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Innovations in credit risk transfer: implications for financial stability

by Darrell Duffie

Monetary and Economic Department

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Foreword

On 18–19 June 2007, the BIS held its Sixth Annual Conference on “Financial systems and macroeconomic resilience”, in Brunnen, Switzerland. The event brought together senior representatives of central banks, academic institutions and the private sector to exchange views on this topic. BIS Paper 41 contains the opening address by William R White (Economic Adviser, BIS), the contributions to the policy panel on “Coping with financial distress in a more markets-oriented environment” and the prepared remarks of the participants at the overview panel of the conference. The participants in the policy panel discussion were Donald Kohn (Board of Governors of the Federal Reserve), Armínio Fraga (Gávea Investimentos) and John Gieve (Bank of England). Yi Gang (People’s Bank of China), Stanley Fischer (Bank of Israel) and Lucas Papademos (European Central Bank) participated in the overview panel, which was chaired by Malcolm Knight (BIS). The present Working Paper includes a paper presented at the conference and the discussant comments.

Conference programme

Sunday 17 June

17:30	Conference registration
19:00	Cocktail reception and informal dinner

Monday 18 June

09:00	Opening remarks:	William White (Bank for International Settlements)
	Chair:	YV Reddy (Reserve Bank of India)
09:15	**Session 1:**	**Financial intermediation through institutions or markets?**
	Paper title:	"Financial intermediaries and financial markets"
	Author:	Martin Hellwig (Max Planck Institute for Research on Collective Goods)
	Discussants:	Bengt Holmström (Massachusetts Institute of Technology) Martín Redrado (Central Bank of Argentina)
10:45	Coffee break	
11:15	**Session 2:**	**Towards market completeness**
	Paper title:	"Innovations in credit risk transfer: implications for financial stability"
	Author:	Darrell Duffie (Stanford University)
	Discussants:	Mohamed El-Erian (Harvard Management Company) Kenneth Froot (Harvard Business School)
12:45	Lunch	
	Chair:	Alan Bollard (Reserve Bank of New Zealand)
14:15	**Session 3:**	**Accounting and financial system behaviour**
	Paper title:	"Liquidity and financial cycles"
	Author:	Hyun Shin (Princeton University) and Tobias Adrian (Federal Reserve Bank of New York)
	Discussants:	Philipp Hildebrand (Swiss National Bank) Mary Barth (Stanford University)
15:45	Coffee break	

Monday 18 June (cont)

16:15	**Session 4:**	**Policy panel discussion on "Coping with financial distress in a more markets-oriented environment"**
	Panellists:	Donald Kohn (Board of Governors of the Federal Reserve System) Armínio Fraga (Gávea Investimentos) John Gieve (Bank of England)
18:00	Adjournment	
19:00	Reception followed by formal dinner	
	Keynote lecture by Robert Merton (Harvard University)	

Tuesday 19 June

	Chair:	Kazumasa Iwata (Bank of Japan)
09:00	**Session 5:**	**Risk transfer to households and macroeconomic resilience**
	Paper title:	"Risk management for households – the democratization of finance"
	Author:	Robert Shiller (Yale University)
	Discussants:	John Campbell (Harvard University) Jaime Caruana (International Monetary Fund)
10:30	Coffee break	
11:00	**Session 6:**	**Financial system: shock absorber or amplifier?**
	Paper title:	"Financial system: shock absorber or amplifier?"
	Author:	Franklin Allen (Wharton School of the University of Pennsylvania) and Elena Carletti (Center for Financial Studies)
	Discussants:	Raghuram Rajan (University of Chicago) Yung Chul Park (Seoul National University)
12:30	Lunch	
14:00	**Overview panel**	
	Chair:	Malcolm Knight (Bank for International Settlements)
	Panellists:	Yi Gang (People's Bank of China) Stanley Fischer (Bank of Israel) Lucas Papademos (European Central Bank)
15:30	Close of conference	

Contents

Innovations in credit risk transfer: implications for financial stability[1]

Darrell Duffie

Stanford University
and
National Bureau of Economic Research

2 July 2007

Banks and other lenders often transfer credit risk to liberate capital for further loan intermediation. In addition to selling loans outright, lenders are increasingly active in the markets for syndicated loans, collateralised loan obligations (CLOs), credit default swaps (CDSs), credit derivative product companies, "specialty finance companies", and other financial innovations designed to transfer credit risk. My purpose here is to explore the design, prevalence and effectiveness of credit risk transfer (CRT). My focus will be the costs and benefits for the efficiency and stability of the financial system.

