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How Does the Market Value Toxic Assets?

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Abstract

How does the market value "toxic" structured-credit securities? We study the valuation of what is possibly the most toxic of all toxic assets: the equity tranche of a collateralized debt obligation (CDO). In theory, CDO equity should be similar in nature to bank stock since both represent residual claims on a portfolio of loans. We find CDO equity returns are much more related to stock returns than to fixed-income returns. CDO equity returns track the returns of financial stocks much more closely than any other industry. Nearly two-thirds of the variation in CDO returns can be explained by fundamentals.

I. Introduction

Prior to the 2007–2008 financial crisis, much of the innovation in financial markets was directed to the creation of structured investment vehicles that allowed investors to take highly leveraged positions in portfolios of assets.[1] The securitized-credit market, in particular, has received a significant amount of attention for its prominent role in the international financial crisis. Given the huge losses that investors have suffered in the complex and opaque securitized-credit market, it is not surprising that these types of investments have frequently been termed "toxic" assets.

One of the most controversial aspects of the securitized-credit market is the issue of how these structured types of securities are valued in the

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[1]Examples include collateralized debt obligations (CDOs), collateralized loan obligations (CLOs), structured investment vehicles (SIVs), conduits that synthesize highly rated debt instruments from portfolios of high-yield bonds or subprime loans, collateralized fund obligations (CFOs) that create leveraged hedge-fund-like structures, and total rate of return swaps (TRORS) that parallel the ownership of stock without the use of the balance sheet.

financial markets. On one hand, many argue that the complexity and lack of transparency of these instruments allowed them to be issued as highly rated investment-grade securities at premium valuations.[2] On the other hand, a key premise behind many of the recent troubled-asset programs implemented by the Treasury and the Federal Reserve was that these investments were discounted in the market at illiquid fire-sale prices far below their intrinsic worth.[3] Thus, securitized-credit investments are viewed as having alternated between being overvalued and undervalued by the financial markets.

In an effort to shed light on the important issue of how the market values these types of assets, this paper studies the valuation of what is probably the most toxic of all toxic assets: the equity tranche of a CDO, or CDO equity. The "toxicity" of this asset arises because CDO equity represents the residual claim position in a leveraged CDO capital structure. The expected loss on CDO equity is often so large that CDO equity trades at prices of one or two for a notional amount of 100. In this analysis, we make use of an extensive proprietary data set made available to us by a major fixed-income asset management firm. The data consist of daily traded tranche prices on both the CDX investment-grade and high-yield indexes.

We begin by describing the characteristics of CDO equity. In theory, CDO equity should have similarities with bank stock since both are residual claims to the cash flows of a portfolio of loans. A direct implication of this is that investors in financial markets may price CDO equity in a way that mirrors the pricing of bank stock. On the other hand, there are important differences between CDO equity and bank stock. For example, CDOs are generally based on static portfolios. In contrast, banks manage their credit portfolios dynamically. From this perspective, CDO equity is to bank stock what a passive index fund is to an actively managed fund. Clearly, however, the issue of whether CDO equity and bank stock are priced similarly in the market is an empirical one.

To address this issue, we first compare the properties of CDO equity returns with those of other major asset classes such as stocks, Treasury bonds, corporate bonds, and mortgage-backed securities (MBS). We find that CDO equity returns are much more closely related to stock returns in terms of their means, excess returns, standard deviations, and market betas than to any of the fixed-income returns. For example, CDO equity betas closely parallel the stock return betas of firms with similar leverage ratios.

We next examine the relation between CDO equity returns and stock returns by industry. Specifically, we regress CDO equity returns on the returns of Fama-French industry portfolios (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html). Our objective in estimating these regressions is to

[2]From an Oct. 31, 2008, speech by Federal Reserve Board Chair Ben S. Bernanke, "As subsequent events demonstrated, however, the boom in subprime mortgage lending was only a part of a much broader credit boom characterized by an underpricing of risk, excessive leverage, and the creation of complex and opaque financial instruments that proved fragile under stress."

[3]From a Sept. 19, 2008, speech by Treasury Secretary Henry M. Paulson, Jr., "These troubled loans are now parked, or frozen, on the balance sheets of banks and other financial institutions, preventing them from financing productive loans. The inability to determine their worth has fostered uncertainty about mortgage assets, and even about the financial condition of the institutions that own them."

identify which industry returns are the most related to CDO equity returns. As expected, the returns for the financial industry are significantly related to CDO equity returns in all cases. Furthermore, the banking industry is by far the most dominant of all the industries in terms of its explanatory power for CDO equity returns. Thus, not only does CDO equity behave like stock, it behaves most like stock in the financial industry. These results provide empirical support for the view that the market values CDO equity and bank stock consistently.

Using individual stock returns for several hundred banks, we conduct a cross-sectional analysis to identify the characteristics of the banks which have the highest correlation with CDO equity returns. We find that there is a strong positive relation between bank size and its correlation with CDO equity. This relation holds true not only among the 30 largest banks (many of which were major CDO issuers), but also among the smallest banks in the sample. Furthermore, after controlling for size, we find significant relations to the fraction of commercial loans to total assets. These results are also consistent with the interpretation of CDO equity as stock in banks with portfolios of commercial loans similar to those in the CDX index.

Finally, following Collin-Dufresne, Goldstein, and Martin (2001), we examine how much of the variation in CDO equity returns can be explained on the basis of fundamental CDO valuation models (e.g., Duffie and Gârleanu (2001), Longstaff and Rajan (2008)). We find that 45%–64% of the returns to CDO equity are linked to variables driving the distribution of losses on an underlying investment-grade credit portfolio. These variables also have significant explanatory power for CDOs which are based on portfolios of high-yield bonds although the fraction of the variation explained is not as high. Additionally, we find that the fundamentals that explain investment-grade CDO equity also explain the returns to bank stock.

These results have a number of important implications. First, the results provide new perspectives on the relation between CDO equity and the stock of traditional financial institutions. The term "shadow banking system" has been used to describe some of the complex, highly levered, and largely unregulated securities created by Wall Street.[4] We show that the term "shadow bank" is a particularly apt description of CDO equity, both conceptually as well as empirically. Also, finding that much of the variation in CDO equity returns can be explained by credit valuation models indicates that the market values even the most toxic of assets rationally in terms of their economic fundamentals.

This paper contributes to the rapidly growing literature on securitized credit. Recent papers in this area include Duffie and Gârleanu (2001), Hull and White (2004), Giesecke (2004), DeMarzo (2005), Berd, Engle, and Voronov (2007), Longstaff and Rajan (2008), and Bhansali, Gingrich, and Longstaff (2008), who present models for valuing CDO tranches. Brennan, Hein, and Poon (2009), Morkötter and Westerfeld (2009), and Benmelech and Dlugosz (2009) consider

[4]This term is attributed to Paul McCulley of PIMCO who, in 2007, defined it as "the whole alphabet soup of levered up, non-bank investment conduits, vehicles, and structures." See www.pimco.com.

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the relation between credit ratings and the CDO market.[5] Franke and Krahnen (2007), Krahnen and Wilde (2006), and Longstaff (2010) consider the effects of risk transfer between securitized-credit markets and other financial institutions and markets.

In an important paper, Shleifer and Vishny (1992) study the pricing of the ABX.HE indexes, which are based on credit default swaps (CDSs) on baskets of MBS. In this paper we focus instead on the equity tranche of a CDO structure based on a basket of CDS contracts on corporate debt. Thus our results complement those of Stanton and Wallace (2011). In another paper, Coval, Jurek, and Stafford (2009a) model the prices of senior CDO tranches. This paper complements Coval et al. (2009a) by focusing on the opposite end of the capital structure, the equity tranche of the CDO.

The remainder of the paper is organized as follows: Section II provides an introduction to CDO equity, discusses the conceptual relation between CDO equity and bank stock, and describes the data used in this study. Section III focuses on the relation between CDO equity and stock market factors. Section IV examines whether CDO equity is priced like bank stock in particular. Section V examines which banks are most similar to CDO equity. Section VI examines the pricing of CDO equity in relation to fundamentals. Section VII concludes.

II. CDO Equity

In this section we provide a brief introduction to CDO equity. One of the most important types of securitized-credit structures in the financial markets has been the collateralized debt or loan obligation. Until the subprime crisis of 2007, CDO issuance exceeded $100 billion per year. Assets that have been securitized by CDOs included investment-grade bonds, high-yield bonds, emerging market debt, leveraged loans, middle-market loans, trust preferred securities, credit card receivables, prime and subprime home-equity mortgages, asset-backed securities, commercial mortgages, and even previously issued CDO tranches.[6] While the securitization of certain asset portfolios have been reduced by the financial crisis, some assets, such as mortgages, continue to be securitized in large amounts.

To illustrate how CDO equity is structured, we consider a simple example based on a diversified portfolio of corporate loans. Imagine that a CDO issuer has a portfolio of 100 loans on its balance sheet that it wishes to securitize. Each loan has a face amount of $1 million, is worth par, and has a 10-year maturity. In addition, each loan is to a different corporate borrower. The total value of the loan portfolio is $100 million. To sell the portfolio, the CDO issuer could sell the

[5]This paper also extends the literature on the valuation of distressed assets. Important papers on distressed asset valuation 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), Longstaff (2004), Vayanos (2004), Acharya and Pedersen (2005), Carlin, Lobo, and Vishwanathan (2007), and Brunnermeier and Pedersen (2009).

