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Who holds the toxic waste? An investigation of CMO holdings

Joseph G. Haubrich
Research Department
Federal Reserve Bank of Cleveland
Cleveland, OH 44101
(216) 597-2802
fax (216) 579-3050
jhaubrich@clev.frb.org

Deborah Lucas
Finance Department
Kellogg School of Management
Northwestern University
2001 Sheridan Rd
Evanston, IL 60208-4054
(847) 491-8333

Abstract

“Toxic waste” refers to the riskiest derivative structures arising from collateralized mortgage obligations (CMOs). We use simulations to predict how this risk would manifest itself in various interest rate environments. We also look for evidence on the total dollar value of these securities, who holds them, and how much they hold. Very limited public information is available, but commercial banks are required to report on their holdings, and we investigate the extent to which the risk is concentrated in that sector.

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1. Introduction

Home mortgages may seem a rather pedestrian investment, but the mortgage financing industry has reached a level of maturity and development worthy of the most sophisticated financial engineer. Individual mortgages are bundled together and used as the collateral behind collateralized mortgage obligations (CMOs). CMOs are divided into tranches of various types, with names such as PACs, TACs, IOs, and sticky jump Zs. The point of this proliferation is to segment the interest rate and pre-payment risk into different classes of instruments, creating a class of fairly safe assets with wide appeal. This of course also creates a class of risky assets, known collectively as toxic waste.¹

To what extent is this toxic waste a problem? Held as a hedge, or by well-capitalized investors who understand the risk, it is not a concern. Held by unsophisticated investors who do not understand their exposure, or by institutions arbitraging regulatory requirements, it may be a problem.

Unfortunately the extent of the possible problem has received little attention, either in the academic literature or the popular press.² Information on the total amount of risky CMO constructs is difficult to come by, and public information about the concentration and eventual disposition of those assets is almost non-existent. In this paper we take a first look at this aspect of the market, endeavoring to ascertain which portfolios hold risky CMO debt and the extent to which it poses a problem for investors and regulators.

The remainder of the paper is as follows. Section 2 develops a simple pricing model that illustrates how the value of CMO constructs can change dramatically with interest rates. Section 3 examines the available data on the size and distribution of risky CMOs. Section 4 takes a closer

¹See Haubrich (1995) for a basic introduction to CMO derivatives and Midanek (1995) for a history of the market. A detailed, but still high-level description of mortgage derivatives can be found in Oldfield (2000).

²While there is also concern about the risk of Fannie Mae and Freddie Mac, and their holdings of toxic waste are an aspect of their risk, our focus is on the pass-through risk to other institutions.

look at CMO holdings at commercial banks, a sector for which there is more detailed information and potentially greater regulatory concern. Section 5 concludes.

2. The Risk in CMOs

Before attempting to track the ownership of risky CMO tranches, we present some examples illustrating the potential risks. Default risk generally is minimal, since most CMOs are protected by the guarantees provided by the major issuers of mortgage-back securities, or by over-collateralization by the issuer. The interest rate risk, on the other hand, can be enormous, particularly as there can be very complicated pre-payment effects.

We construct a Monte Carlo model of stochastic interest rates and mortgage cash flows, and use it to illustrate the risk in the value of several common types of mortgage derivatives -- Zs, IOs and POs. We consider the risks in a variety of interest rate environments, including one of rapidly rising interest rates. To preview the main results, we find that under conditions of typical interest rate volatility, the value of these derivatives is highly volatile. For instance, there is a significant probability that losses on toxic waste holdings will exceed the associated bank capital requirements, even with a 100 percent risk weight. We also find that the effect of an unanticipated and unusually rapid increase in mortgage rates would be to increase the value of some types of derivatives (IOs), and decrease the value of others (Zs and POs). Using the model and historical mortgage rate data, we also simulate the historical patterns of returns on portfolios of these securities. The time series of returns may be helpful in identifying less transparent institutions that are heavily invested in these instruments.

2.1 Some Illustrations

In the model, stochastic interest rates induce stochastic prepayment rates, and hence

variability in the timing, amount and present value of cash flows. More precisely, mortgage interest rates are assumed to follow a discretized Cox, Ingersoll and Ross (1985a) (henceforth CIR) process, with monthly shocks to annual rates described by:

$$(1) \quad r(t) = r(t-1) + s(r(t-1) - r^*) + (r(t-1))^{.5} \sigma \varepsilon(t)$$

In equation (1), $r(t)$ is the mortgage rate at month t , r^* is the mean-reverting level of rates, s is the speed of mean reversion, σ is a volatility parameter, and $\varepsilon(t)$ is a standard normal shock. We impose an upper bound on interest rates of 30 percent to reduce the influence of outliers. The model is roughly calibrated to reflect recent market conditions. In the base case simulations, $s = 0.025/12$, $\sigma = .0378$, and $r^* = 0.07$. The assumed volatility is consistent with monthly mortgage rate volatility from January 1990 to July 2004.³ The speed of mean reversion is from Tuckman (1995). The assumed long-run rate is lower than the average mortgage rate since 1990 of 7.7 percent, implicitly putting more weight on more recent conditions.

The prepayment rate⁴ (PSA) varies inversely with the distance between current mortgage rates as given by equation (1) and the weighted average coupon (WAC) of the underlying mortgage pool. Consistent with mortgages issued in 2003, WAC = .05 in the base case, and $r(0) = .045$. The relation between prepayment rates and interest rates is non-linear, and based on a linear interpolation of recent estimates from investment banks, reported in Table 1.⁵

³This is derived from a monthly volatility of 1 percent, adjusted for the square root of the interest rate in the CIR formulation: $\sigma = (0.01/.07)^{0.5}$.

⁴Prepayment rates are expressed as percentages of the Public Securities Association standard conditional prepayment rate, or PSA. The conditional prepayment rate (CPR) is the annualized fraction of outstanding mortgages in a pool that get prepaid in a given month. The PSA schedule assumes the CPR increases from 0 in month 0 to 6% in month 30 (an increase of 0.2% per month), and is constant thereafter. For example, a PSA of 150 means that after month 30 the CPR is $(6\%)(1.5) = 9\%$.

⁵BondMarkets.com monthly projection survey of PSA rates (August 16, 2004), for 5 percent 30 year conventional mortgage issued in 2003. Participating Dealers include: BS CITI CSFB DB GC GS LB. At 100% PSA, we assume 0.5% of outstanding mortgages are prepaid each month.

In this simple model, prepayments along each path uses this rule, invariant to the pattern of past prepayments.