In addition to allowing lenders to conserve costly capital, CRT can improve financial stability by dispersing risks among many investors. For example, a bank can replace large potential exposures to direct borrowers with smaller and more diversified exposures.[2] Even if the total risk to be borne remains in the banking system, CRT allows individual banks to hold less risk through diversification. In practice, some risk is transferred out of the banking system, for example to institutional investors, hedge funds and equity investors in specialty finance companies, all of which play a less critical role than banks providing liquidity.

If CRT leads to more efficient use of lender capital, the cost of credit is lowered, presumably leading to general macroeconomic benefits such as greater long-run economic growth. Cebenoyan and Strahan (2004) find that banks that manage their credit risk by both buying and selling loans on the secondary market have a ratio of capital to risky assets that is about 7% or 8% lower than that of banks that do not participate in this market. Further, they conclude, banks that "appear to rebalance their risk through both purchase and sale have capital ratios about 1.0 to 1.3 percentage points lower than banks that just sell loans, and this difference is statistically significant". Goderis, Marsh, Castello and Wagner (2006) estimate that banks issuing CLOs permanently increase their target loan levels by about 50%.

An argument against CRT by banks, particularly in the case of CLOs, is that it leads to greater retention by banks of "toxic waste" – assets that are particularly illiquid

[1] I am grateful for motivation from Claudio Borio and for conversations with Richard Cantor, Mark Carey, Larry Forest, Michael Gordy, Serena Ng, David Rowe and Kevin Thompson . I am especially grateful to Cliff Gray and Andreas Eckner for research assistance, and to Linda Bethel and Nicole Goh for technical assistance. I have benefited from comments, many of which remain to be reflected, by Tobias Adrian, Adam Ashcraft, Jesper Berg, Claudio Borio, Eduardo Canabarro, Richard Cantor, Mark Carey, Moorad Choudhry, David Evans, Michael Gordy, Jens Hilscher, Myron Kwast, Joseph Langsam, Sergei Linnik, Alexandre Lowenkron, Joseph Masri, Matthew Pritsker, Til Schuermann, Hisayoshi Shindo, David Shorthouse, Roger Stein, Kevin Thompson and Anthony Vaz. I have also benefited expetionally from comments provided by discussants Kenneth Froot and Mohammed El-Erian at the Sixth Annual Conference of the Bank for International Settlements at Brunnen in June 2007, as well as from comments by others at this conference and at the Financial Advisory Roundtable of the Federal Reserve Bank of New York.

[2] Demsetz (1999) provides evidence favouring the hypothesis that banks sell loans to diversify their loan portfolios.

and vulnerable to macroeconomic performance. Further, a bank that has transferred a significant portion of its exposure to a borrower's default has less incentive to monitor the borrower, control the borrower's risk-taking, or exit the lending relationship in a timely manner. As a result, CRT could raise the total amount of credit risk in the financial system to inefficient levels and lead to inefficient economic activities by borrowers. It has also been suggested Ů for example, by Acharya and Johnson (2007) Ů that because a bank typically has inside information about a borrower's credit quality, the bank could use CRT to exploit sellers of credit protection. CRT also generates complex structured credit products, including collateralised debt obligations (CDOs), whose risks and fair valuation are difficult for most investors and rating agencies to analyse.

I will pay particular attention to the market imperfections that underlie the costs and benefits of CRT, and I will venture some opinions about how the trade-offs between costs and benefits have gotten us to where we are. I will bring up the influences of our regulatory regime, especially with regard to bank capital regulation and accounting disclosure standards.

CRT is intimately linked with innovations in security design, beginning with the emergence of collateralised mortgage obligations in about 1980. As I will emphasise here, banks and other lenders design securitisations and loan covenant packages with the objective of reducing the costs of transferring credit risk to other investors.

With the goal of stimulating a productive debate, I offer the following summary of opinions, some of which are speculative and deserve to be the subject of more research.

1. CRT makes the distribution of risk among investors more efficient. The retention by banks of toxic waste from securitisation is likely to be accompanied by reductions in the effective leverage of bank balance sheets as well as by improvements in diversification that increase the safety and soundness of the financial system.

2. Innovations in the design of CRT securities – especially default swaps, credit derivative product companies, CLOs and specialty finance companies – increase the liquidity of credit markets, lower credit risk premia and offer investors a broader menu of assets and hedging opportunities.

