for the ABX.HE 2, 3, and 4 indexes.

4.2 Empirical Analysis.

Although the subprime mortgage crisis is far from being fully resolved, it merits attention as an almost "perfect storm" example of the type of distress event considered in this paper. As the crisis unfolded during 2007, market participants began to realize that the actual cash flows from their holdings of ABS CDOs might ultimately be far less than they had anticipated given the high credit ratings these securities initially carried. Currently, there is substantial uncertainty about what the ultimate outcome will be. The current situation clearly parallels the first train wreck stage of the model in which an entire asset class becomes distressed.

In exploring the empirical implications of the model, our approach will be to use a vector autoregression (VAR) framework to study the relations between distressed ABS CDO returns, Treasury bond returns, stock market returns, changes in commercial paper funding patterns, and changes in stock-market trading patterns. An important advantage of this VAR framework is its ability to identify empirical relations while avoiding endogeneity problems among variables.

4.2.1 The variables

To capture valuation effects in the distressed ABS CDO market, we use the returns on the ABX indexes (formed from the on-the-run series, e.g. rolling the series from ABX-HE 1 to ABX-HE 2 when the latter index is constructed, etc.). Specifically, we use the weekly (Wednesday to Wednesday) returns for the corresponding on-the-run ABX index. Altogether, we have five such on-the-run series of returns, each representing a different credit rating, which we designate ABX_{AAA}, ABX_{AA}, ABX_{A}, ABX_{BBB}, and ABX_{BBB-}.

As measures of the valuation effects on the riskless asset, we use weekly changes (over the same period as for the ABX returns) in the constant maturity one-year and ten-year Treasury yields (obtained from the Federal Reserve Board's website). Yields are measured in percentage terms. Thus, a one-basis point yield change from, say, 4.50 to 4.51 equals 0.01.

Ideally, we would like to have return data for a risky asset class with cash flows unaffected by the subprime credit crisis. In reality, of course, it is very difficult to identify such an asset class. As an approximation, however, we construct a simple proxy from S&P 500 index returns. Specifically, we collect weekly return data for both the S&P 500 index and the S&P 500 subindex of financial firms (dividends omitted from both return series). This subindex currently consists of 92 commercial and investment banks, insurance companies, home lenders, government sponsored entities such as Fannie Mae and Freddie Mac, and monoline bond insurers such as AMBAC. The S&P 500 subindex of financial firms can be viewed as a broader measure of "moderately distressed" assets since many of these firms have exposure to the subprime market through their portfolio holdings. As a proxy for the returns on risky nondistressed assets in the economy, we regress the returns on the S&P 500 on the returns for the S&P 500 subindex of financial firms and use the residuals from this regression. These residuals then have an interpretation as the portion of the S&P 500 index returns that are orthogonal to the returns on the financial sector. The data for the S&P 500 indexes are obtained from the Bloomberg system.

In general, measuring changes in the aggregate size of the credit sector over a short period such as a week is challenging. This is particularly true given that most lending is done for much longer horizons than the simple single-period loans representing the riskless asset in the distressed asset model. In the current subprime crisis, however, considerable attention has focused on the commercial paper market. Over the past decade, this market has grown to a notional size on the order of $2 trillion and has become a major source of short-term funding for financial institutions, investors, and corporations. Given that the median maturity of commercial paper is on the order of 30 days, percentage changes in the size of this market may provide a useful proxy for discretionary changes in the amount of short-term credit provided in the financial markets. We obtain weekly (Wednesday) data on the size of the commercial paper market from the Federal Reserve Board's website.

Finally, to explore whether the distress event is associated with flight-to-quality behavior in the market, we compute the ratio of the aggregate weekly trading volume for the firms in the S&P 500 subindex of financial firms to the aggregate weekly trading volume for all firms in the S&P 500 index. In computing this ratio for week i, we use the volume data for the week immediately before and including the Wednesday of week i. The rationale for considering this variable is that if agents only trade the market (as the theory suggests), then no segment of the market should be traded more than any other. Thus, this ratio should remain constant during a crisis. On the other hand, finding that the stocks in the S&P 500 subindex of financial firms are traded more intensively than the remaining S&P 500 firms during the crisis would provide evidence consistent with a flight to quality in the financial markets.

4.2.2 Predictability of ABS CDO returns

As a preliminary analysis, we first examine the predictability of ABS CDO returns. In doing this, however, it is important to stress that since we chose this market and time period to study precisely because of the negative shocks it has experienced, the risk of introducing a "look back" bias limits our ability to draw any definitive conclusions from this analysis. Thus, these results should be viewed simply as providing some background for the results in later sections (which are not subject to "look back" bias).

To explore the time series properties of ABS CDO returns, we estimate the following VAR system,

$$ABX_t = \gamma_0 + \sum_{i=1}^{4} \gamma_i' \, ABX_{t-i} + \epsilon_t, \tag{16}$$

where ABX_t is the vector of the ABX indexes. Table 6 reports the estimation results. The results show that there is a strikingly high level of predictability in the returns of ABS CDOs. Using only ex ante data from the previous four weeks, the VAR results show that ex post ABS CDO returns can be forecast with adjusted R^2s ranging from 46 to nearly 87 percent. Interestingly, the returns for the highest rated CDOs are the most predictable; the adjusted R^2s for the CDO returns increase almost monotonically with the credit rating of the CDOs. The reported t-statistics indicate that the lagged returns from the AAA and BBB tranches are most often significant in forecasting tranche returns, although lags from all tranches are frequently significant.

There are a number of potential interpretations for these results. First and foremost, these high levels of predictability may simply be due to look back bias in the sample period we have chosen to study. This important caveat aside, however, it could also the case that the results are consistent with the empirical implications of the model that distress events are associated with asset return predictability. On the other hand, these results are also consistent with the hypothesis of illiquid pricing in the ABS CDO market, requiring multiple weeks for changes in prices to be fully reflected in ABX index values. The question of whether the time series properties of distressed asset returns is due to time varying risk premia or to illiquidity is very relevant given the recently announced investigations by the Federal Bureau of Investigation, the Securities and Exchange Commission and the U.S. Attorney in New York. These agencies have opened criminal inquiries into whether a dozen or more major financial firms including UBS and Merrill Lynch deliberated failed to mark their CDOs to market as their prices continued to decline.[8]

4.2.3 Effects on asset prices and markets

One of the key implications of the model is that a distress event can induce predictability into the returns of all assets via time-varying risk premia. To explore this, along with the other empirical implications of the model, we estimate the following VAR system,

$$Y_t = \gamma_0 + \sum_{i=1}^{4} \gamma_{1i} ABX_{t-i} + \sum_{i=1}^{4} \lambda_i' \; Y_{t-i} + \epsilon_t, \tag{17}$$

where Y_t is the vector of changes in the one-year and ten-year Treasury yields, the returns on the S&P 500 index (orthogonalized) and subindex of financial firms, percentage changes in the amount of commercial paper outstanding, and the ratio of financial to market stock trading volume. The parameters γ_0 and γ_i are constants and λ_i is a parameter vector. The four-week lag structure is suggested by the typical 30-day maturity of the commercial paper market and is also consistent with the Akaike AIC criterion. Note that we estimate this system five different times, each time using a different ABX index. Since our focus in on the effects of the distress event (as proxied by shocks to the ABX index), Table 7 reports just the t-statistics for the lagged ABX returns.