Table 1: PSA rate schedule as a function of interest rate changes

Coupon	Issue Year	Avg -300*	Avg -200	Avg -100	Avg -50	Avg Base	Avg +50	Avg +100	Avg +200	Avg +300
5	2003	1470	1400	667	262	170	150	131	111	102
*Avg – 300 indicates a drop in interest rates 300 basis points below the WAC on the mortgage pool										

The cash flows for a given derivative security over its life are determined according to the rules for that security, and the cash flows the underlying 30-year fixed rate mortgage pool. In the case of Zs, no cash is received until all other classes of security holders are repaid in full. Deferred coupons are invested at the current monthly rate implied by the model, and paid out in full at the time of the first principal repayment to the Z class. Z's are assumed to comprise 10 percent of principal. IOs receive all coupon payments as they arrive, and POs receive all principal payments. Cash flows are discounted at the realized mortgage rates along each Monte Carlo path.⁶

A histogram of the distribution of the present value of a Z residual, based on 2000 Monte Carlo runs and normalized by the average present value, is given in Figure 1. The mean value is normalized to 1, and the coefficient of variation is 25 percent. However, the asymmetric distribution of the risk reduces the informativeness of variance-based measures of spread. In fact, if Zs are priced at their expected value, most of the time the investment will generate a sizable profit (the mode in Figure 1 is well above the mean). The long lower tail, however, indicates that there is a risk of significant losses.

⁶ Discounting along the paths generated by equation (1) implicitly equates risk-neutral and actual probabilities, imparting some bias to the estimates.

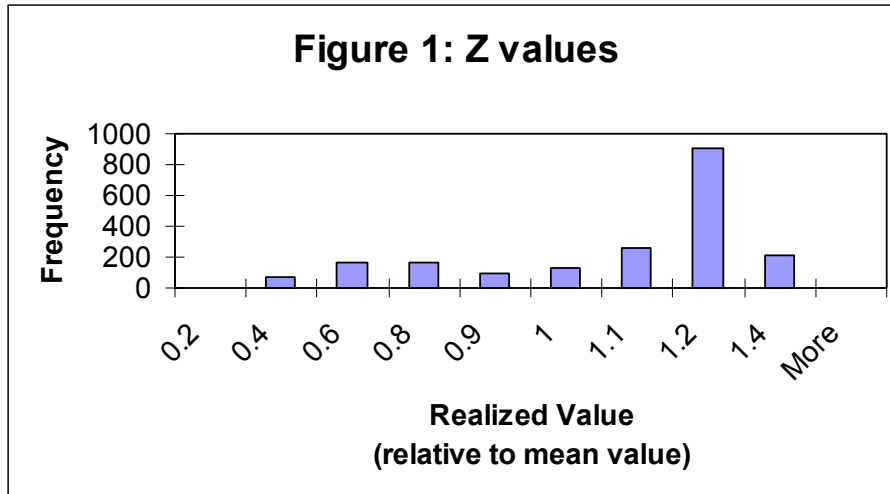
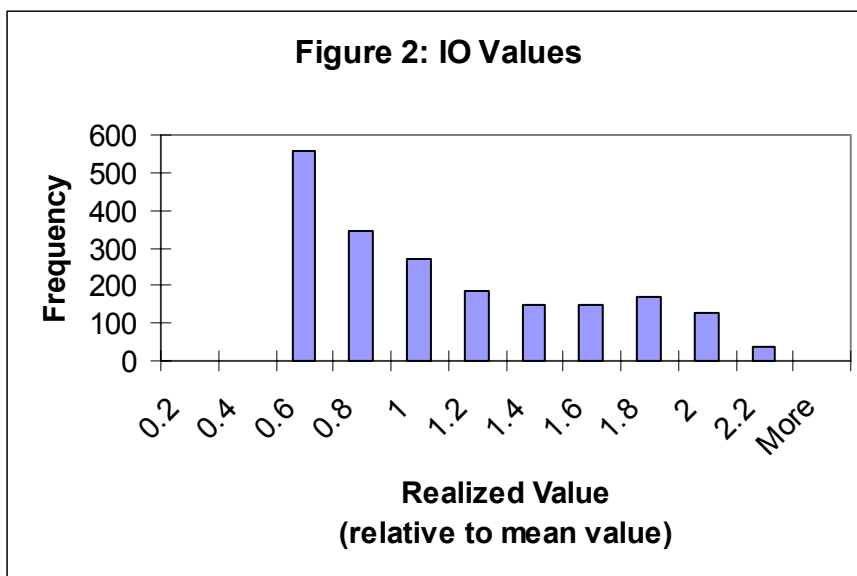
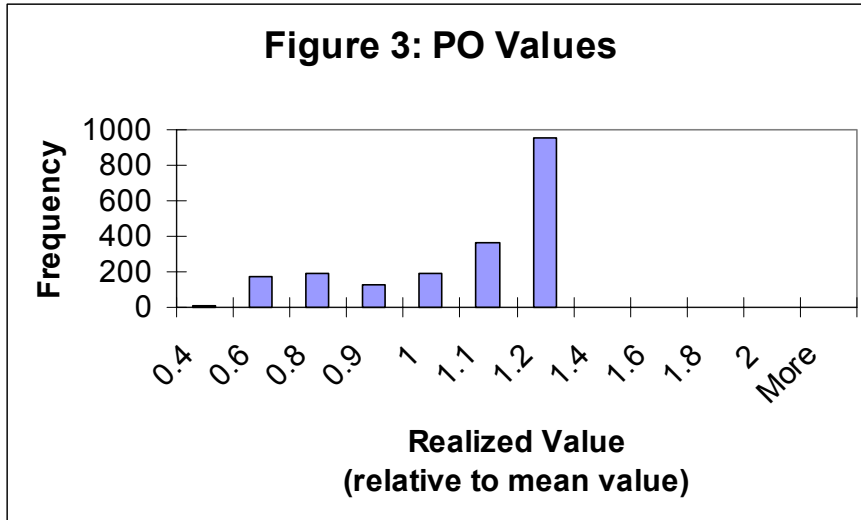


Figure 2 shows the distribution of present values for an IO, and Figure 3 shows the distribution of the corresponding PO, again based on 2000 Monte Carlo runs, with all outcomes normalized by the average present value. The means of both normalized distributions equal 1; the coefficient of variation for the IO is 47.7 percent and 21 percent for the IO and PO respectively. The very high risk of the IO is due to the disappearance of cash flows in the event of prepayments (whereas for the PO prepayment only affects the timing of the cash flows). Unlike Zs and POs, however, IOs have positive skewness





2.2 Losses and Bank Capital Requirements

As discussed below in Section 4.2, the rules governing the capital held against these securities by commercial banks are complicated. It is reasonable to assume that for many banks, particularly the smaller ones, toxic waste will be assigned a risk weight of 1, with a corresponding 8 percent capital requirement.

Under the base case assumptions, the Monte Carlo results suggest that an 8 percent capital requirement for these securities is often inadequate. For the Zs, losses exceed required capital 27.3 percent of the time; for the IOs, losses exceed capital a striking 54.8% percent of the time; and for POs losses exceed capital 24.9 percent of the time.

Larger banks may hold capital based on the more complicated rules for measuring market risk, although they may also follow the 8 percent rule if the securities are not held in a trading account. The market risk rule is based on Value at Risk (VaR) for 10-day period and a 99 percent confidence level. Assessing the VaR for these securities is tricky. If historical price data were available (which it is not), it could be used to create a probability distribution of conditional price changes. The model used in the Monte Carlo experiments provides the conditional distribution of future interest rate and cash flow paths from a given starting point. How should this be used this to represent the distribution of changes in expectation over 10 days about the entire future path of

cash flows and their present value?