3. Even specialists in CDOs are currently ill equipped to measure the risks and fair valuation of tranches that are sensitive to default correlation. This is currently the weakest link in CRT markets, which could suffer a dramatic loss of liquidity in the event of the sudden failure of a large specialty investor or a surprise cluster of corporate defaults.

4. Loans that are sold or syndicated tend to have better covenant packages. CRT is nevertheless likely to lead to a reduction in the efforts of banks and other loan servicers to mitigate default risk. Retention by lenders of portions of loans and of CLO toxic waste improve incentives in this regard.

5. Risk-sensitive regulatory capital requirements improve the incentives for efficient CRT. Adjustments in regulatory capital standards for default correlation, or at least granularity, would offer further improvements.

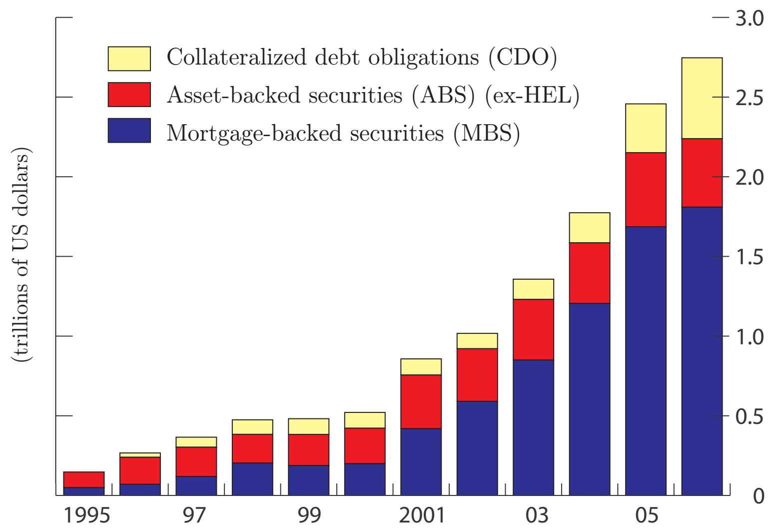
6. Financial innovations designed for more efficient credit risk transfer appear to have facilitated a reduction in the degree to which credit is intermediated

by banks relative to hedge funds, credit derivative product companies and speciality finance companies.

7. While the gross level of credit derivative and CLO activity by banks is high, the available data do not yet provide a clear picture of whether the banking system as a whole is using these CRT instruments to shed a large portion of the total expected losses from defaults on loans originated by banks. The recent dramatic growth of CRT markets has been driven mainly by various other business activities of banks and non-bank financial entities.

Graph 1

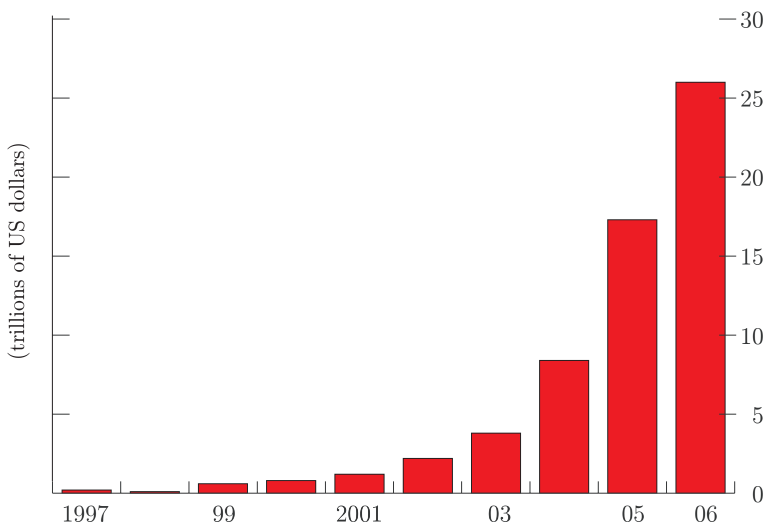
Securitisation of bank credit risk.



Source: IMF.

Graph 2

Outstanding notional amount of default swaps



Source: British Bankers Association.

1. Recent credit risk transfer activity

Graphs 1 and illustrate the significant growth in CRT through securitisation and CDSs, respectively. Graphs 1 and 1 provide Bank of America estimates of the shares of total CDS protection buying and selling, respectively, attributable to loan portfolio risk management in 2006. These graphs also show that the majority of CDSs carried out by banks and securities dealers were due to trading on behalf of clients, rather than to loan portfolio hedging. The volume of net credit risk transfer away from banks' loan portfolios through CDS protection is nevertheless estimated by Bank of America to be significant. Graphs 1 and 1 imply that the net transfer of credit risk away from banks in 2006 through CDSs accounted for about 13% of the $25 trillion CDS market, or about $3.2 trillion.