The asset that is probably mostly easily mapped into the role of the riskless asset in the distressed asset model is the one-year Treasury bond. Admittedly, however, this mapping is far from perfect. Despite this, the VAR results for the Treasury bonds are interesting in their own right. Table 7 shows that the lagged ABX returns are highly significant in predicting changes in the one-year Treasury yield; the second or third lag for the ABX returns is significant for each of the five indexes. The signs of the significant coefficients are uniformly positive, indicating that a negative shock in the value of any of the ABX indexes maps into a lower one-year Treasury yield and, therefore, an increase in the value of the bond. These results are very consistent with the empirical implications of the distressed asset model in which distress leads to a credit-contraction rally in the riskless asset.

[8]See Scannell, Raghavan, and Efrati (2008).

The ten-year Treasury bond could perhaps also be given the interpretation of a riskless asset. Alternatively, it could be viewed as an example of a "risky" asset (ten-year bond returns are random after all) which might not be subject to distress events of the type that affects the ABS market. Either way, the distressed asset model suggests that the value of the ten-year bond should increase with the onset of distress. The VAR parameter estimates are definitely supportive of this interpretation. The second lagged ABX return is significant for the AAA index, and the third lagged ABX return is significant for the other four indexes. Again, the sign of the significant coefficients are all positive, consistent with the credit contraction implication. Interestingly, the magnitude of the coefficients for the ten-year Treasury bonds is roughly the same as that for the one-year Treasury bonds. Recall, however, that the duration and, therefore, the price effect on the value of a ten-year bond is many times that for the one-year bonds. Thus, these results imply large increases in the value of ten-year Treasury bonds stemming from declines in the value of ABS CDOs.

Turning to the stock market results, Table 7 shows that the lagged ABX returns have significant forecasting ability for the S&P 500 financial subindex. In particular, the third lag of the ABX index return is significant at the five-percent level for the AA, A, and BBB− indexes. The sign of the coefficient for each of the significant lagged ABX returns is positive as would be expected. In particular, negative returns for the ABX index forecast negative returns for financial firms.

The results for the orthogonalized S&P 500 index provide some mixed support for the empirical implication of the distressed asset model. For four out of five of the ABX indexes, the coefficient for the first lagged ABX return is negative in sign, consistent with the value of the stock market increasing when there is a downward shock in the value of the ABX index. On the other hand, only the coefficient for the BBB index is significant. Furthermore, two of the coefficients for the second lagged ABX return are positive and significant. The third and fourth lagged ABX returns are split between positive and negative values, but are all statistically insignificant. In interpreting these results, however, it is important to keep in mind that the mapping of the stock in the model to the orthogonalized S&P 500 index may not be perfect. In particular, the stock in the distressed asset model is, by assumption, not susceptible to distress events. In reality, however, there is no such guarantee that even after removing the financial sector component, the stock market may not also experience spillover valuation effects as a result of the growing subprime crisis.

Returning to the return predictability implication of the model, Table 7 shows that both the Treasury bond and stock market returns display a high level of predictability. The adjusted R^2s for the one-year Treasury bond return regressions range from about 35 to 48 percent, while the adjusted R^2s for the ten-year Treasury bond return regressions range from about 20 to 28 percent. These adjusted R^2s are very large and compare favorably to those for the forward rate forecasting models presented in Cochrane and

Piazzesi (2005).

The VAR results show that the stock market returns are likewise highly predictable on the basis of ex ante data. In fact, the S&P 500 financial subindex displays a stunning amount of predictability, with adjusted R^2s ranging from 35 to 50 percent. These values far exceed most of the stock market predictability results previously documented in the literature.[9] The adjusted R^2s for the orthogonalized S&P 500 index returns are not as high, but are still very economically significant, with values ranging from about 15 to 24 percent.

Taken together, this evidence of predictability provides strong support for the implications of the distressed asset model; returns appear to have become highly predictable during the subprime crisis. These results also shed light on the earlier discussion about the source of the predictability in ABX index returns. Our evidence that lagged ABX index returns contain significant information about future stock and bond market returns argues strongly that the predictability stems from time varying risk premia as implied by the model. In contrast, if the time series properties of ABX index returns were due to illiquid pricing instead, lagged values of the ABX index would not contain information useful in forecasting bond and stock returns. These result clearly having implications for the current criminal investigations into the rate at which CDO prices were marked to market by Wall Street firms during the initial stages of the subprime crisis in 2007.

Turning next to the credit-market implications, the VAR results show that the shocks to the lower-rated ABX indexes translate into shocks in the size of the commercial paper market. In particular, the coefficients for the third ABX lags are significant when the BBB, and BBB$-$ indexes are included in the specification. The signs of these coefficients are positive, indicating that a decline in the value of the ABX index is associated with a decline in the size of the commercial paper market. Similar results hold for the second lagged value of the AAA ABX index return. None of the significant coefficients for the any of the lagged ABX returns are negative in sign. Thus, these results provide clear support for the credit contraction implications of the distressed asset model.

The VAR results indicate that ABX index returns have significant forecast ability for the trading volume ratio. In particular, the third lagged ABX return is negative and significant for each of the five ABX indexes. This implies that a downward shock in the value of the ABX indexes maps into a significant increase in the trading volume of financial firms relative to nonfinancial firms in the S&P 500 index. These results suggest that investors did not simply trade the market as the subprime distress event unfolded, but concentrated their trading in the financial sector. Thus, while these results do not

[9] As examples of the recent market predictability literature, see Lettau and Ludvigson (2001) and Cochrane (2006),

directly support the one-fund-separation feature of the model, they at least provide some evidence consistent with flight-to-quality trading in the financial markets.