The approach taken here is to compare the average present value of cash flows at the initial interest rate with the average present value for an adverse change in interest rates at the 99 percent level over 10 days. The 99 percent confidence interval for interest rates in the model, centered on the initial value of .045, is (.0356, .0544). An adverse change for the IOs implies that rates fall to .0356, while for POs and Zs it implies that rates rise to .0544. For IOs, the VaR is 17.7 percent of the original price, for POs it is 8.8 percent of the original price, and for Zs it is 6.5 percent of the original price. Multiplying each by the factor of 3.5 implies a capital requirement far in excess of the 8 percent required for smaller institutions. To the extent that bank portfolios contain securities whose risk fully or partially offsets (e.g., an IO plus a PO has risk identical to a whole mortgage), evaluating capital adequacy one security at a time overstates the risk.

2.3 Rapidly Rising Rates

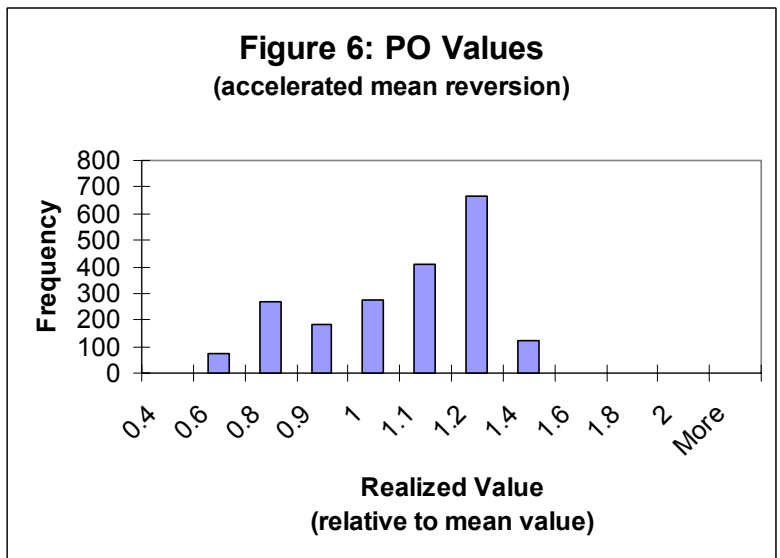
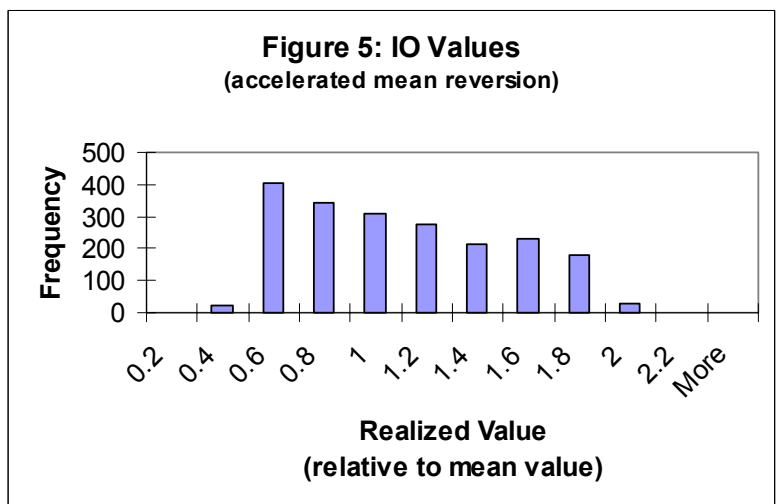
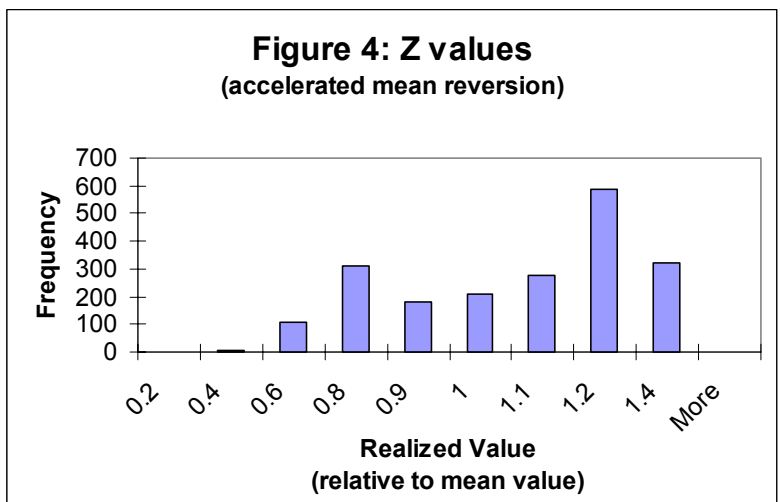
Given the low interest rate environment of recent years and the expectation that rates could rise sharply, it is interesting to ask what would happen to the value of toxic waste if those expectations were realized or exceeded. As a test of this, we assume that the path of interest rates over 14 months follows the pattern of rates from October of 1993 to December of 1994. At that time, interest rates rose abruptly after a long period of gradual decline, climbing a total of 2.37 percent. The episode revealed the vulnerability of several major institutions to large and unhedged derivative positions, including Orange County and Proctor and Gamble. By comparison, the 1994 rate of increase is more than double the expected rise in interest rates suggested by implied forward rates in the yield curve as of September 2004.

To reproduce the 1994 experience, we assume those historical rate changes for the first 14 months of the simulations, with stochastic rates and their corresponding prepayment rates simulated in the Monte Carlo thereafter. We assume that security prices start at the average value predicted by the base case model, and that rates initially are at 4.5 percent. We then calculate the

percentage change in the value of each security at the end of 14 months, assuming payments received along the way are reinvested and rolled over at current rates. For Zs, the average present value falls to 91.3 percent of the base case starting value. The average present value of POs falls to 94.7 percent of the base case starting value. IOs, on the other hand, significantly increase in value, to 179.5 percent of the base case. While these price changes are unlikely to threaten the viability of well-capitalized banks, they could have a significant adverse affect on poorly capitalized institutions with concentrated positions in these securities.

It is possible that the market is already pricing a more rapid increase in interest rates into mortgage derivatives than in the base case model. If so, the above calculations exaggerate the gains or losses likely to be realized. An alternative that takes this into account is to assume a more rapid rate of mean reversion to the long-run 7 percent rate than in the base case. To implement this, we recalculate the distribution of present values under the assumption that s , the mean reversion parameter, increases by a factor of 10 (going from .025 to .25 on an annual basis). This implies that rates on average are expected to rise by about 1 percent in the first two years the mortgages are outstanding, roughly consistent with implied forward rates. All other parameters are as before. Figures 4 to 6 illustrate the effect of faster mean reversion in rates on the distribution of present values. For the Zs, the average present value falls to 97.5 percent of the original base case. The value is depressed due to slower repayments as rates rise, and payments discounted at a higher average rate. For the IOs, value increases to 116 percent of the original base case. The dominant effect causing IO value to rise is that slower prepayments result in more coupon payments being received. For the POs, value decreases on average to 96.6 percent of the base case, as principal is returned more slowly and discounted at higher average rates.