[6]For more details about the structure of the CDO market, see Duffie and Gârleanu (2001), Rajan, McDermott, and Roy (2007), and Coval et al. (2009b).

entire portfolio to a single buyer as a whole or sell the portfolio in tranches as a CDO to multiple buyers.[7]

The CDO equity tranche represents the residual claim on the portfolio of loans and is structured in the following way. First, the CDO issuer determines the total notional amount of the tranche, say, 10% of the total value of the portfolio ($10 million). By definition, this tranche absorbs the first 10% of any defaults on the entire portfolio. Thus, this equity tranche is said to have a thickness of 10% (and is analogous to the percentage of equity capital in a bank). In exchange for being the residual claimant, the equity tranche will receive a coupon rate of perhaps 500 basis points above Treasuries. If there are no defaults, the buyer of the equity tranche earns a high-coupon rate for 10 years and then receives back his or her $10 million notional investment. If, for example, four of the firms default (and assuming that there is zero recovery in the event of default), the equity tranche absorbs the $4 million loss to the portfolio and the notional amount of the equity tranche is reduced to $6 million. Going forward, the equity tranche investor receives the 500-basis-point coupon spread as before, only now on the $6 million notional. If six or more additional firms default, the equity tranche absorbs additional losses of $6 million, the notional amount of the equity tranche investor's position is completely wiped out, and the investor receives neither coupons nor principal going forward. Because a 10% loss in the portfolio translates into a 100% loss for the equity tranche investor, the equity tranche investor is leveraged 10 to 1.

The CDO issuer would then continue to create more senior tranches, each designed to absorb losses after the capital in the more junior tranches is extinguished. Taken together, a set of tranches might include the 0%–10% equity tranche, and 10%–15%, 15%–25%, 25%–35%, and 35%–100% tranches.[8]

A. CDO Equity and Bank Stock

By absorbing the first credit losses on the underlying portfolio, the equity tranche has a key role in the CDO capital structure as the residual claim on the underlying credit portfolio. Thus, despite being typically viewed as a fixed-income security, the designation of this tranche as equity is actually a very apt description in the usual stock-market sense. For example, the simple fact that CDO equity has the word "equity" in the title is a reflection of the widespread belief in financial markets that CDO equity can be viewed as "synthetic stock." To see the intuition behind this, recall that many CDOs were created by banks' and other financial institutions' spinning off their assets into structured portfolios with capital structures closely paralleling those of the original institutions. For example, Table 1 presents the balance sheet for a hypothetical bank with a portfolio of loans

[7] This example parallels Longstaff and Rajan (2008). Also see the illustration of a subprime home-equity asset-backed CDO structure in Longstaff (2010).

[8] In our example, the CDO is based on a portfolio of debt securities and is referred to as a cash CDO. Credit markets have also introduced synthetic CDOs which are similar to cash CDOs but are based on a basket of CDS contracts rather than an actual portfolio of debt securities. If there is a default on the underlying reference debt security, then the buyer of protection is able to put the defaulted bond or loan to the protection seller and receive par. Thus, for the purposes of this paper, the two types of CDOs are economically equivalent.

TABLE 1

Balance Sheets for a Commercial Bank and a CDO

Table 1 presents balance sheets for a stylized commercial bank and for a simple CDO structure created by spinning off the assets of the bank and with a capital structure similar to that of the bank.

Panel A. Commercial Bank			*Panel B. CDO*		
Assets	Liabilities	Loss Order	Assets	Liabilities	Loss Order
Loans	Deposits	30–100	Loans	Super Senior	30–100
	Senior Secured	20–30		Senior	20–30
	Junior Unsecured	15–20		Senior Mezzanine	15–20
	Preferred Stock	10–15		Junior Mezzanine	10–15
	Common Stock	0–10		Equity	0–10

on the asset side and different layers of debt and equity on the liability side. Contrast this balance sheet with that which would be created by spinning off these assets into a CDO structure with tranches mimicking the capital structure of the bank. As can be seen, the two balance sheets are essentially equivalent. From this perspective, it would not be surprising for market participants to view CDO equity as being analogous to bank equity. Thus, to the extent that stocks are driven by unique factors (e.g., sentiment, liquidity, etc.) not shared by fixed-income markets, these factors could possibly show up in CDO equity returns.

Of course, in reality, practitioners are well aware that this analogy can only be taken so far. Actual banks are different from these CDO "shadow banks" in a number of important ways. These include, but are not limited to, an actual bank having growth options, a more diversified and actively managed portfolio of assets, and potentially more diversified operations (e.g., brokerage, investment banking services, and proprietary trading activities). Additionally, deposits and other sources of funding for actual banks are subject to "runs" or other liquidity shocks (e.g., those initiated by regulators) whereas funding for CDOs is essentially "locked in."[9] While we do not wish to minimize these substantive differences, significant similarities between these two structures remain.

The percentage of equity capital in a commercial bank is analogous to the thickness of the equity tranches in a CDO. For example, a CDO equity tranche with a thickness of 10% is analogous to a stylized bank with 10% equity capital. It is important to recognize that equity tranches with different thicknesses can be constructed by combining the equity tranche with tranches that are more senior in the capital structure. For example, an investor could construct a 0%–15% equity tranche by buying both the 0%–10% equity tranche and the 10%–15% junior mezzanine tranche. This is because the investor would absorb the first 15% of credit losses (the first 10% via the equity tranche and the next 5% via the junior mezzanine tranche). Similarly, the investor could construct a 0%–20% equity tranche by buying the 0%–10%, 10%–15%, and 15%–20% tranches, and so forth. Thus we can create CDO equity tranches with varying degrees of leverage.

B. Data

In this study, we focus on CDO equity with cash flows tied to the most liquid U.S. corporate credit derivative indexes: the CDX North American

[9] We thank the referee for this observation.

Investment-Grade (CDX IG) and High-Yield (CDX HY) indexes. These indexes are managed by Dow Jones and are based on liquid baskets of CDS contracts for 125 U.S. firms with investment-grade debt for the CDX IG index and 100 U.S. firms with high-yield debt for the CDX HY index. The CDX indexes themselves trade similar to a single-name CDS contract, with a defined premium based on the equal-weighted basket of its constituents.

Much of our analysis involves comparing CDX equity to bank stock. Ideally the assets of the CDO would match those of a representative commercial bank and would include loans to commercial businesses and households. The reference securities of the CDX include loans to corporations only and therefore do not perfectly reflect the assets of a typical commercial bank. Other credit indexes may better capture different components of a bank's assets, such as the LCDX index (whose reference securities include leveraged loan CDS contracts on syndicated secured first lien loans) and the ABX indexes (whose reference securities consist of CDO tranches on portfolios of subprime residential mortgages). While we do not have CDO tranche data for the LCDX and ABX indexes, the correlation of weekly changes between the CDX indexes and the LCDX and ABX indexes are between 0.65 and 0.85. We argue that the reference securities of the CDX are sufficiently correlated with the assets of a typical commercial bank so as to not invalidate the comparison.

The CDX indexes are reconstituted every 6 months. Consequently, a firm that appears in CDX $n-1$ may not appear in CDX n if the firm defaults, if its credit rating drops below investment grade, or even if the liquidity of CDS contracts of that firm declines. For the CDX IG and CDX HY family of indexes, the average turnover between indexes is approximately 5.2% and 6.2%, respectively. Both the CDX IG and CDX HY indexes are broadly diversified across most major industries. The primary difference in the industry composition between the CDX IG and HY indexes is that the former typically has a 20% weight in the finance industry (within the Fama-French 12-industry groupings) while the latter has a 4% weight.

Index CDO tranches have also been issued, each tied to a specific CDX index. For the CDX IG indexes, the attachment points of these CDO tranches are standardized at 3%, 7%, 10%, 15%, and 30%. For the CDX HY indexes, the attachment points of these CDO tranches are standardized at 10%, 15%, 25%, and 35%. The CDO data include daily closing values for each of these tranches on the 10-year CDX IG index for the period Jan. 2, 2004–Feb. 20, 2009. As discussed earlier, the underlying basket of firms in each index is revised every March and September. Thus, the data are for the 11 individual indexes denoted CDX IG i, $i = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10$, and 11. In addition, we have daily closing values for the 0%–10%, 10%–15%, 15%–25%, and 25%–35% tranches on the 5-year CDX HY index for the period Dec. 29, 2004–Feb. 20, 2009. These data are for the 9 individual indexes denoted CDX HY i, $i = 3, 4, 5, 6, 7, 8, 9, 10$, and 11. These data were provided to us by courtesy of a large top-tier fixed-income asset management firm.

From these tranches, we can construct 0%–3%, 0%–7%, 0%–10%, 0%–15%, and 0%–30% CDO equity tranches for the CDX IG index and 0%–10%, 0%–15%, 0%–25%, and 0%–35% CDO equity tranches for the CDX HY index. We designate these tranches by IG_3, IG_7, IG_{10}, IG_{15}, IG_{30}, HY_{10}, HY_{15},

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HY_{25}, and HY_{35}, where the subscript denotes the tranche thickness, which is analogous to the percentage of equity capital of a stylized bank.