4.2.4 Does Predictability Change when Distress Occurs?

The results presented so far in this section are all based on the full two-year sample which includes both the pre-distress and distress periods. One important question is whether the predictive relations differ in the distress period from those in the pre-distress period.

Ideally, we would like to have a sufficiently long time series of observations to allow the VAR to be estimated separately for these two period. Realistically, however, this is not feasible given the length of the sample period. As an alternative, we modify the VAR specification reported in Table 7 by adding a dummy slope for the lagged ABX return coefficients for the distressed period. Specifically, we estimate the VAR specification

$$Y_t = \gamma_0 + \sum_{i=1}^{4} (\gamma_{1i} + \gamma_{2i} I_t) ABX_{t-i} + \sum_{i=1}^{4} \lambda_i' \, Y_{t-i} + \epsilon_t, \tag{18}$$

where I_t is an indicator that takes value zero for 2006 (pre-distress period) and value one for 2007. Thus, we allow the lagged ABX returns to have a different slope during the second half of the sample period. Table 8 reports the t-statistics for the γ_{2i} coefficients for this expanded VAR specification.

As shown, the results are similar in many ways to those reported earlier. The incremental changes in the slope for the lagged ABX coefficients have values and signs that parallel those in Table 7. In particular, the lagged ABX returns during 2007 are significantly more predictive of both the one-year and the ten-year Treasury yield changes. Typically, the most significant value is again the third or fourth value. Similarly, the AAA, AA, and A ABX indexes have significant incremental predictive power for the S&P subindex of financial firms during 2007, while the AA, A, BBB, and BBB− ABX indexes has significant incremental predictive power for the orthogonalized S&P 500 index returns. The results for the commercial paper market are not as strong as in the Table 7; only the AAA and AA ABX indexes have incremental predictive ability for changes in the size of the commercial paper market during 2007 (at the ten-percent level). The results for forecasting relative trading activity for financial firms are very similar to those reported earlier.

Finally, we examine whether the serial correlation of the ABX returns, Treasury bond yield changes, and stock market returns differ significantly during the first and second parts of the sample period. Although not shown, we find that the serial correlations of weekly changes for one-year and ten-year Treasury bond yields are almost the same during the two halves of the sample period. The same holds for the S&P 500. In contrast, the AA, A, BBB, and BBB− ABX indexes display much more serial correlation during 2007 than during 2006. The same is true for the S&P subindex of financial firms.

4.2.5 Summary

In summary, these results uniformly suggest that shocks to ABX index values contain information useful in predicting returns, changes in the size of the debt sector, and changes in stock market trading patterns. In many cases, ABX index returns have significant forecast ability for as far as three weeks ahead. Furthermore, the ability of ABX index returns to forecast stock and bond price movements is significantly higher during the latter part of the sample period in which the subprime crisis occurs.

Strictly speaking, of course, the model implies that these market effects should all be contemporaneous. Thus, these results raise the interesting question of why ABX returns are able to forecast stock and bond market price changes so far ahead. As described earlier, part of the explanation may lie with time-varying risk premia. Alternatively, however, it could also be argued that these results are compatible with a "deer-in-headlights" reaction on the part of the market to extremely bad news.

5. THE LTCM/HEDGE-FUND CRISIS

As a second case study, we revisit the LTCM/hedge-fund crisis of 1998. We first provide a brief summary of the major events of the crisis. We then use fixed-income derivatives data as a proxy for the distressed asset class and examine the relation between these prices and the equity and Treasury markets.

5.1 A Brief History of the Crisis

There are many in-depth reviews and discussions of the LTCM/hedge-fund crisis in both the financial press and the academic literature. Examples include Perold (1999), Lowenstein (2000), Dunbar (2000), and Duarte, Longstaff, and Yu (2007).

Briefly, the LTCM crisis appears to have been triggered by a confluence of events beginning with the unexpected Russian default on its internal debt (see Duffie, Pedersen, and Singleton (2003)) in August, 1998. The shock resulted in a dramatic widening of credit spreads throughout the global fixed-income markets. At that time, LTCM (Long Term Capital Management) was one of the largest hedge funds in the world with roughly $5 billion of capital. More significantly, LTCM had extremely high levels of both on- and off-balance-sheet leverage, primarily through interest-rate swap positions. When swap spreads increased suddenly in August 1998, the value of LTCM's holdings quickly fell by as much as 70 percent. Each Wall Street firm with swap counterparty exposure to LTCM became immediately concerned about LTCM's ability to meet margin calls.

What led to the distress event, however, is that these Wall Street firms suddenly realized that not only did they individually have massive counterparty exposure to LTCM, but that LTCM had massive counterparty exposure to virtually *every* major Wall Street firm. Apparently, many swap dealers had believed that they were LTCM's "prime" broker and hadn't realized that the other firms on Wall Street each had the same belief. Thus, there was a serious coordination failure on Wall Street as each major investment banking firm provided credit to LTCM on generous terms. When the extent of LTCM's swap positions and counterparty risk began to come to light, serious concerns about the viability of the entire multi-trillion dollar interest-rate swap and fixed-income derivatives market began to emerge. Thus, the uncertainty about the actual counterparty exposure of LTCM became the source of the distress event for interest-rate swaps market. The problem was heightened by LTCM's legendary reputation for being extremely secretive about their trading strategies.

As concerns about the collapse of the swaps and interest-rate derivatives market grew, the entire interest-rate swap market essentially became a distressed asset. Swap spreads and interest-rate option volatilities increased rapidly, possibly because investors demanded a higher credit premium for systemic contagion risk, possibly because swap counterparty default risk increased, or some combination of both (and perhaps other) factors.

To complete the story, in late September, the New York Federal Reserve Bank orchestrated a takeover of LTCM by a broad consortium of 17 Wall Street investment banks. Although the management and original investors of LTCM lost most of their investment, the capital provided by the consortium enabled LTCM to avoid actual default on their interest-rate contractual agreements. Over the course of the subsequent year, the consortium was able to unwind most of LTCM's swap positions in a relatively orderly manner, thereby avoiding the feared collapse of the fixed-income derivatives markets.

5.2 Empirical Analysis

Paralleling the analysis for the subprime crisis, we again examine the interrelations between the distressed fixed-income derivatives market, the Treasury bond market, and the stock market using a VAR framework (debt sector and trading volume data are not available for this time period).