To judge whether banks are indeed laying off a significant share of the risk in their own loan portfolios, I extended the study by Minton, Stulz and Williamson (2005) of US bank activity in default swaps during 2001–03. Graph 1 shows that the CDS positions of large US banks during 2001–06 grew at an average compounding annual rate of over 80%. CDS positions now dramatically exceed loan assets.[3] Of all 5,700 banks reporting to the US Federal Reserve System, however, only about 40 showed CDS trading activity and three banks – JP Morgan Chase, Citigroup and Bank of America – accounted for most of that activity. For example, in 2006, according to new data from the Federal Reserve Bank of Chicago obtained by personal request, JP Morgan Chase reported a total of CDS positions that were approximately 4.7 times the size of its loan portfolio.

Table 1

Aggregate loans and CDS positions of large US banks (banks with at least $ 1 billion in assets in 2003). The first three columns are totals for the 19 largest banks within the sample of Minton et al (2006), or the banks' successors. Bank-specific data for total loans (BHCK2122), CDSs bought (BHCKA535) and CDSs sold (BHCKA534) are from the Federal Reserve Bank of Chicago's bank holding company data, 2001–06, using fourth quarter holdings. The Federal Reserve data are from FR Y-9C reports filed by the banks (www.chicagofed.org).

Year	Total loans	CDSs bought	CDSs sold	CDSs gross	CDSs net	CDSs bought % of loans	CDSs sold % of loans	CDSs net % of loans
2001	2125	217	220	437	–2	10.2%	10.3%	0.0%
2002	2238	342	288	630	54	15.3%	12.9%	2.4%
2003	2379	520	469	988	51	21.8%	19.7%	2.1%
2004	2671	1179	1092	2270	87	44.1%	40.9%	3.3%
2005	2891	3002	2518	5520	484	103.8%	87.1%	16.7%
2006	3298	4165	4094	8259	71	126.1%	124.1%	2.1%

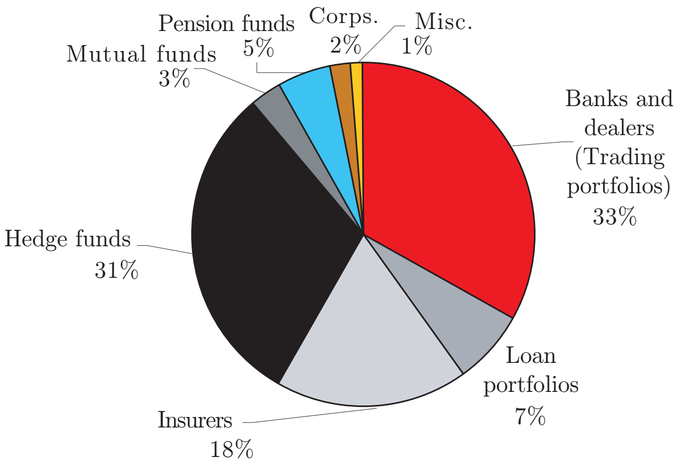
The buying and selling of CDS protection by large US banks were relatively balanced

3 Minton, Stulz and Williamson (2005) selected 345 banks with assets over $1 billion as of 2003. Because of consolidation, only 13 of the 19 largest banks in their study still exist. I follow these large banks or their successors. Of the 345 banks, only 19 had used credit derivatives. Of these, 17 banks were net protection buyers. I am grateful to Cliff Grey for assistance in analyzing these data.

in all years except 2005, when net CDS protection buying was equal to about 17% of the total principal in these banks' loan portfolios. Table 1 provides a breakdown of this CDS activity. Given the available data, it is premature to conclude that banks are systematically using default swaps to significantly reduce the total expected default losses in their loan portfolios. They may be using default swaps to diversify their exposure to default risk. Much of the CDS activity by the three largest bank users of CDS is likely to be driven by CDS trading that is not related directly to loan hedging.