We focus on weekly CDO equity returns throughout the analysis, where the returns are based on Wednesday data (Tuesday when market data for Wednesday are not available). Given the points-up-front price for the CDO equity tranches, computing weekly returns is straightforward. Let p_t be the points-up-front price of a CDO tranche with thickness L. At time t, we construct a funded CDO equity position by buying a riskless floating-rate note with coupon r_t and notional amount 1, and receiving an up-front payment of p_t for bearing the first credit losses on the underlying credit portfolio. Thus, the initial cost of the portfolio is $(1 - p_t)$. At time $t+1$, the portfolio is liquidated at current market prices. Specifically, the cash generated by liquidation is the sum of $r_t/52$ and $(1 - p_{t+1})(1 - x_{t+1}/L)$, where the first term is the accrued interest on the floating-rate note and the second term is the cash generated by liquidating the floating-rate note and credit protection leg (taking into account the impact of any realized credit losses x_{t+1} on the CDX index during the return period).[10]

Table 2 contains summary statistics for the weekly return data of our CDX equity tranches. We also include the coefficient estimate from a first-order

TABLE 2

Summary Statistics for Weekly Returns

Table 2 reports summary statistics for weekly returns of the CDX equity tranches, equity market indexes, bank stock indexes, and fixed-income indexes. The CDX IG equity tranches are denoted IG_3, IG_7, IG_{10}, IG_{15}, and IG_{30}, where the subscript denotes the amount of equity capital in the tranche. The CDX HY equity tranches are similarly denoted as HY_{10}, HY_{15}, HY_{25}, and HY_{35}. We also include summary statistics for the S&P 500 total return index and the CRSP VW market index. We include three bank indexes. The first represents the largest 30 banks in our sample by asset size (large Wall Street banks). The second consists of the next largest 100 banks (large regional banks). The third bank index consists of the smallest 232 banks in our sample (small regional banks). Fixed-income indexes are from Barclays and include Treasury, investment-grade, high-yield, a finance industry, and MBS indexes. Summary statistics include the mean, median, standard deviation, and observations representing the 5th and 95th percentile for each variable (all variables are reported in percentages). Also included are the coefficient estimates from an AR(1) model for each of the time series used in this study, where * and ** indicate significance at the 10% and 5% levels, respectively.

				Percentile		
	Mean	Median	Std Dev	5th	95th	AR(1)
IG_3	−0.64	0.07	8.85	−15.40	10.48	−0.019
IG_7	−0.68	−0.04	8.52	−14.36	10.26	0.016
IG_{10}	−0.49	0.01	6.20	−9.56	6.28	0.027
IG_{15}	−0.28	0.01	3.70	−5.03	3.64	0.027
IG_{30}	−0.10	−0.01	1.59	−2.39	2.13	−0.030
HY_{10}	−0.67	0.03	11.33	−20.19	15.39	−0.050
HY_{15}	−0.74	0.20	9.77	−17.07	11.71	0.029
HY_{25}	−1.28	0.10	12.38	−16.07	9.80	0.139
HY_{35}	−1.08	0.08	10.35	−9.14	6.90	0.124
S&P 500	−0.11	0.11	2.28	−3.66	2.96	−0.010
CRSP VW market	−0.05	0.24	2.40	−3.86	3.25	−0.009
Banks (national)	−0.33	0.01	4.52	−8.37	5.03	−0.218*
Banks (large regional)	−0.11	−0.02	3.44	−6.05	4.29	−0.186**
Banks (small regional)	−0.18	−0.08	2.45	−3.93	3.39	−0.041
Barclays Treasury (intermediate)	0.09	0.06	0.47	−0.71	0.90	−0.070
Barclays IG (intermediate)	0.05	0.07	0.62	−0.88	0.92	0.116
Barclays HY (intermediate)	0.01	0.17	1.17	−1.56	1.04	0.520**
Barclays finance industry	0.02	0.05	0.81	−0.87	0.96	−0.002
Barclays MBS	0.11	0.11	0.51	−0.66	0.81	−0.218**

[10]There were a number of firms included in the on-the-run CDX IG and HY indexes that defaulted during the sample period including Fannie Mae, Freddie Mac, Collins & Aikman, Delphi, Calpine, Tribune, and Smurfit-Stone Container.

autoregression (AR(1)) model on the weekly data where a negative coefficient could signal measurement error. For weekly returns, none of the CDX equity tranches display a significant and negative coefficient estimate.[11]

III. Is CDO Equity Similar to Stock?

As discussed in Section II.A, there are many economic similarities between CDO equity and bank stock. A first step in studying how the market values CDO equity is to examine whether or not CDO equity returns are similar to stock returns in general.

Table 2 contains summary statistics for the weekly returns for a number of asset categories. Included are summary statistics for the weekly returns for each of the CDX equity tranches, the Standard & Poor's (S&P) 500 total return index, and the Center for Research in Security Prices (CRSP) value-weighted (VW) market index. To facilitate a comparison between bank stock and CDO equity, we create three bank indexes for commercial banks and savings institutions, 3-digit Standard Industrial Classification (SIC) codes 602 and 603, respectively. The first consists of the largest 30 banks by total assets (large Wall Street banks). This index includes banks such as Citigroup, Bank of America, JPMorgan Chase, and Wells Fargo. The second bank index consists of the next 100 banks by size (large regional banks). These include City National Bank, TCF Bank, and Citizens Bank. The third index includes the smallest 232 banks (small regional banks and savings institutions). These include Bank of the Ozarks, Farmers Capital Bank, and Indiana Community Bank. In terms of the complexity of their assets, the regional banks are likely to be more similar to the portfolios of CDO equity than the assets of Wall Street banks. We also include several fixed-income indexes, provided by Barclays Capital. These include an intermediate Treasury index, an investment-grade corporate bond index, a high-yield index, a finance industry bond index, and an index based on MBS.

In terms of their first moments, the mean returns of all the CDX equity tranches and equity indexes are all negative, while the mean returns to the fixed-income indexes are all positive. Thus, CDO equity is more similar to stock than fixed-income securities in terms of average returns. In terms of their volatilities, CDO equity appears to be much more similar to stocks as opposed to the fixed-income securities. In particular, CDO equity volatilities are most similar to the volatilities of the bank indexes, which are as much as twice that of the general equity indexes (the S&P 500 and CRSP VW indexes). Only the IG_{30} tranche has a volatility that is less than the general equity market indexes.

[11]We also run AR(1) processes on the daily CDX equity tranche returns, in which we find that only one, the HY_{15} equity tranche, has a significant negative coefficient. In addition, we also note the number of daily observations for which there is no points-up-front price change from one day to the next. For the CDX IG equity tranches, the percentage of daily observations for which there is no price change ranges from 14.0% to 21.7%. By way of comparison, the percentage of daily observations for which there is no price change in constant maturity Treasury data for the same time period ranges from 8.0% (for 5-year Treasuries) to 15.7% (for 3-month Treasuries). For the CDX HY tranches, the percentage of observations for which there is no price change is somewhat higher, ranging from 22.8% to 39.8%. None of the weekly price changes are equal to 0.

Not surprisingly, the volatility of the CDX IG tranches is increasing with leverage. The tranches whose volatilities are most similar to the bank indexes are those whose equity capital is 10% and 15%, with volatilities of 6.20% and 3.70%, respectively. This is similar to the equity capital range of the typical bank. By comparison, the volatility of the bank indexes ranges between 2.45% for the small regional banks and 4.52% for the Wall Street banks. Thus it appears the volatility of the CDX IG tranches is close to the volatility of similarly levered banks.

By way of comparison, the volatilities of the fixed-income indexes are much smaller, typically only about one-tenth the volatility of the CDX equity tranches. Thus, at first glance, the returns to CDO equity appear to be more similar to the stock indexes than the fixed-income indexes.

To further examine the relation between CDO equity and stock market factors, we regress weekly excess CDX equity returns within a single-factor model for equity returns as well as a Fama-French (1993) 3-factor model,[12]

$$R_t = \alpha + \mathrm{MKT}_t + \epsilon_t, \quad (1)$$

$$R_t = \alpha + \beta_1 \mathrm{MKT}_t + \beta_2 \mathrm{SMB}_t + \beta_3 \mathrm{HML}_t + \epsilon_t, \quad (2)$$

where R_t is the excess weekly return to CDO equity, MKT_t is the weekly Fama-French excess market return, and SMB_t and HML_t are the weekly Fama-French size and value factors, respectively.

Results of this analysis can be seen in Table 3. Panel A presents the results of the single-factor model, and Panel B presents the results of the Fama-French (1993) 3-factor model. One question studied in the mutual fund literature is whether actively managed mutual funds add value relative to their passively managed counterparts. An analogous question could be raised here: Do relatively passive "shadow banks," which do not have employee salaries to pay or similar levels of regulation with which to comply, outperform their actively managed and heavily regulated counterparts on a risk-adjusted basis? Panel A does not support the idea that they do; the alphas of all the CDX equity and bank indexes are statistically insignificant. The alphas of the Fama-French 3-factor model in Panel B are negative and significant for two of the bank indexes, however, while the alphas of the CDX equity tranches are not significant above the 10% level (though they are negative). The result in Panel B provides weak evidence that the passively managed "shadow banks" outperform their active counterparts on a risk-adjusted basis.

Turning our attention to the estimated market betas, in Panel A of Table 3 we find that the CDX IG equity tranches have market betas that are significant at a reasonable confidence interval. The beta exposure increases almost monotonically with leverage within the CDX IG equity tranches. For the least levered CDX IG tranche, IG_{30}, beta is 0.35 while the beta exposure for the most highly levered tranche, IG_3, is 1.82. By comparison, the beta exposure for our bank indexes ranges from 0.77 for the small regional banks, to 1.37 for the Wall Street banks.

[12]Weekly equity returns are calculated similar to the weekly CDX equity returns, as discussed in Section II.B.

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In terms of their leverage and the credit quality of their asset portfolio, the IG_{10} and IG_{15} tranches are most similar to banks, and their market betas are 1.48 and 0.85, respectively. Thus, in terms of their beta exposure, CDX IG equity is similar to that of similarly levered banks. The CDX HY market betas range between 1.02 and 1.69 and increase monotonically with leverage. However, only the two most levered CDX HY equity tranches (HY_{10} and HY_{15}) have market betas whose statistical significance is above the 10% level.