To proxy for the valuation effects of distress during the crisis, we use a measure from the fixed-income derivatives market. Specifically, we use weekly changes (Friday to Friday) in the slope of the swap spread curve, defined as the difference between the ten-year and two-year constant maturity swap rates. The slope of the swap spread curve measures the extra credit/liquidity premium the market requires for extending swap maturities. Thus, an increase in the slope should reflect the distress premium in the swap market during the crisis.[10] The swap rate data are obtained from Citigroup and the Bloomberg system. The Treasury constant maturity data are again obtained from the Federal Reserve Board's website. The other variables in the analysis are obtained from the same sources and calculated in the same manner as described in the previous section (using Friday to Friday changes instead). To capture the distress event and the subsequent unwinding of LTCM's swap positions, we use the January 1, 1997 to December 31, 1998 sample period. Table 8 reports the results from the estimation of the following VAR system,

$$Y_t = \gamma_0 + \sum_{i=1}^{4} \gamma_{1i} \text{ Slope}_{t-i} + \sum_{i=1}^{4} \lambda_i' \, Y_{t-i} + \epsilon_t, \tag{19}$$

where Y_t is now the vector of the one-year and ten-year Treasury bond yield changes and the returns on the S&P 500 subindex of financial firms and on the (orthogonalized) S&P 500.

Despite the fundamental differences between the two distress events, there are some clear similarities in the VAR results. In particular, the second lagged value of the slope of the swap spread curve is significantly negative for changes in both the one-year and ten-year Treasury yields, providing evidence that Treasury bonds increase in value in response to the event. We note, however, that the fourth lag is also significant for the one-year Treasury yield but is positive in sign. Thus, the sign of the effects are not as clearcut as in the subprime case earlier. The results also suggest that there are some weak effects for the stock returns. In particular, the first lagged change in the slope of the swap spread is negatively related to the orthogonalized S&P 500 index return, although only at the ten-percent level.

The results for the Treasury yield equations show that there is again a considerable amount of predictability. The adjusted R^2s for the one-year and ten-year equations are 20.9 and 21.7 percent, respectively. While these adjusted R^2s are somewhat smaller than their counterparts in the previous case, these R^2s are still very large for predicting weekly yield changes and are based on fewer explanatory variables than in the earlier results. In contrast, the adjusted R^2s for the stock returns equations are very close to zero.

[10] Swap spreads and their economic determinants are discussed in Duffie and Singleton (1997) and Liu, Longstaff, and Mandell (2006).

In summary, these results provide empirical support for the implications of the distressed asset model. There is evidence that Treasury yields decline as the market becomes more distressed. Overall, however, the asset-pricing effects observed in the LTCM/hedge-fund crisis appear to be somewhat weaker than those we document for the subprime crisis.

6. CONCLUSION

We study asset pricing in a financial market in which some assets can become severely distressed. Using a standard asset-pricing framework, we show that distress can result in a significant contraction in the size of the debt market. In turn, this can lead to large increases in the values of safe assets such as Treasury bonds, resembling the well-known phenomenon of a flight to quality. We show that distress results in significant time variation in risk premia, which then induces predictability into asset returns.

We explore the empirical implications of the model using data from the current subprime CDO crisis. We show that negative shocks in the value of the subprime asset-backed CDOs are associated with subsequent shocks in the size of the commercial paper market, increases in the value of one-year and ten-year Treasury bonds, and important effects on the stock index returns and trading patterns. These result provide support for the empirical implications of the model, but raise questions are why distressed asset prices are so informative about future Treasury bond and stock market returns. Additional research is needed to identify the source of the apparent time variation in the predictability of asset returns.

REFERENCES

Acharya, Viral, and Lasse H. Pedersen, 2005, Asset Pricing with Liquidity Risk, *Journal of Financial Economics* 77, 375-410.

Allen, Franklin, and Douglas Gale, 2000, Financial Contagion, *Journal of Political Economy* 108, 1-33.

Andrade, Gregor, and Steven N. Kaplan, 1998, How Costly is Financial (not Economic) Distress? Evidence from Highly Leveraged Transactions that Became Distressed, *Journal of Finance* 53, 1443-1493.

Asquith, Paul, Robert Gertner, and David Scharfstein, 1994, Anatomy of Financial Distress: An Examination of Junk-Bond Issuers, *Quarterly Journal of Economics* 109, 625-658.

Brunnermeier, Markus K. and Lasse H. Pedersen, 2005, Predatory Trading, *Journal of Finance* 60, 1825-1863.

Brunnermeier, Markus K. and Lasse H. Pedersen, 2007, Market Liquidity and Funding Liquidity, Working paper, Princeton University.

Carlin, Bruce I., Miguel S. Lobo, and S. Vishwanathan, 2007, Episodic Liquidity Crises: Cooperative and Predatory Trading, *Journal of Finance* 62, 2235-2274.

Clarida, Richard H., 2007, A Hard Day's Knight: The Global Financial Market Confronts Uncertainty, Not Just Risk (and the Difference is Important), *Global Perspectives*, www.pimco.com.

Clark, Kent and Eli Ofek, 1994, Mergers as a Means of Restructuring Distressed Firms: An Empirical Investigation, *Journal of Financial and Quantitative Analysis* 29, 541-565.

Cochrane, John H., 2006, The Dog that did not Bark: A Defense of Return Predictability, *Review of Financial Studies*, forthcoming

Cochrane, John H., Francis A. Longstaff, and Pedro Santa-Clara, 2007, Two Trees, *Review of Financial Studies*, forthcoming.

Cochrane, John H., and Monika Piazzesi, 2005, Bond Risk Premia, *American Economic Review* 95, 138-160.

Duarte, Jefferson, Francis A. Longstaff, and Fan Yu, 2007, Risk and Return in Fixed Income Arbitrage: Nickels in Front of a Steamroller?, *Review of Financial Studies* 20, 769-811.

Duffie, Darrell, Lasse H. Pedersen, and Kenneth J. Singleton, 2003, Modeling Sovereign Yield Spreads: A Case Study of Russian Debt, *Journal of Finance* 58, 119-159.

Duffie, Darrell and Kenneth J. Singleton, 1997, An Econometric Model of Term Structure of Interest-Rate Swap Yield, *Journal of Finance* 52, 1287-1321.

Dunbar, N., 2000, Inventing Money, West Sussex: John Wiley & Sons Ltd.

John, Kose, and Eli Ofek, 1995, Asset Sales and Increase in Focus, *Journal of Financial Economics* 37, 105-126.

Kahl, Matthias, 2002, Economic Distress, Financial Distress, and Dynamic Liquidation, *Journal of Finance* 57, 135-168.

Kodres, Laura and Matthew Pritsker, 2002, A Rational Expectations Model of Financial Contagion, *Journal of Finance* 57, 769-800.