Using this alternate base case, the losses to Zs and POs that would result from an interest rate experience like that in 1994 are considerable smaller - with values at the end of 14 months equal to about 99 percent of the modified base case values for both Zs and POs.



2.4 Estimating Historical Price Paths

As discussed below, it appears impossible to directly identify non-bank financial institutions that have concentrated holdings of toxic waste. One possible way to identify such institutions is to estimate the historical time path of the value of these derivatives, and look for patterns of institutional returns that are similar, for instance, for insurance companies or hedge funds with relatively large CMO holdings.

Such an exercise requires a number of additional assumptions. We consider portfolios with a single type of security (IO, PO or Z). Each month, all principal and interest payments are assumed to be reinvested in new securities of the same type with an original maturity of 30 years.⁷ Portfolio value is tracked from January of 1990 to the present. Prepayment behavior, as in the base case model, is a function of the realized interest rate.⁸ Over the first 14 years (from Jan. 1990 to Dec. 2003) the realization is the historical experience. Thereafter cash flows are projected using a Monte Carlo and the interest rate/prepayment rate model as before. The results will be reported in the next draft of the paper.

3. Market Data

The mortgage market in the United States is large: as of the third quarter of 2005 the value of mortgage debt outstanding was \$11.50 trillion, of which \$8.82 trillion was residential mortgages (one to four family residences). This compares with Federal Debt in private hands of \$3.86 trillion and total assets of domestically chartered commercial banks of \$7.73 trillion for the same time period.(Federal Reserve Bulletin, Tables 1.54, 1.41 and 1.26.)

⁷This differs from the 1994 experiment, where incoming cash was assumed to be reinvested short-term at current rates, and revaluations over time were not recorded. Here the longer time horizon suggests rebalancing and revaluing the portfolio is a better approach.

⁸This is a strong assumption, since prepayment behavior varies dramatically over time and with mortgage characteristics. However, implementing a more complex prepayment model is beyond the scope of this analysis.

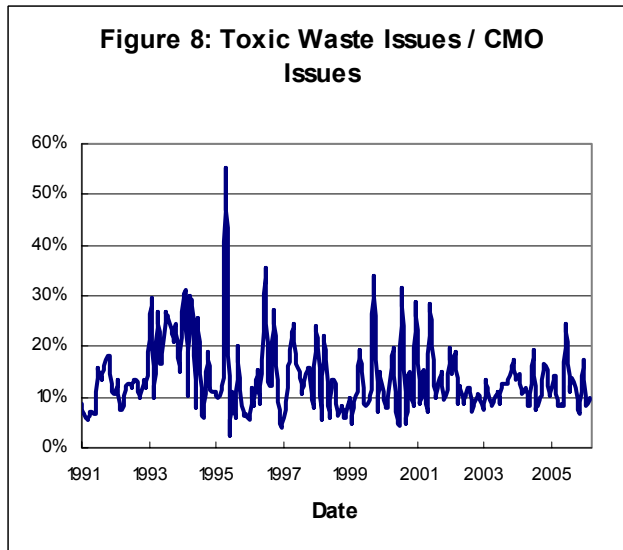
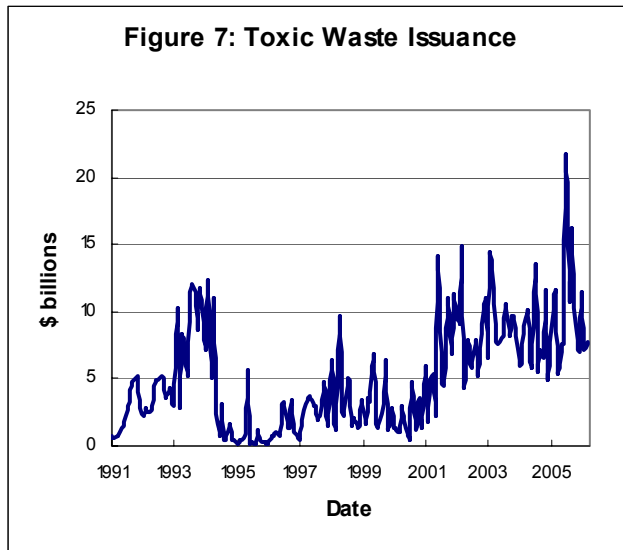
Much of the mortgage debt is securitized: \$4.69 trillion of the total mortgage debt, and \$4.22 trillion of the residential mortgages, most of it securitized by the major government sponsored enterprises: Ginne Mae did \$474 billion, Freddie Mac did \$1,148 billion, and Fannie Mae did \$1,787 billion, leaving \$842 billion to the private mortgage conduits. Not all of these are CMOs/REMICs (Real Estate Mortgage Investment Conduits). The Mortgage Market Statistical Annual (2004) reports that as of 2003 Q4, Agency-backed CMO/REMICs were at \$955 billion. Interestingly, they report total mortgage securities at \$4,207 billion while the Federal Reserve Bulletin reports 2003 pool and trusts as \$4,692 billion).

3.1 How Much Toxic Waste?

Of the CMO/REMICs out there, how much is extremely risky, and should count as toxic waste? This is a difficult question to answer. The mortgage debt outstanding number is a stock measure, and as such it combines securities issued in many different years. Furthermore, a major characteristic of CMOs is that tranches may be of short or variable duration. To our knowledge, there is no accurate aggregate estimate of the number or value of outstanding tranches. There is somewhat more information on the flow variable, CMO issuance.

One source for this is Bloomberg, with the ICMO function. The “Deal Structure” part of this splits the CMO tranches issued in a particular month into eight classes: PAC (Planned Amortization Class), AD (Accretion Directed), Z (accrual), FLT (Floater), INV (inverse floater), IO/PO (Interest Only/Principal Only), SUB (Subordinate), and Other (all others, but mostly standard sequential pay classes). What exactly counts as toxic waste is a matter of judgment, but a reasonable definition would be Z+INV+IO/PO+SUB and this is the definition we use here. Accretion Directed bonds, PACs, and to a lesser extent, floaters, are designed to be safe, and most of the other, as generic sequential pay bonds, will also be relatively safe (see Amerman, 1996, for a discussion). The Federal Reserve's *Trading and Capital-Markets Activities Manual* (section 4110.1, p. 12) states that “prepayment risk is concentrated within a few volatile classes, most

notably residuals, inverse floaters, IOs and POs, Z bonds, and long-term support bonds.” As an example, in April 2000, Bloomberg lists 46 CMO issuances that total \$16.6 billion, with toxic waste of \$3.0 billion, most of it (\$2.4 billion) as IOs and POs.