By way of comparison, the Treasury, investment-grade, finance industry, and MBS indexes have economically insignificant market betas (all less than 0.012, though the Treasury index is statistically significant at −0.055) and do not appear to behave like stock at all in this regard. Consistent with the findings of previous

TABLE 3

Regressions of the Excess Returns to CDX Equity, Bank Stocks, and Fixed-Income Indexes on Fama-French Equity Market Factors

Table 3 reports the coefficient estimates and Newey-West (1987) *t*-statistics from regressions of the weekly excess returns to CDX equity tranches, bank stock indexes, and fixed-income indexes on equity market factors. Dependent variables are listed by row, and independent variables listed by column. Panel A reports coefficient estimates of a single-factor model; Panel B reports estimates of a Fama-French (1993) 3-factor model. * and ** indicate significance at the 10% and 5% levels, respectively.

$$R_t \quad = \quad \alpha + \text{MKT}_t + \epsilon_t$$

Panel A. Single-Factor Model

	α	MKT	Adj. R^2
IG_3	−0.005 (−1.09)	1.824** (6.69)	0.243
IG_7	−0.005 (−1.24)	1.984** (6.50)	0.312
IG_{10}	−0.004 (−1.28)	1.478** (6.43)	0.324
IG_{15}	−0.002 (−1.32)	0.854** (5.98)	0.300
IG_{30}	−0.001 (−1.51)	0.353** (5.80)	0.283
HY_{10}	−0.004 (−0.63)	1.693** (3.63)	0.140
HY_{15}	−0.005 (−0.90)	1.613** (4.02)	0.177
HY_{25}	−0.011 (−1.37)	1.246 (1.54)	0.060
HY_{35}	−0.010 (−1.50)	1.020 (1.62)	0.062
Banks (Wall Street)	−0.002 (−1.31)	1.370** (11.12)	0.521
Banks (large regional)	−0.000 (−0.37)	1.120** (14.11)	0.610
Banks (small regional)	−0.002 (−1.60)	0.770** (15.64)	0.562
Barclays Treasury	0.000 (1.19)	−0.055** (−3.36)	0.080
Barclays IG	−0.000 (−0.23)	0.012 (0.41)	0.000
Barclays HY	−0.000 (−0.37)	0.250** (3.95)	0.260
Barclays finance industry	−0.000 (−0.62)	0.025 (0.60)	0.000
Barclays MBS	0.000 (1.55)	−0.000 (−0.01)	0.000

(continued on next page)

TABLE 3 (continued)

Regressions of the Excess Returns to CDX Equity, Bank Stocks, and Fixed-Income Indexes on Fama-French Equity Market Factors

$$R_t = \alpha + \beta_1 \text{MKT}_t + \beta_2 \text{SMB}_t + \beta_3 \text{HML}_t + \epsilon_t$$

Panel B. Fama-French 3-Factor Model

	α	MKT	SMB	HML	Adj. R^2
IG_3	−0.005 (−1.13)	1.703** (5.68)	0.376 (0.79)	0.414 (0.85)	0.247
IG_7	−0.006 (−1.31)	1.819** (6.44)	0.134 (0.29)	0.854* (1.69)	0.324
IG_{10}	−0.004 (−1.33)	1.379** (6.28)	0.067 (0.19)	0.524 (1.42)	0.332
IG_{15}	−0.003 (−1.37)	0.791** (5.50)	0.123 (0.56)	0.273 (1.25)	0.310
IG_{30}	−0.001 (−1.57)	0.323** (5.09)	0.065 (0.64)	0.122 (1.41)	0.291
HY_{10}	−0.005 (−0.67)	1.444** (3.28)	0.088 (0.12)	1.316 (1.49)	0.156
HY_{15}	−0.005 (−0.95)	1.364** (3.67)	0.078 (0.12)	1.321* (1.69)	0.193
HY_{25}	−0.012 (−1.42)	0.836 (1.08)	0.297 (0.36)	2.093** (2.08)	0.102
HY_{35}	−0.010 (−1.55)	0.693 (1.27)	−0.273 (−0.33)	1.935 (1.61)	0.111
Banks (Wall Street)	−0.003** (−2.16)	1.118** (10.88)	−0.404** (−2.61)	1.757** (7.13)	0.752
Banks (large regional)	−0.001 (−0.76)	0.902** (10.65)	0.525** (4.06)	0.864** (5.78)	0.713
Banks (small regional)	−0.002** (−2.24)	0.591** (11.77)	0.761** (6.47)	0.465** (4.86)	0.700
Barclays Treasury	0.000 (1.17)	−0.059** (−3.27)	0.017 (0.63)	0.007 (0.19)	0.070
Barclays IG	−0.000 (−0.23)	0.011 (0.36)	0.016 (0.32)	−0.009 (−0.18)	0.000
Barclays HY	−0.000 (−0.44)	0.222** (3.40)	0.106 (1.59)	0.087 (1.13)	0.270
Barclays finance industry	−0.000 (−0.64)	0.022 (0.51)	−0.000 (−0.00)	0.014 (0.21)	0.011
Barclays MBS	0.000 (1.53)	−0.005 (−0.20)	0.033 (0.61)	0.000 (0.01)	0.002

work, however, the high-yield index has a statistically significant market beta of 0.25 and does appear to be affected by stock market factors, though its equity beta is lower than those of CDX equity tranches.

The results for market beta exposure are qualitatively similar when a Fama-French (1993) 3-factor model is used in Panel B. Taken together, the results for market betas in Table 3 are consistent with CDX equity being priced similar to stock, and this is not generally true for the fixed-income securities.

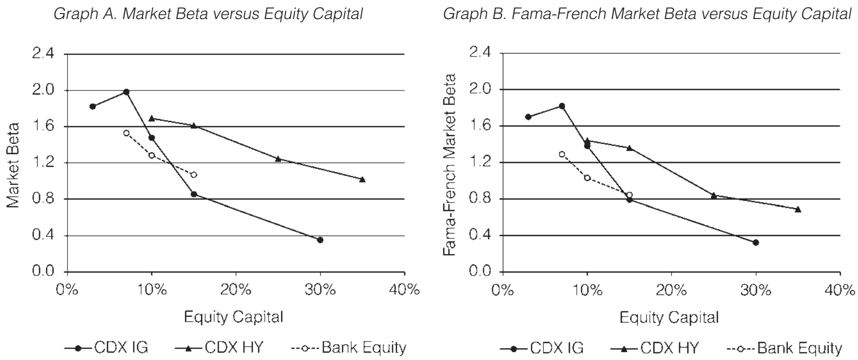
We examine the effect of leverage on market betas (as measured by equity capital in banks, or the equity tranche thickness in the case of CDX equity) in Figure 1. To do this, we create three new bank indexes based on their equity capital. The first index includes banks whose equity capital is between 0% and 7%, the second between 7% and 10%, and the third between 10% and 15% (very few banks have equity capital greater than 15%). We then plot the resulting market betas versus leverage for the bank stock as well as the CDX indexes in Figure 1.

Graph A shows the beta from a single-factor model while Graph B shows the resulting market betas from a Fama-French (1993) 3-factor model. While not exactly the same, the market betas for the bank stock and CDX IG equity are very similar for given levels of leverage, consistent with the market's viewing them as economically similar structures and pricing them accordingly. The results are not as similar between banks and CDX HY equity, although this is not surprising; the reference portfolio of the CDX HY index consists entirely of high-yield debt, and the assets of most commercial banks do not contain similar levels of risk.

FIGURE 1

Market Betas versus Equity Capital for CDX Equity Tranches and Bank Indexes

Figure 1 plots the market betas of two different models versus the equity capital for three bank indexes as well as the IG and HY CDX equity tranches. Graph A plots the market betas estimated from a single-factor model while Graph B plots the market betas estimated from a Fama-French (1993) 3-factor model.



Adjusted R^2 values in Table 3 are similar for CDX IG tranches and bank indexes within the single-factor model in Panel A (between 0.24 and 0.32 for the CDX IG equity tranches, and 0.52 and 0.61 for the bank stocks). The adjusted R^2 values of the fixed-income indexes are very low, typically around 0 (the exception being the high-yield index at 0.26). As before, the results for the Fama-French (1993) 3-factor model in Panel B are qualitatively similar to those in Panel A. As with the results for market beta, the results for adjusted R^2 indicate that CDX equity is explained by equity market factors, and this stands in contrast to most of the fixed-income assets considered which do not appear to be related to equity market factors.

IV. Is CDO Equity Similar to Bank Stock?

The results in the previous section are consistent with CDO equity's being priced similarly to stock. The next question is this: What kind of stock? We wish to determine which industry returns are most similar to CDO equity returns. To make this determination, we run a regression of excess CDX equity returns on the excess Fama-French 12-industry returns, or

$$R_t = \alpha + \sum_{i=1}^{12} \beta_i R_t^i + \epsilon_t, \tag{3}$$

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where R_t is the excess return for one of the CDX equity tranches and R_t^i is the excess sector return for industry i. Despite the economic similarities between CDO equity and bank stock, it is not obvious ex ante that CDX equity returns are most similar to the finance sector or bank stock. Recall that the reference portfolios of our CDX indexes is comprised of corporate debt, so it would not be entirely surprising if the returns to our CDX equity tranches were better explained by an industry sector other than finance.