Kyle, Albert S. and Wei Xiong, 2001, Contagion as a Wealth Effect, *Journal of Finance* 56, 1401-1440.

Lettau, Martin, and Sydney Ludvigson, 2001, Consumption, Wealth, and Expected Returns, *Journal of Finance* 55, 815-849.

Liu, Jun, and Francis A. Longstaff, 2004, Losing Money on Arbitrage: Optimal Dynamic Portfolio Choice in Markets with Arbitrage Opportunities, *Review of Financial Studies* 17, 611-641.

Liu, Jun, Francis A. Longstaff, and Jun Pan, 2003, Dynamic Asset Allocation with Event Risk, *Journal of Finance* 58, 231-259.

Liu, Jun, Francis A. Longstaff, and Ravit Mandell, 2006, The Market Price of Risk in Interest Rate Swaps: The Roles of Default and Liquidity Risks, *Journal of Business* 79, 2337-2359.

Longstaff, Francis A., 2001, Optimal Portfolio Choice and the Valuation of Illiquid Securities, *Review of Financial Studies* 14, 407-431.

Longstaff, Francis A., 2004, The Flight-to-Liquidity Premium in U.S. Treasury Bond Prices, *Journal of Business* 77, 511-526.

Longstaff, Francis A. and Monika Piazzesi, 2004, Corporate Earnings and the Equity Premium, *Journal of Financial Economics* 74, 401-421.

Longstaff, Francis A. and Arvind Rajan, 2008, An Empirical Analysis of the Pricing of Collateralized Debt Obligations, *Journal of Finance* 63, 529-563.

Longstaff, Francis A. and Jiang Wang, 2007, Asset Pricing and the Debt Market, Working paper, UCLA.

Lowenstein, R., 2000, *When Genius Failed: The Rise and Fall of Long-Term Capital Management*, Random House.

Lucas, Robert E., 1978, Asset Prices in an Exchange Economy, *Econometrica* 46, 1429-1445.

Opler, Tim C. and Sheridan Titman, 1994, Financial Distress and Corporate Performance, *Journal of Finance* 49, 1015-1040.

Perold, A., 1999, Long-Term Capital Management, L.P. (A), Harvard Business School Case 9-200-007, Harvard University, Boston, MA.

Pritsker, Matthew, 2005, Large Investors: Implications for Equilibrium Asset Returns, Shock Absorption, and Liquidity, Working paper, Federal Reserve Board.

Pulvino, Todd C., 1998, Do Asset Fire Sales Exist? An Empirical Investigation of Commercial Aircraft Transactions, *Journal of Finance* 53, 939-978.

Rajan, Arvind, Glen McDermott, and Ratul Roy, 2007, *The Structured Credit Handbook*, John Wiley & Sons, Hoboken, NJ.

Rubinstein, Mark, 1974, An Aggregation Theorem for Securities Markets, *Journal of Financial Economics* 1, 225-244.

Scannell, Kara, Anita Raghavan, and Amir Efrati, 2008, The Subprime Cleanup Intensifies, *Wall Street Journal*, February 2, B1.

Shleifer, Andrei, and Robert W. Vishny, 1992, Liquidation Values and Debt Capacity: A Market Equilibrium Approach, *Journal of Finance* 47, 1343-1366.

Vayanos, Dimitri, 2004, Flight to Quality, Flight to Liquidity, and the Pricing of Risk, Working paper, London School of Economics.

Wang, Jiang, 1996, The Term Structure of Interest Rates in a Pure Exchange Economy with Heterogeneous Investors, *Journal of Financial Economics* 41, 75-110.

Table 1

Equilibrium Consumption and Portfolio Holdings. This table reports the share of total consumption for each of the agents as well as their optimal portfolio holdings in terms of the number of shares of the stock, the number of shares of the distressed asset, and the notional amount of bonds for each of the agents. Also reported are the optimal portfolio weights for the each of the agents. At time zero, the agents are each endowed with 50 percent of the assets in the economy and make consumption and investment decisions. At time one, a distress event occurs and the agents make their consumption and investment decisions without knowing how severe the event will be. At time two, the uncertainty is resolved. The results reported assume that the value of the dividend equals one at times zero, one, and two, and that the realized loss for the distressed asset equals the expected loss of 50 percent.

			Portfolio Holdings			Portfolio Weights		
Time	Agent	Share of Consumption	Stock	Distress Asset	Bond	Stock	Distress Asset	Bond
0	Less-Risk-Averse	0.4171	0.6918	0.6918	−6.3503	1.2682	0.1261	−0.3943
	More-Risk-Averse	0.5829	0.3082	0.3082	6.3503	0.5563	0.0553	0.3884
1	Less-Risk-Averse	0.4057	0.6918	0.6918	−5.9089	1.2885	0.0625	−0.3510
	More-Risk-Averse	0.5943	0.3082	0.3082	5.9089	0.6025	0.0292	0.3683
2	Less-Risk-Averse	0.4233	0.6902	0.6902	−6.3005	1.3481	0.0674	−0.4155
	More-Risk-Averse	0.5777	0.3098	0.3098	6.3005	0.5758	0.0288	0.3954

Table 2

Equilibrium Asset Prices and Risk Premia. This table reports the equilibrium prices of each of the assets. The table also reports the risk premium for the stock and the distressed asset. The risk premium is computed as the difference between the expected return on the respective asset minus the riskless interest rate. At time zero, the agents are each endowed with 50 percent of the assets in the economy and make consumption and investment decisions. At time one, a distress event occurs and the agents make their consumption and investment decisions without knowing how severe the event will be. At time two, the uncertainty is resolved. The results reported assume that the value of the dividend equals one at times zero, one, and two, and that the realized loss for the distressed asset equals the expected loss of 50 percent.

	Equilibrium Prices			Risk Premia	
Time	Stock	Distress Asset	Bond	Stock	Distress Asset
0	29.5193	2.9361	0.9948	0.04717	0.04725
1	31.3598	1.5204	1.0562	0.05118	0.08016
2	29.6173	1.4809	0.9947	0.04541	0.04541

Table 3

Timeline of the 2007 Subprime Crisis. Source: Reuters.