Figures 7 and 8 plot the time series flow of total toxic waste value and toxic waste value as a fraction of total value from Bloomberg. One possible concern about our measure is that it on occasion exceeds 50 percent. Can there be that many highly risky CMO constructs? As it turns out, for the three months where the fraction exceeds one-third, in two of them (May 1995 and October 1999) the high number results from components that we have the most confidence are

risky: Zs and Subs. Usually these are much lower; the median of their sum is only 4 percent. In the other (July 1996) the cause was a high level of IO/POs, which also are generally regarded as high risk.

Another source on the extent of toxic waste arises from regulatory concern about the risk in bank portfolios. In 1992, the Federal Reserve Board issued a Supervisory Policy Statement on Securities Activities that became effective on February 10, 1992. That statement defined the “high-risk mortgage securities” deemed unsuitable investments for banks. This became known as the FFIEC test, and CMO bonds that passed (deemed not high risk) became known as FFIEC-Qualified. Those deemed high risk had to be carried in the institution's trading account or as assets held for sale. High risk generally meant “exhibits greater price volatility than a benchmark fixed rate thirty-year mortgage-backed pass-through security” (p. 30) but in general a more specific test was used. A mortgage derivative product that met any of the following three criteria was deemed high risk:

- 1) Average Life Test: expected weighted average life greater than 10.0 years
- 2) Average Life Sensitivity Test: expected weighted average life extends by more 4.0 years if the yield curve shifts up 300 basis points or shortens by more the 6.0 years if the yield curve shifts down 300 basis points (both shifts sustained and parallel).
- 3) Price Sensitivity Test: the estimated change in the price of the security exceeds 17 percent with a shift in the yield curve of 300 basis points.

This regulation also led to a revision of the FFIEC Call Reports, having banks report the amount of high risk mortgage securities they held.

On April 23, 1998, the FFIEC issued a Supervisory Policy Statement on Investment Securities and End-Use Derivatives Activity, which rescinded the high risk mortgage derivatives constraints (and shortly thereafter, banks stopped reporting it). The Comptroller's Office, which had tracked bank holdings of high-risk mortgage securities in their *Quarterly Derivatives Fact Sheet*, stopped reporting in the last quarter of 1998. At the time, they noted that 466 banks

reported holding high-risk mortgage securities, with those securities amounting to about one percent of their total assets.

Bloomberg reports some aggregate FFIEC test results for CMOs in the “Bloomberg universe.”⁹ For May 16, 2000, this had a value of \$2,728.2 billion, of which \$884.4 was a solid pass and \$1,110.2 was a solid fail. For May 3, 2004, out of a total market value of the Bloomberg universe of \$3,753 billion, \$1,301 billion were solid pass and \$1,053 billion, or 28%, were solid fail. Should a fail count as toxic waste? In some sense it is an objective criterion, in that regulators deemed these securities high risk for banks.

3.2 Who holds CMOs and their constructs?

Who holds the risky CMO constructs--the exotic tranches, the toxic waste? That question is not so easy to answer. Anecdotally, much goes to private partnerships and hedge funds, entities with little regulation a few reporting requirements (Passmore, et. al., 2002). A preliminary step is to establish which investors hold CMOs in their portfolios, though the distribution of risky CMO constructs may differ. Furthermore, concentration matters: a sector's aggregate holdings may be low, but that does not preclude an unhealthy concentration in a few firms. Table 2 lists the mortgage-related security holdings by investor type for year-end 20003 reported in the Mortgage Market Statistical Annual (MMSA).

Notice from Table 2 that the three largest holders of CMOs appear to be commercial banks, life insurance companies, and foreign investors (with Fannie Mae, and presumably Freddie Mac although they are not listed by MMSA, in close 4th place). Details on holdings of foreigners is exceedingly difficult to come by, and we will have little more to say about them. Recent press

⁹Some measure of the coverage of the Bloomberg universe can be gained by noting that excluding re-REMICs, Bloomberg lists \$836.8 billion in CMOs as of June 30, 2000. Compare this with the \$690 billion for mid-year 2000 from the Mortgage Market Statistical Annual, and it appears Bloomberg covers a substantial fraction of the market.

reports, however, foreign holdings of mortgage-backed securities has been growing rapidly. A small amount of information exists about life insurance companies, but little of that is centralized, as States are the primary regulators of insurance firms. The best data exists for commercial banks, though even there the breakdown of portfolios is often sketchy.

Table 2: CMO Holdings (\$ billions, by investor type, year-end 2003)		
Investor Type	CMOs	% of Assets
FDIC Commercial Banks	263.1	3.46
S&Ls	45.5	3.09
Federal Credit Unions	12.9	2.11
FHL Banks	40.0	4.86
Pension Funds ¹	42.5	0.65
Life Insurance Cos.	155.0	4.11
Fannie Mae & Freddie Mac	N.A.	N.A.
Foreign Investors ²	182.0	N.A.
MBS Dealer Inventory	18.0	N.A.
(sub)Total	709.8	

¹year-end 2004 estimate

²No longer reported; 2001 estimate

Source: Mortgage Market Statistical Annual, 2004 and FNMA 10-k,2004

3.2.1 Life Insurers

Although as Table 2 shows, life insurers are major investors in CMOs, detailed portfolio data is difficult to come by, particularly since insurers are regulated at the state level. One rating agency, at least, occasionally reports more detailed information. Weiss Ratings reported on what they termed the “riskiest types of CMOs...multi-class, non-defined, mortgage and asset-backed securities,” putting these holdings at \$ 105 billion at the end of 1998 and \$123 billion at the end of 1999 among the nation's life and health insurers. Anecdotal evidence suggests that at least some life insurers over-invest in risky CMO constructs. The most prominent example is the failure of Coastal States Life Insurance, which was seized by the Georgia Department of Insurance in January 1993. Coastal States had invested heavily in mortgage-backed securities, and their portfolio of CMOs had a book value nearly \$9 million less than what the company

reported (Knowles, 1993).

3.2.2 Banks

Banks hold many CMOs, and this raises two concerns. First, under current capital requirements, it may be advantageous to hold the riskier forms of any given asset class to increase return on equity. Secondly, the expense of bank failures may be borne by the public because of the safety net.

How much toxic waste do banks hold? At the end of December, 1998, banks held a total of \$7.50 billion of FFIEC risky mortgage securities. This excludes what they held in their trading account (only including RCON 8781 in the call report data). Even adding all the CMOs in the trading account (RCON 3535 and 3536) only brings the number up to \$14.2 billion. The point of this is that while banks hold some risky CMO residuals, they account for a modest portion of the total. The question with regard to banks becomes, do some hold too much?