Graph 3

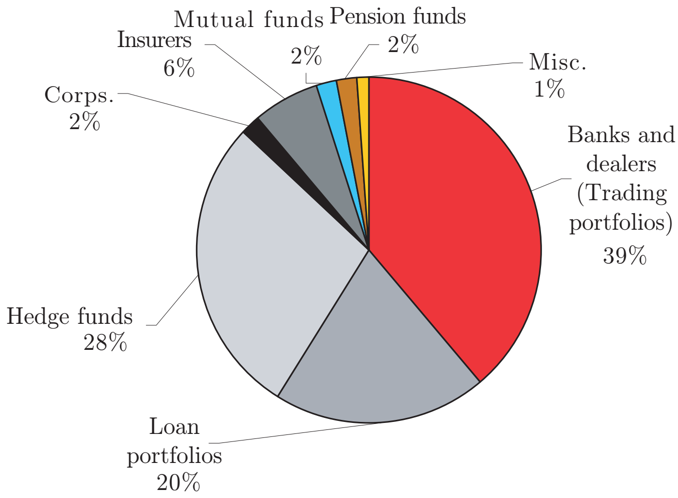
Estimated breakdown of CDS buyers of protection



Source: Bank of America, March 2007.

Graph 4

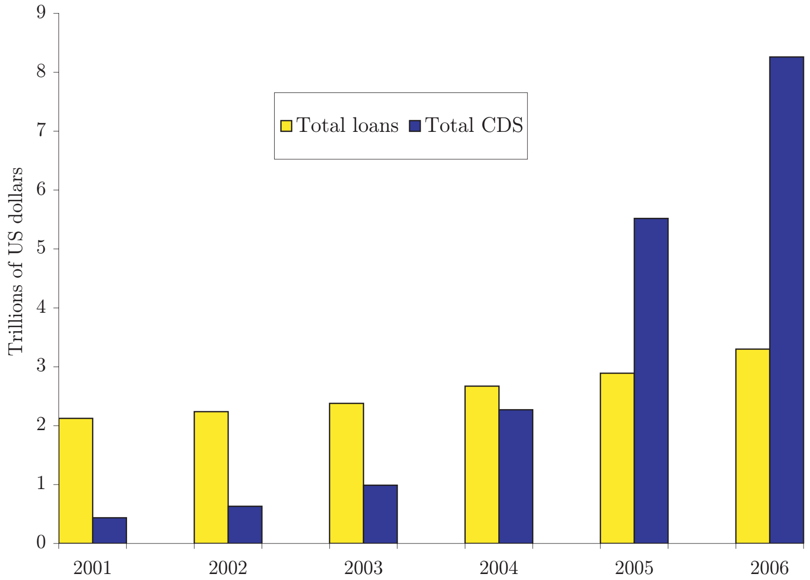
Estimated breakdown of CDS sellers of protection



Source: Bank of America, March 2007.

Graph 5

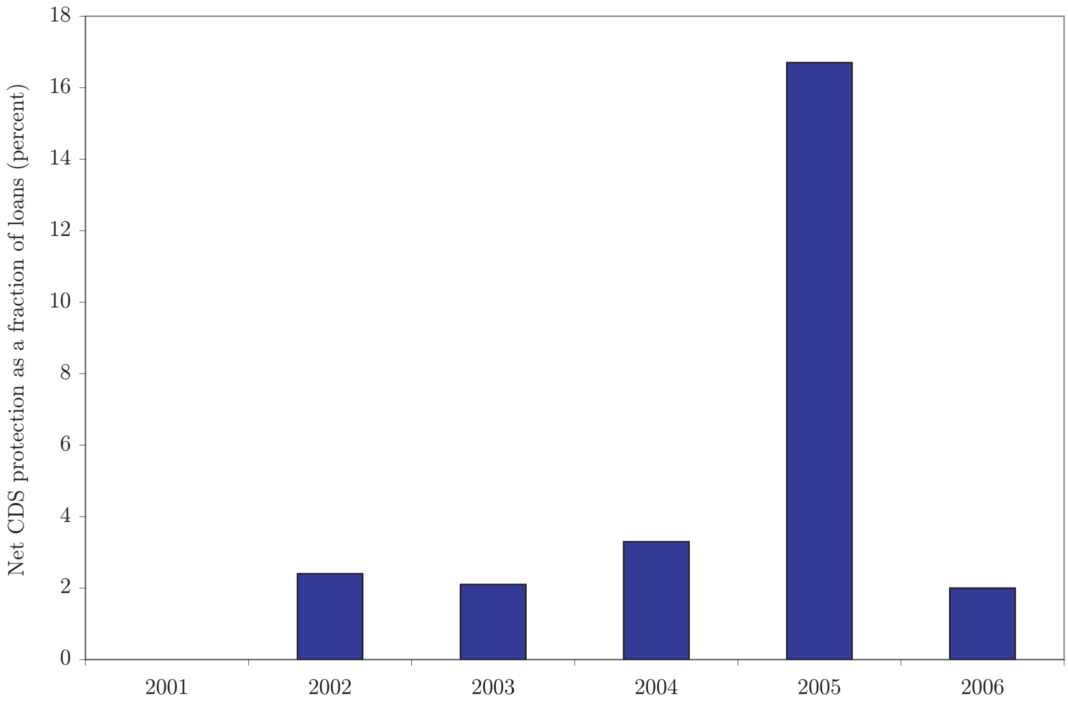
Aggregate U.S. Large-Bank Loans and CDS positions