Late 2006	The U.S. housing market slows after 2 years of increases in official interest rates. Delinquencies rise, a wave of bankruptcies.
Feb 7	Europe's biggest bank HSBC holdings blamed soured U.S. subprime loans for its first-ever profit warning.
Feb 13	Countrywide shares drop as Fremont General Corp., one of the largest providers of subprime loans, says it has stopped offering some second mortgages.
Apr 2	Subprime lender New Century Financial Corp. files for bankruptcy.
Jun 20	Two Bear Stearns funds sell $4 billion of assets to cover redemptions and expected margin calls after making bad bets on securities backed by subprime mortgages.
Jul 10	Standard & Poor's said it may cut ratings on some $12 billion of subprime debt.
Jul 17	Bear Stearns says two hedge funds with subprime exposure have very little value; credit spreads soar.
Jul 20	Home foreclosures rose 9 percent in July from June and soared 93 percent from a year ago.
Aug 9	French bank BNP Paribas bars investors from redeeming cash in $2.2 billion worth of funds, telling the markets it is unable to calculate the value of the asset-backed securities funds.
Aug 10	Central banks pump billions of dollars into banking systems in a concerted effort to beat back a credit crisis.
Aug 17	Fed surprises by cutting its discount rate by half a percentage point to 5.75 percent, cites tightening credit markets.
Sep 13	UK mortgage lender Northern Rock sought emergency financial support from the Bank of England. The report sparked a run on the bank's deposits by worried savers.
Oct 1	Swiss bank UBS said it would write down $3.4 billion in its fixed-income portfolio and elsewhere, first quarterly loss in 9 years.
Oct 15	Bank of America, Citigroup, and JP Morgan Chase plan fund to pool assets from stressed SIVs to prevent a fire sale of these assets.
Oct 30	Merrill Lynch ousts Chairman and Chief Executive Stan O'Neal after reporting biggest quarterly loss in company's history.
Nov 4	Citigroup announces a further $8-11 billion of subprime-related writedowns and losses. Charles Prince resigns as CEO.
Dec 6	Treasury, lenders set plan to bring reset relief to many of the 2 million homeowners facing higher rates.
Dec 12	Central banks coordinate the launch of a new temporary term auction facility to address pressures in short-term funding markets.

Table 4

Countrywide Subprime ABS CDO Structure CWABS 2006-1. This table reports some of the contractual terms listed in the prospectus for this asset-backed CDO structure. The L in the initial pass-thru rate represents one-month Libor. The seniority ranking n/m means that the tranches seniority is n-th out of m tranches.

Tranche	Notional Amount	Price to Public	Under-Writer Fee	Initial Pass-thru Rate	Maturity	Initial Moody's Rating	Initial S&P Rating	Seniority Ranking
AF-1	147,232,000	100.0000	0.0521	L+ 0.130%	Nov 2025	Aaa	AAA	1/7
AF-2	22,857,000	99.9995	0.1042	5.281%	May 2027	Aaa	AAA	1/7
AF-3	90,995,000	99.9998	0.1563	5.384%	Jul 2033	Aaa	AAA	1/7
AF-4	21,633,000	99.9985	0.2500	5.714%	Sep 2034	Aaa	AAA	1/7
AF-5	38,617,000	99.9987	0.3333	5.884%	Jul 2036	Aaa	AAA	1/7
AF-6	44,200,000	99.9980	0.4167	5.526%	May 2036	Aaa	AAA	1/7
MF-1	13,260,000	99.9981	0.4167	5.917%	May 2036	Aa1	AA+	2/7
MF-2	12,155,000	99.9972	0.5000	6.016%	May 2036	Aa2	AA+	3/7
MF-3	7,293,000	99.9965	0.5833	6.115%	Apr 2036	Aa3	AA	4/7
MF-4	6,409,000	99.4627	0.8333	6.200%	Apr 2036	A1	AA-	5/7
MF-5	6,188,000	98.9985	1.0000	6.200%	Mar 2036	A2	A+	6/7
MF-6	5,525,000	98.5371	1.2500	6.200%	Feb 2036	A3	A	7/7
AV-1	139,560,000	100.0000	0.0522	L+0.080%	Jul 2028	Aaa	AAA	1/8
AV-2	115,712,000	100.0000	0.1033	L+0.190%	May 2035	Aaa	AAA	1/8
AV-3	25,042,000	100.0000	0.1033	L+0.300%	Jun 2036	Aaa	AAA	1/8
MV-1	14,320,000	100.0000	0.4167	L+0.390%	May 2036	Aa1	AA+	2/8
MV-2	13,067,000	100.0000	0.5000	L+0.410%	May 2036	Aa2	AA+	3/8
MV-3	7,518,000	100.0000	0.8333	L+0.440%	May 2036	Aa3	AA	4/8
MV-4	6,802,000	100.0000	0.9167	L+0.560%	Apr 2036	A1	AA-	5/8
MV-5	6,802,000	100.0000	0.9667	L+0.600%	Apr 2036	A2	A+	6/8
MV-6	5,907,000	100.0000	1.0000	L+0.660%	Mar 2036	A3	A	7/8
MV-7	5,549,000	100.0000	1.0833	L+1.300%	Mar 2036	Baa1	A	8/8

Table 5

Summary Statistics for ABX Home-Equity CDO Tranches. This table reports summary statistics for the indicate ABX indexes. Prices are quoted relative to a $100 notional position. The sample consists of daily closing prices for the January 25, 2006 to December 26, 2007 period.

Index	Rating	Mean	Standard Deviation	Minimum	Median	Maximum	*N*
ABX HE 1	AAA	99.35	1.88	90.09	100.26	100.38	486
	AA	98.06	4.75	77.58	100.31	100.73	486
	A	93.51	12.04	47.11	100.12	100.51	486
	BBB	87.53	20.66	25.00	99.83	101.20	486
	BBB−	84.54	23.29	21.83	99.24	102.19	486
ABX HE 2	AAA	97.36	4.52	79.97	99.57	100.12	362
	AA	92.60	12.56	51.47	99.50	100.12	362
	A	83.67	21.36	33.59	95.04	100.12	362
	BBB	72.98	27.82	18.61	83.00	100.58	362
	BBB−	68.70	28.83	16.63	73.32	100.94	362
ABX HE 3	AAA	93.74	8.31	68.92	99.08	100.09	236
	AA	82.99	20.07	37.47	97.42	100.09	236
	A	68.35	27.58	24.00	81.82	100.01	236
	BBB	54.35	25.77	17.56	61.43	98.35	236
	BBB−	50.01	23.61	16.84	54.30	97.47	236
ABX HE 4	AAA	86.75	10.15	66.41	91.44	99.33	109
	AA	68.67	20.32	34.67	78.06	97.00	109
	A	49.04	15.93	23.97	56.65	81.94	109
	BBB	33.83	10.24	19.88	39.56	56.61	109
	BBB−	31.27	9.20	18.90	36.73	50.33	109