The results of the regression specified in equation (3) are reported in Table 4. It can be seen that, for every CDX equity tranche, the beta estimate on the finance industry is positive and significant. With a few exceptions, none of the other industry betas are statistically significant and, among those that are, the results are not consistent between the various CDX equity tranches (e.g., the beta for the telecommunications industry is significant for the IG_3 returns, but not for any of the other CDX equity tranches). Similarly, the pairwise correlations between the

TABLE 4

Regressions of Excess Returns to CDX Equity on Fama-French 12-Industry Factors

Table 4 reports the coefficient estimates and Newey-West (1987) *t*-statistics from regressions of the weekly excess returns to CDX equity tranches R_t on excess returns to the Fama-French 12-industry factors, R_t^i for industry *i*. Dependant variables are listed by column, and independent variables are listed by row. * and ** indicate significance at the 10% and 5% levels, respectively.

$$R_t = \alpha + \sum_{i=1}^{12} \beta_i R_t^i + \epsilon_t$$

	CDX IG Equity					CDX HY Equity			
Industry	IG_3	IG_7	IG_{10}	IG_{15}	IG_{30}	HY_{10}	HY_{15}	HY_{25}	HY_{35}
Nondurable	0.017	0.338	0.319	0.189	0.017	–0.857	–0.631	–0.679	–0.991
	(0.03)	(0.58)	(0.75)	(0.72)	(0.15)	(–0.87)	(–0.73)	(–0.60)	(–0.94)
Durable	–0.688*	–0.415	–0.375	–0.271	–0.126*	0.276	0.351	0.238	0.362
	(–1.81)	(–1.02)	(–1.23)	(–1.49)	(–1.65)	(0.53)	(0.77)	(0.37)	(0.83)
Manufacturing	0.943	1.482*	1.158*	0.614*	0.211	0.606	0.569	0.685	0.488
	(1.27)	(1.79)	(1.87)	(1.67)	(1.38)	(0.64)	(0.67)	(0.49)	(0.57)
Energy	–0.148	0.124	0.089	0.052	0.023	0.143	0.118	–0.368	–0.368
	(–0.53)	(0.35)	(0.33)	(0.32)	(0.34)	(0.33)	(0.31)	(–0.65)	(–0.86)
Chemicals	–0.438	–0.739	–0.516	–0.249	–0.064	0.138	0.150	0.935	0.530
	(–0.78)	(–1.04)	(–1.01)	(–0.83)	(–0.52)	(0.17)	(0.19)	(0.55)	(0.48)
Business equipment	0.463	–0.040	–0.055	0.014	0.048	–0.017	–0.127	–0.080	–0.350
	(1.22)	(–0.11)	(–0.19)	(0.07)	(0.61)	(–0.03)	(–0.23)	(–0.10)	(–0.52)
Tele-communications	1.187**	0.379	0.250	0.085	0.039	0.533	0.524	–0.306	–0.023
	(2.99)	(0.89)	(0.81)	(0.45)	(0.45)	(1.07)	(1.12)	(–0.34)	(–0.04)
Utility	0.087	–0.295	–0.181	–0.110	–0.050	0.020	0.235	0.825	1.200
	(0.21)	(–0.68)	(–0.57)	(–0.58)	(–0.63)	(0.02)	(0.30)	(0.82)	(0.99)
Shops	–0.377	–0.393	–0.250	–0.117	–0.053	–1.387	–1.339*	–1.732*	–1.714
	(–0.76)	(–0.69)	(–0.56)	(–0.44)	(–0.49)	(–1.60)	(–1.72)	(–1.93)	(–1.61)
Health	–0.238	0.366	0.297	0.211	0.096	0.477	0.474	0.535	0.236
	(–0.59)	(0.97)	(1.08)	(1.20)	(1.23)	(0.72)	(0.80)	(0.45)	(0.31)
Finance	0.718**	0.971**	0.677**	0.423**	0.233**	1.204**	1.007**	1.221**	0.861**
	(2.01)	(3.01)	(2.52)	(2.41)	(3.27)	(2.95)	(2.75)	(2.25)	(1.99)
Other	–0.022	–0.218	–0.168	–0.072	–0.067	–0.192	–0.268	–0.263	0.384
	(–0.03)	(–0.18)	(–0.19)	(–0.14)	(–0.34)	(–0.20)	(–0.30)	(–0.18)	(0.34)
Constant	–0.005	–0.005	–0.004	–0.003	–0.001	–0.001	–0.003	–0.008	–0.007
	(–1.09)	(–1.21)	(–1.34)	(–1.39)	(–1.50)	(–0.23)	(–0.53)	(–1.13)	(–1.25)
No. of obs.	267	267	267	267	267	216	216	216	216
Adj. R^2	0.271	0.320	0.332	0.317	0.311	0.162	0.203	0.083	0.110

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CDX equity returns and the Fama-French 12-industry finance sector are higher than the correlations between CDX equity returns and the other industry groupings.

In untabulated results, we repeat the analysis in equation (3) with Fama-French 49-industry groupings. The 49-industry sectors further divide the finance sector into four subsectors: banks, insurance companies, real estate, and trading. We find that, out of the 49 industries, the betas on the banking sector are consistently positive and significant whereas very few of the other sector betas are estimated with statistical significance at a reasonable confidence interval (typically only one or two other sectors are significant above the 10% level for each equity tranche). Similar to the previous analysis, and consistent with the regression results, the pairwise correlations between CDX equity returns and the banking sector are highest within the 49-industry classifications.

The results of Table 4 and our untabulated analysis are consistent not only with CDX equity's being priced similar to equity in general, but the finance sector and banks in particular. Thus the market appears to value CDO equity similar to its stock market equivalent.

V. What Kinds of Bank Stocks Are Similar to CDO Equity?

Having established that CDO equity is similar to bank stock, we turn our attention toward determining what kinds of bank stocks are most similar to CDO equity. Not all bank stocks are the same, and some are more similar to CDX equity than others. For example, the CDX index consists of corporate debt, and while some banks count a large portion of commercial loans in their portfolio, others hold little or no commercial debt. Furthermore, the funding of banks is subject to liquidity shocks, such as "runs" on the bank by depositors, the availability and cost of wholesale funding, or corrective action by regulators (e.g., the Federal Deposit Insurance Corporation (FDIC)). These types of liquidity shocks can cause banks to fail if they cannot convert some of their assets to cash. CDO equity, on the other hand, is not subject to these kinds of shocks, having effectively "locked in" the funding source when they were created and sold. To determine the characteristics of those banks which are most similar to CDO equity, we calculate the correlation ρ_{ij} between the weekly returns for each CDX equity tranche i and each bank j over the entire sample period.[13] We then estimate the parameters of the following model,

$$(4) \qquad \text{logit}(\rho_{ij}) = \gamma_0 + \gamma_1 \ln(\text{Asset Size})_j + \gamma_2 \text{Commercial Loans}_j + \gamma_3 \text{Core Funding}_j + \gamma_4 \text{Equity Capital}_j + \epsilon_j.$$

The bounded support for the correlation ρ_{ij} raises a potential concern within a linear regression, so we transform ρ_{ij} using a logit transformation which maps ρ_{ij}

[13]Correlations are calculated across the entire sample period, and calculations with less than 52 observations are thrown out. All bank characteristics are measured at the beginning of the sample period. Accounting data for banks and bank holding companies are from regulatory filings with the Federal Reserve Bank of Chicago and made available through Wharton Research Data Services (WRDS). Accounting data was matched to returns from CRSP using a join table from the Federal Reserve Bank of New York.

to the whole real line.[14] The independent variables include ln(Asset Size)$_j$, the log of the total assets; Commercial Loans$_j$, the ratio of commercial loans to total assets; Core Funding$_j$, the core funding ratio; and Equity Capital$_j$, the ratio equity capital for each bank i. Among other things, asset size may capture some of the likelihood that the bank is holding derivatives similar to CDO equity (the larger the bank, the more likely this is the case). We therefore expect the coefficient on asset size to be positive. Commercial loans is a proxy for the level of similarity between the assets of a particular bank and CDX equity tranche; the CDX indexes consist entirely of corporate debt, and so the higher the percentage of assets consisting of commercial loans for a given bank, the greater the economic similarity between that bank's stock and CDX equity. We therefore expect the coefficient estimate on commercial loans to be positive. Core funding is a proxy for the stability of a bank's funding, and the higher the level of financing stability, the more economically similar the bank is to a CDO structure. We therefore expect the coefficient estimate on core funding to be positive. Finally, the more similar the level of equity capital of a bank is to the thickness of CDX equity tranche j, the higher we expect the correlation to be. All variables are measured at the beginning of the sample period and are from the bank regulatory filings with the Federal Reserve Bank of Chicago and made available through WRDS. Accounting data was matched to returns in CRSP using a join table from the Federal Reserve Bank of New York.

Results from estimating equation (4) are contained in Table 5. We estimate the model for banks within each of our banking indexes. Panel A reports the results for large Wall Street banks (the top 30 banks in our sample). As expected, the coefficient estimates on bank size and ratio of commercial loans is positive and significant for each of the CDX equity tranches. Coefficient estimates on equity capital are significant only for the CDX IG tranches. The coefficient estimates on core funding are not significant, either statistically or economically, for any of the CDX tranches. Adjusted R^2 values are also fairly high, ranging from 0.32 to 0.42.

Panel B of Table 5 reports results for the large regional banks (the next largest 100 banks in our sample). Within this sample, none of the coefficient estimates are significant, and the adjusted R^2 values are all very low (typically around 0). Note this does not mean that CDX equity returns are uncorrelated with the large regional banks; rather, our model does not capture any factors that seem to explain this correlation in the cross section. Unconditionally, the average correlation between the banks and CDX equity tranches does not differ much among the banks within each bank index. For example, the average pairwise correlation between Wall Street banks and the CDX IG tranches is 0.27. The average pairwise correlations between large and small regional banks and the CDX IG trances are 0.26 and 0.20, respectively. Finally, Panel C contains results for the small regional banks (the final 232 banks in the sample). As with Panel A, the coefficient estimates on size are significant for most of the CDX equity tranches whereas the coefficient estimates on commercial loans is statistically significant only for the most levered

[14]We define $\text{logit}(\rho_{ij}) = \ln[(1 + \rho_{ij})/(2 - (1 + \rho_{ij}))]$. Results are very similar if we use ρ_{ij} as the independent variable in equation (4).