4. Bank Risk

Bank capital requirements are designed to differentiate between different instruments according to risk, and to a large extent are directed at credit rather than interest rate risk. Accordingly, for risk based capital purposes, any sort of mortgage backed security falls into one of several broad categories. Agency CMOs get generally favorable treatment. Securities backed by Ginnie Mae, Freddie and Fannie get a 20 percent weight (though pass-throughs from Ginnie get a zero weight). Privately-issued CMOs have a weight dependent on the weights of the underlying assets, and thus often get a risk weight of 50 or 100 percent. Instruments viewed as risky, such as strips, get a 100 percent weight. The criterion for a 100 percent weighting is “any class of an MBS that can absorb more than its pro rata share of loss without the whole issue being

in default”¹⁰ Apparently, this is applied on a security by security basis.

While the most obvious form of regulatory arbitrage may be banks amassing risky CMO constructs that for some reason get a 20 percent weight, that is not the only possibility. Roughly speaking, banks must hold eight percent capital against their risk weighted assets. It is entirely possible that eight percent capital is not enough given the risk of some CMO constructs. Thus, even with a 100 percent risk weighting, holding some CMOs may constitute regulatory arbitrage.

Since 1998 however, there has been another capital requirement on market risk. For banks with trading activity exceeding \$1 billion or 10 percent of total assets, market risk capital requirements also apply. This means that banks must increase their credit-risk weighted assets by a “market risk equivalent” factor. This factor is based on the Value at Risk (VaR) of the bank's trading account (and commodity position).¹¹ The regulations allow a broader definition of capital (called Tier 3) to be held against this, however.

In organizing the data on bank CMO holdings we take two approaches. The first looks for particularly high concentrations of CMOs or risky CMOs. The other looks into the determinants of CMO holdings, the factors influencing the CMO component of bank portfolios. The hope is to uncover the reasons (evading capital requirements, etc.) that lead some banks to a high, or inappropriate, level of holdings.

Here we should be precise about exactly what we are reporting. CMOs listed in the call reports are in two sections, the portfolio (RC-B) and the trading account. For the measure of total CMOs, we report the sum of the portfolio measures (RCON A561 and RCON A562) and the trading account measures (RCON 3535 and RCON 3536). For a narrow measure of risky CMOs,

¹⁰ Commercial bank examination manual, Nov. 1998, section 3020.1, p. 14. This is essentially the language in Regulation H, 12 CFR 208 appendix A.

¹¹The market risk equivalent assets are defined as 12.5 (the reciprocal of 8 percent) times the larger of the the 60 day average VaR (99 percent level, calculated on 10 days) times a factor between three and four and the previous day's VaR, plus an additional charge for specific risk.

we report those held in the portfolio failing the FFIEC test, RCON 8781 (technically, the maximum of RCON 8781 and RCFD8781). An alternative would be to report RCONA562, which includes other mortgage backed securities with an expected average life of over three years, and although this gives perhaps too broad a measure of what is risky, it has the advantage of still being reported. Our broader measure adds in RCON 8781 plus mortgage-backed securities other than pass-throughs held in the trading accounts (RCON3535 and RCON 3536). Trading account assets are not necessarily risky, but they are certainly a place where banks may hold riskier assets; in fact, regulations mandated that risky CMOs be housed there.

Table 3 lists the 10 banks holding the most CMOs for the fourth quarter of 2005. Because we have a more detailed breakdown for risky CMOs in 1998, we also report those figures in Table 4. Similarly, Table 5 lists the 10 banks with the largest ratio of CMOs to total assets for the fourth quarter of 2005, and Table 6 lists the 10 banks with the largest ratio of CMOs to total assets for the fourth quarter of 1998.

Table 3: Largest CMO holdings among banks, 2005			
Name	CMOs (in \$ 000)	% Total Assets	% Capital
COMMERCE BANK, NA	14,551,881	41.89	724.96
MERRILL LYNCH BANK	7,930,545	13.14	138.34
COUNTRYWIDE BANK, NA	4,946,132	6.76	92.56
MERRILL LYNCH B&T	4,460,239	42.47	583.85
FIFTH THIRD BANK	3,700,011	7.77	75.17
CHARLES SCHWAB BANK, NA	3,424,178	50.13	619.49
NEW YORK COMMUNITY BANK	2,684,223	10.48	132.87
BRANCH B&T, VIRGINIA	2,577,437	11.45	162.71
HSBC BANK USA, NA	2,339,228	1.66	24.03
ASSOCIATED BANK, NA	2,251,297	10.31	150.99

Table 4: Largest CMO holdings among banks, 1998

Name	CMOs (\$ 000)	% Total Assets	% Capital
WASHINGTON MUTUAL	5,009,473	15.43	279.77
COMPASS BANK	4,487,579	27.22	390.55
MORGAN GUARANTY TRUST, NEW YORK	2,892,712	4.61	27.98
NORTH FORK BANK	2,454,078	23.23	347.44
NATIONAL CITY BANK, MICHIGAN/ILLINOIS	2,060,031	10.39	119.36
APPLE BANK FOR SAVINGS	1,849,563	34.45	478.41
INVESTORS SAVINGS BANK	1,546,131	39.05	625.57
CITIZENS BANK, MASSACHUSETTS	1,502,782	25.05	390.22
CITIZENS BANK, RHODE ISLAND	1,440,246	24.17	358.34
FIRST UNION NATIONAL BANK	1,438,575	0.70	10.02

Table 5: Ratio of CMO holdings to total assets, 2005

Name	% Total Assets	% Capital
FIRST SIGNATURE B&T	91.03	1127.99
HSBC TRUST (DELAWARE), NA	85.66	86.18
FRONTIER STATE BANK	77.75	1075.74
WASHITA STATE BANK	75.84	1078.65
FIRSTBANK NORTH	55.64	879.81
FIRSTBANK, ARVADA	55.19	902.73
FIRSTBANK, DOUGLAS COUNTY	53.90	851.25
FISERV TRUST	53.37	578.89
FIRSTBANK, EVERGREEN	52.23	802.01
FIRSTBANK, PARKER	51.99	893.74

Table 6: Ratio of CMO holdings to total assets, 1998

Name	% Total Assets	% Capital
FIRST NATIONAL BANK, OKEENE	59.22	184.92
LINCOLN TRUST COMPANY	56.87	591.49
BANK OF BEULAH	47.87	512.44
ROCHESTER BANK	45.91	347.68
FIRST TRUST CORPORATION	45.72	607.45
CITIZENS' AND PEOPLE'S BANK, NA	42.27	416.04
MERRILL LYNCH B&T	41.24	339.66
FIRSTBANK, PARKER	39.26	360.52
INVESTORS SAVINGS BANK	39.05	625.57
FIRSTBANK, PARKER	51.99	893.74

The portfolios with a high concentration of CMOs are rarely large in an absolute sense: only one bank in tables 5 and 6 are among the top 10 CMO holders for the quarter. But the concentration seems quite impressive.