Table 6

VAR Estimation Results for ABX Index Returns. This table reports the t-statistics for the indicated ABX Index returns from the VAR specification below. The superscript ** denotes significance at the five-percent level; the superscript * denotes significance at the ten-percent level. The sample period is January 25, 2006 to December 31, 2007 (100 weekly observations).

$$ABX_t = \gamma_0 + \sum_{i=1}^{4} \gamma_i' \, ABX_{t-i} + \epsilon_t$$

		t-Statistics for Lagged ABX Returns					
ABX_t	Lag	ABX_{AAA}	ABX_{AA}	ABX_A	ABX_{BBB}	ABX_{BBB-}	Adj. R^2
ABX_{AAA}	1	-6.05**	4.77**	0.72	4.77**	-4.35**	
	2	4.69**	1.65*	-2.31**	0.90	0.59	
	3	-7.40**	5.70**	-1.95*	-3.81**	4.04**	
	4	-6.74**	6.54**	-3.94**	4.52**	-3.92**	0.867
ABX_{AA}	1	-1.92*	-0.96	3.06**	2.38**	-1.55	
	2	5.76**	0.39	-0.48	0.23	0.85	
	3	-2.54**	0.79	0.13	-4.77**	3.84**	
	4	-3.98**	5.80**	-5.25**	6.13**	-5.22**	0.770
ABX_A	1	-5.61**	-0.60	3.50**	3.54**	-2.67**	
	2	3.92**	2.32**	-1.84*	3.27**	-1.79*	
	3	-3.11**	1.07	0.25	-5.87**	5.32**	
	4	-7.02**	8.45**	-6.75**	7.26**	-5.59**	0.819
ABX_{BBB}	1	-3.62**	-1.57	3.83**	1.67*	-1.48	
	2	2.11**	0.86	-0.12	3.27**	-1.79*	
	3	0.48	-0.49	-0.15	-3.46**	3.03**	
	4	-2.09**	2.92**	-3.75**	2.83**	-1.09	0.571
ABX_{BBB-}	1	-3.19**	-1.28	3.16**	1.54	-1.51	
	2	1.90*	1.23	-0.97	2.75**	-2.26**	
	3	0.28	-0.59	-0.20	-2.89**	2.65**	
	4	-1.96**	3.48**	-4.46**	2.53**	-0.57	0.460

Table 7

VAR Estimation Results for Bond and Stock Returns, Size of the Debt Sector, and Market Trading Activity. This table reports the t-statistics for the indicated lagged ABX index returns from the VAR specification below. Each line represents a seperate specification in which the ABX index with the indicated credit rating is included. The vector Y_t consists of the change in the one-year Treasury constant maturity yield, the change in the ten-year Treasury constant maturity yield, the return on the S&P 500 subindex of financial firms (excluding dividends), the (orthogonalized) return on the S&P 500 (excluding dividends), the percentage change in amount of commercial paper outstanding, and the ratio of trading volume for the S&P 500 financial subindex to the trading volume for the S&P 500 index. The sample period is January 25, 2006 to December 31, 2007 (100 weekly observations).

$$Y_t = \gamma_0 + \sum_{i=1}^{4} \gamma_{1i}\ ABX_{t-i} + \sum_{i=1}^{4} \lambda_i'\ Y_{t-i} + \epsilon_t$$

Y_t	ABX Index	t-Statistics for Lagged ABX Returns Lag 1	Lag 2	Lag 3	Lag 4	Adj. R^2
One-Year Treasury	AAA	0.02	4.37**	1.85*	−1.76*	0.387
	AA	2.29**	1.81*	2.92**	−1.29	0.442
	A	0.22	1.64	4.85**	0.49	0.482
	BBB	0.54	0.66	3.40**	1.48	0.373
	BBB−	0.94	0.76	3.34**	1.37	0.351
Ten-Year Treasury	AAA	−0.41	2.94**	1.61	−1.19	0.200
	AA	1.04	0.31	2.96**	−0.93	0.238
	A	0.45	0.13	3.61**	0.73	0.282
	BBB	1.31	−0.39	2.69**	1.34	0.373
	BBB−	1.61	−0.35	2.73**	1.64	0.247
S&P Financials	AAA	1.67*	1.77*	0.97	−0.97	0.346
	AA	1.49	−0.55	3.85**	−0.19	0.429
	A	1.33	−1.05	4.45**	1.74*	0.500
	BBB	1.55	1.39	1.93*	1.85*	0.435
	BBB−	2.10**	1.04	2.49**	1.78*	0.432

Table 7 Continued

Y_t	ABX Index	t-Statistics for Lagged ABX Returns Lag 1	Lag 2	Lag 3	Lag 4	Adj. R^2
S&P 500	AAA	1.04	2.22**	−1.26	−0.12	0.200
	AA	−0.75	1.93*	0.09	−0.18	0.156
	A	−0.46	1.58	−0.09	1.24	0.172
	BBB	−2.31**	2.01**	0.97	1.21	0.239
	BBB−	−1.03	1.12	0.28	0.93	0.149
Comm Paper	AAA	−0.51	2.61**	−1.25	−0.54	0.390
	AA	0.24	0.95	0.57	−0.45	0.338
	A	−0.36	1.38	1.61	0.90	0.393
	BBB	−0.85	1.31	2.64**	−0.20	0.420
	BBB−	−0.30	1.58	2.35**	−1.06	0.409
Volume Ratio	AAA	−2.93**	0.18	0.53	−0.73	0.933
	AA	−3.70**	0.32	−0.90	0.66	0.942
	A	−3.29**	0.61	−2.11**	0.26	0.944
	BBB	−1.49	−1.94**	−2.16**	1.14	0.943
	BBB−	−0.92	−2.45**	−2.79**	0.92	0.943

Table 8

VAR Estimation Results for Bond and Stock Returns, Size of the Debt Sector, and Market Trading Activity Using Distress Period Dummy Variables. This table reports the t-statistics for the indicated distress period dummy slope coefficient (γ_{2i}) for the lagged ABX index returns from the VAR specification below. Each line represents a seperate specification in which the ABX index with the indicated credit rating is included. The vector Y_t consists of the change in the one-year Treasury constant maturity yield, the change in the ten-year Treasury constant maturity yield, the return on the S&P 500 subindex of financial firms (excluding dividends), the (orthogonalized) return on the S&P 500 (excluding dividends), the percentage change in amount of commercial paper outstanding, and the ratio of trading volume for the S&P 500 financial subindex to the trading volume for the S&P 500 index. The indicator I_t takes value zero for 2006 observations and value one for 2007 observations. The sample period is January 25, 2006 to December 31, 2007 (100 weekly observations).