TABLE 5

Cross-Sectional Analysis of the Correlation between CDX Equity and Bank Stock Returns

Table 5 reports the coefficient estimates and robust *t*-statistics for regressions of the correlation of weekly returns between the CDX equity tranches and bank stock returns on various factors. The dependent variable is logit(ρ_{ij}), which is a logit transformation of the correlation ρ_{ij} between the returns to CDX equity tranche *i* and the stock returns of bank *j* over the entire sample period (from Jan. 2004 through Feb. 2009). The independent variables consist of various bank characteristics as measured at the beginning of the sample period. These characteristics include the log of total assets, the percentage of assets consisting of commercial loans, the ratio of core funding, and the bank's equity capital percentage. Panel A reports results for the regression within the largest 30 banks in our sample (large Wall Street banks), Panel B reports results for the next largest 100 banks (large regional banks), and Panel C reports results for the smallest 232 banks (small regional banks). * and ** indicate significance at the 10% and 5% levels, respectively.

$$\text{logit}(\rho_{ij}) = \gamma_0 + \gamma_1 \ln(\text{Asset Size})_j + \gamma_2 \text{Commercial Loans}_j + \gamma_3 \text{Core Funding}_j + \gamma_4 \text{Equity Capital}_j + \epsilon_j$$

	CDX IG Equity					CDX HY Equity			
Independent Variables	IG_3	IG_7	IG_{10}	IG_{15}	IG_{30}	HY_{10}	HY_{15}	HY_{25}	HY_{35}
Panel A. Wall Street Banks									
ln(Asset Size)	0.066**	0.114**	0.109**	0.102**	0.096**	0.080**	0.090**	0.088**	0.087**
	(2.68)	(3.09)	(2.92)	(2.76)	(2.77)	(3.72)	(3.50)	(2.89)	(2.91)
Commercial Loans	0.994**	0.878**	0.837**	0.854**	0.861**	0.716**	0.853**	1.006**	1.017**
	(4.92)	(2.85)	(2.67)	(2.93)	(3.34)	(2.12)	(2.21)	(3.37)	(2.75)
Core Funding	–0.300	–0.017	–0.007	0.006	0.001	0.014	0.010	0.061	0.116
	(–1.01)	(0.05)	(–0.02)	(0.02)	(0.00)	(0.05)	(0.03)	(0.19)	(0.36)
Equity Capital	–5.001**	–4.469**	–3.857**	–3.410**	–3.557**	–0.914	–1.495	–0.060	–0.052
	(–2.85)	(–2.35)	(–2.11)	(–2.04)	(–2.48)	(–0.75)	(–1.11)	(–0.05)	(–0.03)
Constant	–0.425	–1.250*	–1.210*	–1.143*	–1.002	–0.974**	–1.109**	–1.342**	–1.308**
	(–0.80)	(–1.76)	(–1.67)	(–1.64)	(–1.59)	(–2.53)	(–2.49)	(–2.78)	(–2.54)
No. of obs.	30	30	30	30	30	30	30	30	30
Adj. R^2	0.421	0.357	0.320	0.319	0.365	0.357	0.354	0.363	0.333
Panel B. Large Regional Banks									
ln(Asset Size)	0.003	–0.016	–0.013	–0.016	–0.004	–0.007	–0.003	–0.017	0.008
	(0.11)	(–0.40)	(–0.35)	(–0.43)	(–0.10)	(–0.20)	(–0.08)	(–0.48)	(0.22)
Commercial Loans	–0.154	–0.137	–0.107	–0.103	–0.127	0.011	–0.075	–0.037	–0.036
	(–0.50)	(–0.37)	(–0.30)	(–0.31)	(–0.37)	(0.05)	(–0.31)	(–0.14)	(–0.15)
Core Funding	–0.140	0.038	0.042	0.087	0.149	0.001	–0.008	0.039	0.029
	(–0.86)	(0.19)	(0.22)	(0.49)	(0.86)	(0.01)	(–0.04)	(0.24)	(0.17)
Equity Capital	0.816	1.105	1.248	1.265	1.341	–0.038	0.175	–0.412	–0.290
	(0.96)	(1.07)	(1.23)	(1.32)	(1.40)	(–0.05)	(0.20)	(–0.50)	(–0.35)
Constant	0.324	0.666	0.625	0.643	0.472	0.512	0.453	0.610	0.240
	(0.70)	(1.14)	(1.12)	(1.20)	(0.85)	(0.96)	(0.79)	(1.10)	(0.49)
No. of obs.	100	100	100	100	100	100	100	100	100
Adj. R^2	0.023	0.016	0.019	0.025	0.032	0.000	0.001	0.004	0.002
Panel C. Small Regional Banks									
ln(Asset Size)	0.192**	0.206**	0.204**	0.194**	0.190**	0.100**	0.098**	0.040	0.046
	(7.74)	(7.32)	(7.24)	(7.10)	(7.07)	(3.44)	(3.27)	(1.26)	(1.34)
Commercial Loans	0.419*	0.268	0.259	0.252	0.313	0.328	0.343	0.065	0.234
	(1.81)	(1.10)	(0.96)	(0.96)	(1.26)	(1.38)	(1.42)	(0.26)	(0.91)
Core Funding	0.061	0.106	0.118	0.108	0.074	0.064	0.089	0.055	0.111
	(0.59)	(0.88)	(0.97)	(0.92)	(0.67)	(0.57)	(0.78)	(0.48)	(0.92)
Equity Capital	0.847**	0.765*	0.660	0.524	0.499	–0.542	–0.415	–0.509	–0.272
	(2.38)	(1.72)	(1.57)	(1.35)	(1.36)	(–0.96)	(–0.77)	(–1.09)	(–0.56)
Constant	–2.398**	–2.536**	–2.504**	–2.354**	–2.294**	–1.069**	–1.038**	–0.279	–0.393
	(–7.22)	(–6.78)	(–6.64)	(–6.43)	(–6.38)	(–2.70)	(–2.57)	(–0.66)	(–0.85)
No. of obs.	232	232	232	232	232	232	232	232	232
Adj. R^2	0.195	0.167	0.165	0.161	0.164	0.057	0.050	0.002	0.000

CDX IG tranche (although the coefficient estimates for the remaining tranches are all positive and economically significant).

Taken together, bank assets seem to explain much of the correlation between CDX equity and individual bank stock returns in the cross section. For the largest banks, the percentage of commercial loans is also important. Core funding does not appear to explain the correlation between bank stock and CDX equity.

VI. Are CDO Equity Returns Driven by Fundamentals?

Another angle from which we can study how the market values "toxic assets" such as CDO equity is to examine whether their returns can be explained by fundamental factors implied by no-arbitrage CDO valuation models. In doing this, our approach closely parallels that used by Collin-Dufresne et al. (2001), who regress credit spread changes on changes in the variables that appear in various structural credit models. They find that changes in these fundamental structural variables explain only a relatively small portion of the variation in credit spread changes. Following Collin-Dufresne et al., our approach is to regress CDO equity returns on changes in key variables suggested by fundamental CDO valuation models.

A number of papers present fundamental CDO valuation models, including Duffie and Gârleanu (2001), Hull and White (2004), Longstaff and Rajan (2008), and Bhansali et al. (2008). A common thread throughout this literature is the representation of losses on CDO tranches in terms of options on the realized credit losses on the portfolio of bonds or loans underlying the CDO. For example, equation (16) of Longstaff and Rajan implies that the total fraction of losses on a CDO equity tranche of thickness $M \in [0, 1]$ can be expressed as

$$\frac{1}{M}\left[L_t - \max\left(0, L_t - M\right)\right], \tag{5}$$

where L_t is the total fraction of portfolio credit losses at date t. This expression is the equivalent of a long position in L_t and short call option on L_t with strike price M. Clearly, the present value of the expression in equation (5) is determined by the distribution (under the risk-neutral or Q-measure) of L_t. Typically, the realized portfolio credit losses L_t are expressed in terms of the realizations of a jump or Poisson process with a possibly time-varying intensity λ_t. The intensity λ_t, therefore, plays a central role in determining the distribution of L_t. For example, recall that both the mean and variance of a Poisson process are proportional to the intensity. In turn, the intensity can be mapped into the credit spread of the debt securities in the underlying portfolio.

Because of this standard credit modeling framework, these types of CDO valuation models all imply that there are at least two key categories of factors driving CDO equity values: the probability of default for assets within the underlying portfolio and the correlation of default events. To capture these, we estimate the coefficients of a model of CDX equity returns similar to that of Collin-Dufresne et al. (2001),

$$\begin{aligned} R_t \quad = \quad & \gamma_0 + \gamma_1 \Delta y_t^{10\text{yr}} + \gamma_2 (\Delta y_t^{10\text{yr}})^2 + \gamma_3 \Delta\text{Slope}_t + \gamma_4 \Delta\text{Volatility}_t \\ & + \gamma_5 \Delta\text{Jump}_t + \gamma_6 \Delta\text{EDF}_t + \gamma_7 \Delta\text{Correl}_t + \gamma_8 \left(\text{EDF}_t \times \Delta\text{Correl}_t\right) \\ & + \gamma_9 \left(\Delta\text{EDF}_t \times \text{Correl}_t\right) + \epsilon_t. \end{aligned} \tag{6}$$

As in Collin-Dufresne et al., we include Δy_t^{10yr}, the weekly change in the 10-year Treasury rate; $(\Delta y_t^{10yr})^2$, the weekly change in the Treasury rate squared; and ΔSlope_t, the weekly change in the slope of the yield curve (where the slope is defined as the difference between the 10- and 2-year Treasury yields). Similar to Collin-Dufresne et al., we also include $\Delta \text{Volatility}_t$, defined as the weekly change in the average implied volatility of stock options on the underlying CDX constituents, and ΔJump_t, the weekly change in the average slope of the volatility smirk of stock options on the underlying CDX constituents in order to proxy for the risk of jump magnitudes and probabilities (estimated as in Collin-Dufresne et al.).