Name	CMOs (\$ 000)	% Total Assets	% Capital
COMPASS BANK	1,681,433	10.20	146.33
FIRST MIDWEST BANK, NA	391,596	7.75	116.15
LAFAYETTE AMERICAN BANK	192,725	7.63	127.37
NORTH FORK BANK	190,622	1.80	26.99
HARRIS SAVINGS BANK	150,157	6.02	93.66
SOUTHSIDE BANK	127,740	14.60	236.60
NATIONAL CITY, MICHIGAN/ILLINOIS	127,419	0.64	7.38
CITIZENS BANK NEW HAMPSHIRE	94,771	2.09	36.30
CITIZENS 1ST BANK	90,076	21.49	162.26
COMMUNITY BANK, NA	85,452	5.07	90.64

Table 7 lists the 10 banks with the most risky CMOs (under the broad definition). Not surprisingly, several of the largest CMO holders are also among the largest holders of risky CMOs. Compass and North Fork appear among the top ten CMO holders. Some others, however, concentrated their holdings more in risky CMOs.

Name	CMOs (\$ 000)	% Total Assets	% Capital
KENTUCKY-FARMERS, CATLETTSBURG	36,602	30.55	101.64
CITIZENS 1ST BANK	90,076	21.49	162.26
SOUTHSIDE BANK	127,740	14.60	236.60
WATERTOWN SAVINGS BANK	56,269	10.99	121.60
SOUTH SHORE BANK OF CHICAGO	85,216	10.86	195.42
COMPASS BANK	1,681,433	10.20	146.33
FIRST UNITED SECURITY BANK	36,965	8.29	76.22
FIRST BANK RICHMOND, NA	36,281	8.16	92.31
FIRST NATIONAL BANK, CHILLICOTHE	6,040	8.12	113.79
FIRST NATIONAL BANK, OKEENE	5,246	8.11	25.34

Table 8 lists the 10 banks with the largest ratio of risky CMOs to total assets. Southside and Compass stand out as banks with a position in risky CMOs that is large both absolutely and

relative to their assets.

One thing to notice in table 8 is the relatively quick drop off in holding concentration. Few banks hold much more than ten percent of their assets as risky CMOs. The top banks show surprisingly high concentrations, though. In eight of sixteen quarters for which we have this data, at least one bank is holding more than one quarter of total assets as risky CMOs. The peak is nearly 43 percent. Possibly, these are just special purpose vehicles and not “real banks.” If they are conduits for mortgage firms or securitization, there may be less of a problem, if management knows the relevant risks.

4.1 CMO holdings and stock returns

Because detailed breakdowns of CMOs in bank balance sheets ended in 1998, we must use another approach to attempt to identify banks holding risky CMOs currently. As shown in Section 2, risky CMOs tend to be very interest rate sensitive, with accrual Zs and POs losing considerable value in rising interest rate environments, and conversely for IOs. The underlying hypothesis is that the stock of banks with an overabundance of risky CMOs will show particular sensitivity to long-term interest rates. A further test then looks for any correlation between CMO holdings and the banks' interest rate sensitivity.

For bank stock returns, we took the 25 banks with the largest holdings of CMOs as of December 2004. Of these, 18 had daily returns in the CRSP files from 1/1/1990 to 12/31/2004. They ranged in total asset size from Wachovia, at \$345 billion down to \$3.8 billion for Charles Schwab Bank, N.A. The ratio of CMOs to assets varied from 0.4% (Wachovia) up to 38.1% (Commerce Bank). Since the key risk in CMOs concerns prepayment timing, we took the interest rate most relevant to homeowners, the conventional mortgage rate from the Board of Governors H15 release. The daily stock returns were converted to weekly returns to match the weekly interest rate data. The stock returns were then regressed against a portfolio of all bank stocks in CRSP and the weekly change in the mortgage rate.

$$(2) \quad R_i = \alpha_i + \beta R_M + \gamma \Delta R_I.$$

Note that of the 18 banks in the sample, seven had statistically significant coefficients on the change of interest rate and all the signs on this coefficient are negative (see Table 9).

We also used the absolute value of the change in mortgage rate, as some CMO constructs can lose value when rates fall; depending on its portfolio, either a rise or fall in rates may hurt the bank. None of the estimates of γ were significant in that case, so the results are not reported.

$$(3) \quad R_i = \alpha_i + \beta R_M + \gamma |\Delta R_I|.$$

The correlation between the coefficients for interest rate changes and the bank's CMO as holdings as a percentage of assets is -.3436, saying that as a bank held a greater fraction of CMOs, it tended to have a more negative response to an increase in interest rates. Put differently, the more CMOs, the more interest rate increases hurt stock returns. Of course, several caveats are in order, as banks may be using other derivatives or investment strategies to attain the interest rate exposure observed in Table 9. It is of further interest that the bank known to have a high concentration of risk CMOs (North Fork) has the largest (in absolute value) and most significant coefficient on interest rate changes. The pattern does not hold up when looking at the absolute value of rate increases. This is not surprising, since results of estimating (2) and (3) suggest that falling rate environments are beneficial to banks with large CMO holdings, and considering the absolute value of rate changes therefore reduces likelihood of finding a relationship.

Table 9: Stock Returns and Interest rates

Bank	const	market	interest rate	R^2
BANK OF AMERICA CORP	0.0037 (2.07)	0.0005 (0.07)	-0.0147 (-0.93)	0.0012
JPMORGAN CHASE & CO	0.0046 (2.33)	0.0086 (0.89)	-0.0145 (-0.82)	0.0022
WACHOVIA CORP	0.0037 (2.32)	-0.0016 (-0.25)	-0.0289 (-2.09)	0.0054
WELLS FARGO & CO	0.0043 (3.07)	-0.001 (-0.15)	-0.0138 (-1.21)	0.0015
CITIGROUP INC	0.0058 (3.27)	0.0012 (0.15)	-0.0393 (-2.78)	0.0074
FLEETBOSTON FINANCIAL CORP	0.0031 (1.61)	-0.0001 (-0.01)	-0.0288 (-1.86)	0.0041
U S BANCORP	0.0043 (2.69)	-0.0002 (-0.03)	-0.0151 (-0.85)	0.0013
SUNTRUST BANKS INC	0.0037 (2.89)	0.0006 (0.11)	-0.0264 (-2.16)	0.006
KEYCORP	0.0039 (2.77)	0.0036 (0.62)	-0.0172 (-1.32)	0.0027
PNC FINANCIAL SVCS GROUP INC	0.003 (1.97)	0.0024 (0.39)	-0.0263 (-2.04)	0.0046
MERRILL LYNCH & CO	0.0061 (3.07)	0.0024 (0.26)	-0.0357 (-2.21)	0.0052
COMMERCE BANCSHARES INC	0.0033 (2.92)	-0.0002 (-0.04)	-0.0171 (-1.67)	0.0039
NORTH FORK BANCORPORATION	0.0045 (2.39)	0.0004 (0.06)	-0.0487 (-3.09)	0.0112
FIFTH THIRD BANCORP	0.0044 (3.08)	0.0054 (0.75)	-0.0284 (-2.36)	0.0068
NEW YORK CMNTY BANCORP INC	-0.0006 (-0.25)	0.0062 (0.88)	-0.0317 (-1.58)	0.005
HUDSON UNITED BANCORP	0.0045 (2.79)	0.0009 (0.17)	-0.0335 (-2.06)	0.0065
INDEPENDENCE CMNTY BK CORP	0.0015 (1.57)	-0.0012 (-0.26)	0.0008 (0.11)	0.0001
SCHWAB (CHARLES) CORP	0.0086 (3.13)	0.0132 (1.1)	-0.0408 (-1.97)	0.0052