$$Y_t = \gamma_0 + \sum_{i=1}^{4}(\gamma_{1i} + \gamma_{2i} I_t)\ ABX_{t-i} + \sum_{i=1}^{4} \lambda_i'\ Y_{t-i} + \epsilon_t$$

		t-Statistics for Distress Period Lagged ABX Returns				
Y_t	ABX Index	Lag 1	Lag 2	Lag 3	Lag 4	Adj. R^2
One-Year Treasury	AAA	2.41**	1.84*	2.41**	1.85*	0.431
	AA	0.59	0.34	−0.28	0.44	0.414
	A	0.37	−1.04	1.66*	−3.32**	0.551
	BBB	0.41	−0.86	1.88*	0.51	0.380
	BBB−	−0.16	−0.87	2.29**	0.74	0.379
Ten-Year Treasury	AAA	1.10	0.37	1.22	0.87	0.177
	AA	1.08	0.66	0.63	0.71	0.214
	A	0.89	−0.58	0.64	−1.87*	0.295
	BBB	0.38	0.29	2.92**	0.40	0.294
	BBB−	0.77	0.55	2.91**	0.80	0.312
S&P Financials	AAA	0.81	−1.00	0.85	3.46	0.513
	AA	0.84	1.12	3.17**	−4.26**	0.576
	A	−2.02**	1.40	−0.59	0.78	0.526
	BBB	0.25	−0.70	1.60	0.48	0.429
	BBB−	0.11	1.85*	−0.46	0.14	0.428

Table 8 Continued

Y_t	ABX Index	t-Statistics for Distress Period Lagged ABX Returns Lag 1	Lag 2	Lag 3	Lag 4	Adj. R^2
S&P 500	AAA	−1.57	0.73	−1.66*	0.34	0.204
	AA	−1.85*	0.29	−3.54**	1.50	0.262
	A	−3.44*	−1.79**	−1.34	0.51	0.302
	BBB	−0.85	0.65	−2.09**	−1.71*	0.283
	BBB−	−1.65*	2.28**	−1.67*	−1.87*	0.246
Comm Paper	AAA	2.00**	0.80	1.51	1.14	0.397
	AA	1.85*	−0.19	0.30	0.41	0.342
	A	−0.12	−0.13	0.80	−1.72*	0.389
	BBB	0.93	−1.50	−0.33	0.44	0.412
	BBB−	−0.61	−0.86	0.78	−0.74	0.390
Volume Ratio	AAA	−2.36**	−0.88	−2.26**	−1.10	0.935
	AA	−1.10	2.35**	−1.27	1.22	0.946
	A	1.72*	0.28	−1.97**	2.91**	0.952
	BBB	−3.13**	1.74*	−1.61	−1.16	0.952
	BBB−	−3.70**	1.16	−0.63	−2.75**	0.953

Table 9

VAR Estimation Results for the LTCM Crisis. This table reports the t-statistics for the indicated lagged changes in the slope of the swap spread curve from the VAR specification below. Slope denotes the change in difference between the ten-year and two-year swap spreads. The vector Y_t consists of the change in the one-year Treasury constant maturity yield, the change in the ten-year Treasury constant maturity yield, the return on the S&P 500 subindex of financial firms (excluding dividends), and the (orthogonalized) return on the S&P 500 (excluding dividends). SP500 denotes the return on the S&P 500 index. The sample period is January 1, 1997 to December 31, 1998 (104 weekly observations).

$$Y_t = \gamma_0 + \sum_{i=1}^{4} \gamma_{1i} \text{ Slope}_{t-i} + \sum_{i=1}^{4} \lambda_i' \, Y_{t-i} + \epsilon_t$$

	t-Statistics for Lagged Slope Changes				
Y_t	Lag 1	Lag 2	Lag 3	Lag 4	Adj. R^2
One-Year Treasury	0.37	−2.61**	−0.06	2.42**	0.209
Ten-Year Treasury	0.39	−2.18**	1.40	1.01	0.217
S&P Financials	−0.95	−0.73	1.64	0.13	−0.024
S&P 500	−1.77*	0.94	0.96	1.19	0.040

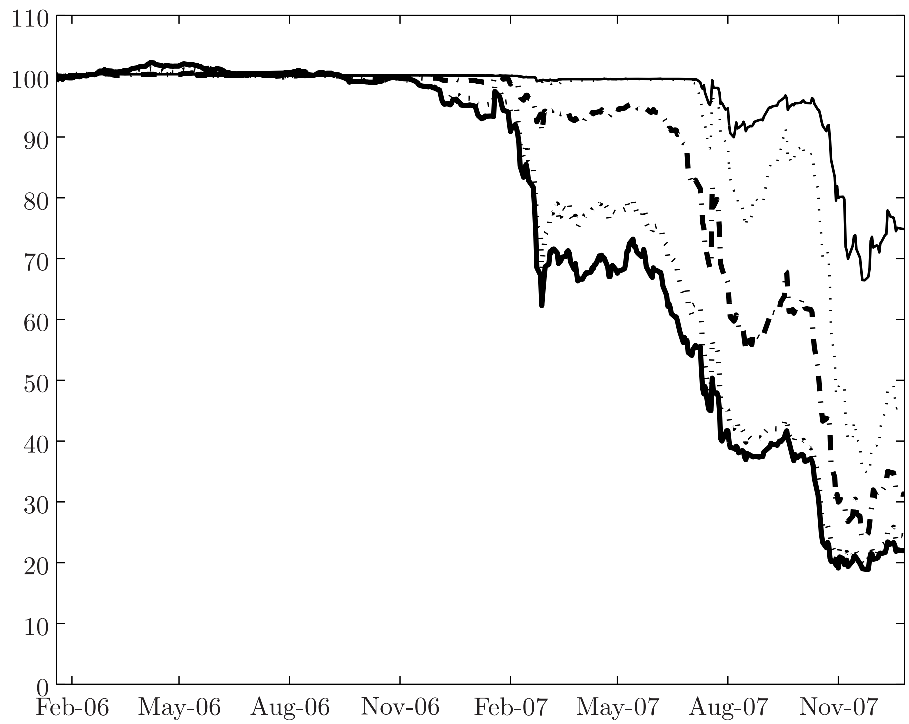

Figure 1. ABX Index Values.
From top to bottom: AAA index is the solid thin line; AA Index is the thin dotted line; A Index is the dotted dashed line; BBB Index is the thick dotted line; BBB- Index is the solid thick line.