Using the approach of Bharath and Shumway (2008), we create estimates of the expected default frequency (EDF) for each of the constituents of the CDX IG and CDX HY indexes following an application of Merton (1974) and similar to a model developed by the Kealhofer, McQuown, and Vasicek (KMV) Corporation.[15] Estimates of the expected default frequencies are updated weekly using the most recent quarterly accounting data and weekly market capitalization data from CRSP. We then calculate ΔEDF_t, the weekly change of the average EDF values for the CDX constituents.

We also estimate the change in average EDF correlations as follows.[16] First, for each day we estimate the EDF values for each constituent. We then construct a correlation matrix of daily EDF changes for each week (or 5-trading-day rolling period).[17] Finally, we calculate the average pairwise correlation each week. For the CDX IG index, we have sufficient data to construct EDF estimates for approximately 101 firms each week. Thus the average weekly pairwise correlation is based on $(101^2 - 101)/2 = 5{,}050$ unique observations. For the CDX HY index, we construct EDF estimates for approximately 79 firms each week, and so the average weekly pairwise correlation for this index is based on 3,081 unique observations. We then calculate ΔCorrel_t as the weekly change in average pairwise EDF correlations of CDX constituent firms.

We also include interaction terms $\text{EDF}_t \times \Delta \text{Correl}_t$, defined as the average level of constituent EDF measures multiplied by the change in EDF correlations, and $\Delta \text{EDF}_t \times \text{Correl}_t$, defined as the average change in EDF measures multiplied by the level of EDF correlations. These latter two variables capture nonlinear effects due to changes in the average EDF conditional on a given level of EDF correlation, and vice versa.

Table 6 reports the results of our regressions. The dependent variables in Panel A include the returns for the CDX IG equity tranches. For these we find that, similar to Collin-Dufresne et al. (2001), the change and squared change in the 10-year Treasury yield is statistically significant at a reasonable confidence interval for almost all of the tranches. In terms of the variables derived from the underlying portfolio of assets of the CDX IG index, the average changes in implied volatilities, as well as the interaction terms between EDF and EDF correlations,

[15]The required data are available for about 80% of the constituents in each index.

[16]We thank the referee for this suggestion.

[17]Results are similar if we use a 1-month or a 3-month rolling period.

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are also statistically significant. Overall, the adjusted R^2 values are between 0.45 and 0.64.

Panel B of Table 6 includes the results from the regression where the dependent variables consist of returns to the CDX HY equity tranches. As with the CDX IG tranches, and similar to Collin-Dufresne et al. (2001), the change and squared change in the 10-year Treasury yield is statistically significant for most of the CDX HY equity tranches. However, none of the variables derived from the underlying portfolio of CDX HY index are significant. The adjusted R^2 values are lower than those of the CDX IG tranches, ranging from 0.20 to 0.28. Thus, it does not appear that fundamentals explain as much of the CDX HY equity returns as they do those of CDX IG equity.

If bank stocks are economically similar to CDX equity, we expect the underlying fundamentals of the CDX indexes to also explain returns to bank stock.

TABLE 6

Regressions of Weekly CDX Equity Returns on Fundamentals

Table 6 reports the coefficient estimates and robust t-statistics for regressions of weekly CDX equity and bank stock returns on fundamental factors. Dependent variables are listed by column, and independent variables are listed by row. Fundamental factors are similar to those in Collin-Dufresne et al. (2001) and include Δy_t^{10yr}, the change in the 10-year constant maturity Treasury rate; $(\Delta y_t^{10yr})^2$, the change in the Treasury rate squared; and ΔSlope_t, the change in the slope of the yield curve (where the slope is defined as the difference between the 10- and 2-year yields). Also included are $\Delta \text{Volatility}_t$, defined as the average change in the implied volatilities of stock options on the underlying CDX constituents; ΔJump_t, the average change in slope of the volatility smirk of stock options on underlying CDX constituents; ΔEDF_t, the average change of the expected default frequencies of the CDX constituents (computed similar to Bharath and Shumway (2008)); and ΔCorrel_t, defined as the change in the weekly average pairwise correlation between expected default frequencies of CDX constituent firms. We also include interaction terms $\text{EDF}_t \times \Delta \text{Correl}_t$, defined as the average level of constituent EDF measures multiplied by the change in EDF correlations, and $\Delta \text{EDF}_t \times \text{Correl}_t$, defined as the average change in EDF measures multiplied by the level of EDF correlations. * and ** indicate significance at the 10% and 5% levels, respectively.

$$R_t = \gamma_0 + \gamma_1 \Delta y_t^{10yr} + \gamma_2 (\Delta y_t^{10yr})^2 + \gamma_3 \Delta \text{Slope}_t + \gamma_4 \Delta \text{Volatility}_t + \gamma_5 \Delta \text{Jump}_t + \gamma_6 \Delta \text{EDF}_t + \gamma_7 \Delta \text{Correl}_t + \gamma_8 (\text{EDF}_t \times \Delta \text{Correl}_t) + \gamma_9 (\Delta \text{EDF}_t \times \text{Correl}_t) + \epsilon_t$$

Panel A. CDX IG Equity

Independent Variables	IG_3	IG_7	IG_{10}	IG_{15}	IG_{30}
Δy_t^{10yr}	0.220**	0.139**	0.093**	0.055**	0.028**
	(6.92)	(4.87)	(4.31)	(3.84)	(4.01)
$(\Delta y_t^{10yr})^2$	−0.218	−0.416**	−0.283*	−0.189**	−0.079*
	(−1.35)	(−2.25)	(−1.88)	(−2.00)	(−1.84)
ΔSlope_t	−0.038	0.085	0.057	0.020	−0.003
	(−0.73)	(1.64)	(1.51)	(0.89)	(−0.30)
$\Delta \text{Volatility}_t$	−1.491**	−1.340**	−0.969**	−0.546**	−0.238**
	(−7.98)	(−6.50)	(−5.98)	(−5.19)	(−4.89)
ΔJump_t	−0.596	−0.235	−0.203	−0.272	−0.108
	(−0.86)	(−0.44)	(−0.51)	(−1.09)	(−0.88)
ΔEDF_t	0.630*	0.515	0.380	0.158	0.020
	(1.69)	(0.76)	(0.68)	(0.52)	(0.19)
ΔCorrel_t	−0.004	0.016	0.014*	0.009*	0.003
	(−0.32)	(1.36)	(1.72)	(1.79)	(1.49)
$\text{EDF}_t \times \Delta \text{Correl}_t$	0.355**	−0.502**	−0.414**	−0.242**	−0.077**
	(2.10)	(−2.32)	(−2.54)	(−2.76)	(−2.33)
$\Delta \text{EDF}_t \times \text{Correl}_t$	−1.097	−2.758*	−2.210**	−1.164*	−0.279
	(−1.02)	(−1.87)	(−2.05)	(−1.93)	(−1.33)
Constant	0.001	0.005	0.003	0.002	0.001
	(0.16)	(1.28)	(1.24)	(1.42)	(1.33)
No. of obs.	267	267	267	267	267
Adj. R^2	0.452	0.617	0.643	0.614	0.542

(continued on next page)

TABLE 6 (continued)

Regressions of Weekly CDX Equity Returns on Fundamentals

Panel B. CDX HY Equity and Banks

Independent Variables	CDX HY Equity				Banks		
	HY_{10}	HY_{15}	HY_{25}	HY_{35}	National	Large Regional	Small Regional
Δy_t^{10yr}	0.135** (2.36)	0.091** (2.01)	0.103* (1.73)	0.044 (0.99)	0.028 (1.10)	0.013 (0.70)	0.020 (1.62)
$(\Delta y_t^{10yr})^2$	−0.347 (−1.22)	−0.443* (−1.74)	−1.135** (−2.32)	−0.444 (−1.20)	−0.213* (−1.96)	−0.105 (−1.47)	−0.090* (−1.77)
ΔSlope_t	−0.096 (−0.82)	−0.016 (−0.16)	0.201 (1.50)	0.180 (1.33)	−0.009 (−0.23)	−0.014 (−0.48)	−0.019 (−1.04)
$\Delta \text{Volatility}_t$	−0.312 (−0.63)	−0.385 (−0.92)	−0.441 (−0.61)	0.161 (0.25)	−0.651** (−4.92)	−0.551** (−5.20)	−0.374** (−5.40)
ΔJump_t	0.623 (0.52)	0.606 (0.60)	−0.255 (−0.19)	0.538 (0.44)	0.571* (1.68)	0.586** (2.02)	0.226 (1.10)
ΔEDF_t	−0.812 (−1.02)	−0.631 (−1.13)	−0.890 (−1.41)	−0.821 (−1.34)	−1.894** (−4.02)	−1.002** (−3.52)	−0.191 (−0.74)
ΔCorrel_t	−0.005 (−0.17)	0.002 (0.07)	0.009 (0.27)	0.006 (0.27)	−0.001 (−0.13)	−0.006 (−1.17)	−0.005 (−1.00)
EDF × ΔCorrel_t	−0.194 (−0.88)	−0.173 (−0.90)	−0.255 (−0.70)	−0.283 (−0.97)	−0.205 (−1.31)	0.037 (0.42)	0.050 (0.81)
ΔEDF × Correl_t	−0.281 (−0.13)	−0.967 (−0.54)	−0.292 (−0.14)	−1.612 (−0.68)	3.287** (3.70)	1.626** (3.08)	0.185 (0.43)
Constant	0.004 (0.50)	0.005 (0.73)	0.011 (1.43)	0.001 (0.10)	0.002 (0.97)	0.002 (1.21)	0.001 (0.40)
No. of obs.	216	216	216	216	267	267	267
Adj. R^2	0.201	0.262	0.284	0.198	0.543	0.475	0.362