N=249

4.2 Tobits

Which factors lead a bank to invest in CMOs? Tables 12 and 13 provide some preliminary information via Tobit analysis. We use Tobits because many banks hold no CMOs at all.¹² The time period for the bank Tobits is 94:Q1 to 98:Q4. Table 11 lists the variables used in the Tobit. We include standard controls; for size we use dummies as well as the log of total assets. We include a dummy for holding company status and include a term spread and a risk spread to control for changes in the interest rate environment. The other variables speak more directly to bank strategies and incentives. We include the bank's capital ratio to explore the theory that banks use CMO holdings to arbitrage capital requirements. High CMO holdings should then be associated with low capital. Likewise, banks with a low net interest margin and high charge-offs may be looking for ways to increase profits, even at the expense of higher risk. Banks with a high proportion of off-balance sheet activities and "hot" funds show a commitment to sophisticated financing and may have developed a higher comfort level with more exotic products, such as CMO constructs.

Table 11: Tobit variable descriptions, 1998

Variable	Description
Intercept	
Dum1	Dummy for size. 1 if total assets <\$50 million
Dum2	1 if total assets between \$50 and \$100 million
Dum3	1 if between \$100 and \$500 million
Dum4	between \$500 and \$1000 million
Dum5	between \$1 and \$5 billion
Caprat	ratio of bank capital to total assets
Hotrat	hot funds to total assets
Bhc	dummy for bank holding co. affiliation
Tass	log of total assets
Chrat	ratio of total charge-off net of recoveries to total assets
Nlrat	net loans and leases to total assets
Netmar	net interest margin
Tsprd	spread between 30 year T bond and 3 month T-bill
Baasp	spread between Baa portfolio and 3 month T-Bill
Offrat	ratio of off balance sheet activities to total assets

¹²See Maddala (198)] for more on the Tobit.

For Table 12, notice that most coefficients are highly significant. The size dummies are mostly significant and negative. Since the excluded group is banks with total assets above five billion, the negative coefficients indicate that smaller banks tend to hold fewer CMOs (as a fraction of total assets). One thing that stands out is that the coefficient on the capital ratio is negative, implying that a higher capital ratio implies lower holdings of CMOs. This is at least consistent with the story that some CMO holdings might be for gaming capital regulations. Is the coefficient a large number? Increasing the capital ratio of the bank by one percentage point (say from 8% to 9%) should decrease the percentage of CMOs in the bank's portfolio by 0.2%. Since a truly huge change in bank capital of 5 percent would decrease the CMO percentage by only one percent, this does not appear to be highly important (see Maddala, 1983, section 6.6).

Table 12: Tobit: CMO/Total Assets, 1998

Variable	estimate	STD Err	Pval
Intercept	-0.019	0.014	0.1943
Dum1	-0.179	0.027	0.0001
Dum2	-0.015	0.005	0.0070
Dum3	-0.014	0.004	0.0011
Dum4	-0.011	0.004	0.0039
Dum5	-0.004	0.003	0.2165
Caprat	-0.227	0.011	0.0001
Hetrat	0.017	0.003	0.0001
Bhc	0.016	0.001	0.0001
Tass	0.011	0.001	0.0001
Chrat	-1.348	0.126	0.0001
Nlrat	-0.143	0.003	0.0001
Netmar	0.156	0.007	0.0001
Tsprd	0.003	0.001	0.0676
Baasp	0.000	0.002	0.7831
Offrat	-0.009	0.001	0.0001

In Table 13, which looks at the ratio of risky CMOs to total assets, the coefficient on the capital ratio remains negative and significant, though even smaller than before. One of the interest rate variables -- the Baa-Treasury spread -- becomes significant, and the other, the Term spread, changes sign and becomes significant. The size dummies turn positive, indicating larger

banks tend to hold a smaller proportion of assets in risky CMOs.

Table 14 looks at the question of when banks would specialize in risky CMOs. The coefficient on the capital ratio remains negative but becomes statistically insignificant.

Another coefficient that has changed is that on the net interest margin, which increases in size by a factor of fifteen. It appears that in this time period at least, a higher fraction of risky CMOs is associated with a healthy return on the portfolio.

5. Conclusion

Although we find no smoking gun in call report data, CMO constructs can be dangerous. That became obvious *ex post* when interest rates rose dramatically in 1994. Then, the losses from CMO constructs made the headlines, with multi-million dollar losses at Askin Capital Management, Piper Jaffray, the Louisiana State retirement plan and Yamachi securities, among others (Canadian Institute of Actuaries (1996)). Unfortunately, the institutions that have assumed this risk in recent years are opaque, and it is impossible to determine whether and where there are concentrated exposures. At a time when interest rates are again rising, understanding who is exposed to such risk is a question investors--and taxpayers--should ponder.

Table 13: Tobit: Risky(broad) CMO/Total Assets, 1998

Non-censored:3194 censored:38504			
Variable	estimate	STD Err	Pval
Intercept	-0.1818207	0.012523	0.0001
Dum1	-0.3501799	1332.627	0.9998
Dum2	0.01513873	0.004572	0.0009
Dum3	0.01094492	0.003285	0.0009
Dum4	0.0050788	0.002777	0.0674
Dum5	0.00109907	0.002368	0.6426
Caprat	-0.0318325	0.009439	0.0007
Hotrat	0.01525661	0.0026	0.0001
Bhc	0.00101018	0.00087	0.2457
Tass	0.01111653	0.000746	0.0001
Chrat	-0.1418837	0.061826	0.0217
Nlrat	-0.0364996	0.002168	0.0001
Netmar	0.08664372	0.007874	0.0001
Tsprd	-0.002567	0.001157	0.0264
Baasp	0.00552368	0.00146	0.0002
Offrat	-0.0159142	0.002578	0.0001

Table 14: Risky CMO/Total CMO Tobit

Non-censored:3194 censored:22773			
Variable	estimate	STD Err	Pval
Intercept	-9.6410129	0.698133	0.0001
Dum1	-6.1323261	1935.48	0.9975
Dum2	1.07527094	0.260996	0.0001
Dum3	0.86284894	0.180303	0.0001
Dum4	0.43323038	0.150903	0.0041
Dum5	0.26165568	0.126629	0.0388
Caprat	-0.0421872	0.526891	0.9362
Hotrat	0.80265018	0.17182	0.0001
Bhc	-0.1739541	0.051841	0.0008
Tass	0.56593323	0.041713	0.0001
Chrat	8.26703334	6.914959	0.2319
Nlrat	-1.1811564	0.128124	0.0001
Netmar	1.55691703	0.422557	0.0002
Tsprd	-0.1665201	0.066252	0.0120
Baasp	0.28659371	0.083353	0.0006
Offrat	-0.8318989	0.160502	0.0001

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