To test this possibility, Panel B of Table 6 also includes regressions of fundamentals on the returns of our three bank indexes. Of course, we do not have enough information on the banks' asset portfolios to properly construct some of the variables used in this regression. However, we expect estimates of volatility to our CDX constituents, their expected default frequencies, etc., to be correlated with the loan portfolios of banks. Thus, we use the variables derived from the CDX IG constituents as independent variables in regressions on our bank indexes. We find that the fundamentals driving returns to our CDX IG equity tranches also explain much of the returns to our bank indexes, and with similar adjusted R^2 values, which range from 0.54 for the Wall Street bank index to 0.36 for the small regional banks.

Collin-Dufresne et al. (2001) also examine the factor structure of the portion of credit spreads changes not explained by fundamental credit variables. They find that the first principal component explains a large fraction of the variation that is not captured by credit valuation models. As in their paper, we also conduct a principal components analysis of the portion of CDO equity returns not explained by the regressions reported in Table 6, which we designate the CDO equity return residuals. We find that the cumulative percentage of variation in CDO equity return residuals (for both the CDX IG and CDX HY tranches) explained by the first three principal components is 66.5%, 86.4%, and 93.3%, respectively. Thus, our results parallel those of Collin-Dufresne et al.

VII. Conclusion

The issue of how the market values complex, opaque, credit-related securities has become of fundamental importance in light of their macroeconomic impact of the 2007–2008 financial crisis. This paper examines this issue from a novel perspective by studying how the market values CDO equity tranches.

We find that CDO equity returns can be linked to equity market factors and are particularly related to bank stock. The intuition for considering equity market factors is that CDO tranches are often viewed as synthetic versions of commercial banks since they are often formed as banks spin off their assets into conduits and special investment vehicles. Thus, CDO equity tranches appears to take on some of the characteristics of the banking industry. While there is an issue of causality in which some of this result may be driven by large banks holding securities similar to CDO equity, we find that some of the correlation between bank stock and CDO equity is explained by the ratio of commercial loans in a bank's portfolio of assets. Thus at least some of the correlation appears to owe to economic similarities between bank stock and CDO equity.

We also find that much of the variation in CDO equity tranches can be explained by no-arbitrage CDO valuation models. In particular, changes in credit spreads and a measure of default correlations account for 45%–64% of the variation in CDX IG equity returns. We find, however, that the returns for the CDO equity tranches on portfolios of high-yield debt are the most difficult to explain in terms of credit valuation models. We also find that the fundamentals that appear to drive CDO equity to a portfolio of investment-grade debt also explain returns to bank stock.

These results have many potential implications for the current debate about the viability of banks and policy initiatives to recapitalize banks directly or through the purchase of troubled assets. For example, if the market values these troubled assets in a way that is consistent with the valuation of bank stock, then the economic costs of these two initiatives may be comparable.

Finally, our analysis focuses primarily on CDO equity based on corporate credit portfolios. An interesting issue for future research is how these results would extend to CDO equity based on other types of underlying debt portfolios such as mortgage, consumer, or asset-backed loans.

References

Acharya, V., and L. H. Pedersen. "Asset Pricing with Liquidity Risk." *Journal of Financial Economics*, 77 (2005), 375–410.

Andrade, G., and S. N. Kaplan. "How Costly Is Financial (Not Economic) Distress? Evidence from Highly Levered Transactions That Became Distressed." *Journal of Finance*, 53 (1998), 1443–1493.

Asquith, P.; R. Gertner; and D. Scharfstein. "Anatomy of Financial Distress: An Examination of Junk-Bond Issuers." *Quarterly Journal of Economics*, 109 (1994), 625–658.

Benmelech, E., and J. Dlugosz. "The Alchemy of CDO Credit Ratings." *Journal of Monetary Economics*, 56 (2009), 617–634.

Berd, A.; R. Engle; and A. Voronov. "The Underlying Dynamics of Credit Correlations." *Journal of Credit Risk*, 3 (2007), 27–62.

Bhansali, V.; R. Gingrich; and F. A. Longstaff. "Systemic Credit Risk in Financial Markets: What Is the Market Telling Us?" *Financial Analyst Journal*, 66 (2008), 16–24.

Bharath, S. T., and T. Shumway. "Forecasting Default with the Merton Distance to Default Model." *Review of Financial Studies*, 21 (2008), 1339–1369.

Brennan, M. J.; J. Hein; and S. H. Poon. "Tranching and Rating." *European Financial Management Journal*, 15 (2009), 891–922.

Brunnermeier, M., and L. H. Pedersen. "Market Liquidity and Funding Liquidity." *Review of Financial Studies*, 22 (2009), 2201–2238.

Carlin, B. I.; M. S. Lobo; and S. Vishwanathan. "Episodic Liquidity Crises: Cooperative and Predatory Trading." *Journal of Finance*, 62 (2007), 2235–2274.

Clark, K., and E. Ofek. "Mergers as a Means of Restructuring Distressed Firms: An Empirical Investigation." *Journal of Financial and Quantitative Analysis*, 29 (1994), 541–565.

Collin-Dufresne, P.; R. S. Goldstein; and J. S. Martin. "The Determinants of Credit Spread Changes." *Journal of Finance*, 56 (2001), 2177–2207.

Coval, J.; J. Jurek; and E. Stafford. "Economic Catastrophe Bonds." *American Economic Review*, 99 (2009a), 628–666.

Coval, J.; J. Jurek; and E. Stafford. "The Economics of Structured Finance." *Journal of Economic Perspectives*, 23 (2009b), 3–25.

DeMarzo, P. "The Pooling and Tranching of Securities: A Model of Informed Intermediation." *Review of Financial Studies*, 18 (2005), 1–35.

Duffie, D., and N. Gârleanu. "Risk and Valuation of Collateralized Debt Obligations." *Financial Analysts Journal*, 57 (2001), 31–59.

Fama, E. F., and K. R. French. "Common Risk Factors in the Returns on Stocks and Bonds." *Journal of Financial Economics*, 33 (1993), 3–56.

Franke, G., and J. P. Krahnen. "Default Risk Sharing between Banks and Markets: The Contribution of Collateralized Debt Obligations." In *The Risks of Financial Institutions*, M. Carey and R. M. Stulz, eds. Chicago, IL: University of Chicago Press (2007), 603–633.

Giesecke, K. "Correlated Default with Incomplete Information." *Journal of Banking and Finance*, 28 (2004), 1521–1545.

Hull, J., and A. White. "Valuation of a CDO and an *n*-th to Default CDS without Monte Carlo Simulation." *Journal of Derivatives*, 12 (2004), 8–23.

John, K., and E. Ofek. "Asset Sales and Increase in Focus." *Journal of Financial Economics*, 37 (1995), 105–126.

Kahl, M. "Economic Distress, Financial Distress, and Dynamic Liquidation." *Journal of Finance*, 57 (2002), 135–168.

Krahnen, J. P., and C. Wilde. "Risk Transfer with CDOs and Systemic Risk in Banking." Working Paper, Goethe-University Frankfurt (2006).

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

Longstaff, F. A. "The Subprime Credit Crisis and Contagion in Financial Markets." *Journal of Financial Economics*, 97 (2010), 436–450.

Longstaff, F. A., and A. Rajan. "An Empirical Analysis of the Pricing of Collateralized Debt Obligations." *Journal of Finance*, 63 (2008), 529–563.

Merton, R. C. "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates." *Journal of Finance*, 29 (1974), 449–470.

Morkötter, S., and S. Westerfeld. "Rating Model Arbitrage in CDO Transactions: An Empirical Analysis." *International Review of Financial Analysis*, 18 (2009), 21–33.

Newey, W. K., and K. D. West. "A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix." *Econometrica*, 55 (1987), 703–708.

Opler, T. C., and S. Titman. "Financial Distress and Corporate Performance." *Journal of Finance*, 49 (1994), 1015–1040.

Pulvino, T. C. "Do Asset Fire Sales Exist? An Empirical Investigation of Commercial Aircraft Transactions." *Journal of Finance*, 53 (1998), 939–978.

Rajan, A.; G. McDermott; and R. Roy. *The Structured Credit Handbook*. Hoboken, NJ: John Wiley & Sons (2007).

Shleifer, A., and R. W. Vishny. "Liquidation Values and Debt Capacity: A Market Equilibrium Approach." *Journal of Finance*, 47 (1992), 1343–1366.

Stanton, R., and N. Wallace. "The Bear's Lair: Index Credit Default Swaps and the Subprime Mortgage Crisis." *Review of Financial Studies*, 24 (2011), 3250–3280.

Vayanos, D. "Flight to Quality, Flight to Liquidity, and the Pricing of Risk." National Bureau of Economic Research Working Paper No. w10327 (2004).