Source: Federal Reserve Bank of Chicago (2006).

Graph 6

Net CDS protection bought as a fraction, in percent, of loan portfolio size



2. Why does a bank transfer credit risk?

When transferring credit risk to another investor, a bank incurs two major costs:

1. The lemons premium that the investor charges because of the bank's inside information regarding the credit risk. For example, as suggested by Akerlof (1970), if the bank offers to sell a loan at par, the investor infers that the loan is worth par at most, and therefore offers less, whether or not the loan is truly worth par. That banks indeed have private information about a borrower's default risk, and that are banks are likely to suffer lemons premia from loan sales, are consistent with research by Dahiya, Puri and Saunders (2003) and Marsh (2006), who show that the sale of a bank loan is associated with a significant drop in the price of the borrower's equity.
2. Moral hazard, resulting in inefficient control by the lender of borrowers' default risks. For example, a bank has less incentive to control the credit risk of a loan that it sells than of a loan that it retains. Thus, the price received from the sale of a loan is less than it would be if the bank, as sole owner of the loan asset, controlled the borrower's default risk.

The costs of legal, marketing and other arrangements for CRT are relevant but not our primary focus in this paper.

The principle benefits of credit risk transfer are diversification and a reduction in the costs of raising external capital for loan intermediation. As suggested by Froot, Scharfstein and Stein (1993) and Froot and Stein (1998), we expect an equilibrium in which a lender transfers credit risk until the costs of doing so exceed the benefits associated with lower capital requirements relative to the scale of the lending business.

If financial markets are imperfect, CRT in the form of CDOs can also provide specialised investors with access to relatively low-risk investments that might otherwise be available only at a higher price. Extremely low-risk securities are easily exchanged[4] and very transparent, such as government bonds, are in demand with investors that place a relatively high value on liquidity. There is a relatively small supply of extremely highly rated (Aaa) corporate debt instruments, which often command a price premium associated with liquidity. Moreover, super-safe corporate bonds have adversely skewed risk. The probability of such a bond being paid off in full is high, but the value of its principal is roughly reduced by half in default. CDO payoffs are not so adversely skewed because investors' exposure to any one default is normally a small fraction of total CDO principal. Investors with a low demand for liquidity but a high demand for safety benefit from access to senior CDOs, which offer a moderate reward to patient institutional investors, such as pension funds and insurance companies, for bearing a small amount of default risk and some illiquidity.[5] Gale (1992) emphasises the value of "standard securities" – those whose design is understood by making them less costly. The relative standardisation of CDOs and CDSs has increased market acceptance of these instruments and contributed to the growth of CDO and CDS markets.

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4 In the United States, Treasuries and agency securities are among the few securities accepted by Fedwire for same-day secure exchange in the interbank market.

5 This motivation for innovation is related to, but somewhat different from, that of Allen and Gale (1988).

Consider a bank whose assets consist of $100 billion of risky loans, and suppose that it is optimal, or that the bank is required by regulation, to hold $9 billion in capital as a buffer against default risk on this loan portfolio. The capital buffer mitigates distress costs to the bank and systemic risk costs to the financial system. At first, we suppose that the only available form of CRT is the outright sale of loans in the secondary market. If the frictional costs of raising capital are high enough relative to the frictional costs associated with selling loans, and if loan origination is sufficiently profitable, the bank increases the return on its capital by selling loans for cash (and for regulatory capital relief) which enables it to intermediate additional loans. Unless some loans are costlier to sell than others, the bank should sell loans as soon as possible after their origination, holding only the capital necessary to cover the loans while they are temporarily on the bank's balance sheet. As we shall discuss, CDS hedging and loan syndication can be near substitutes for loan sales.

3. What credit risk to keep, and what to transfer?

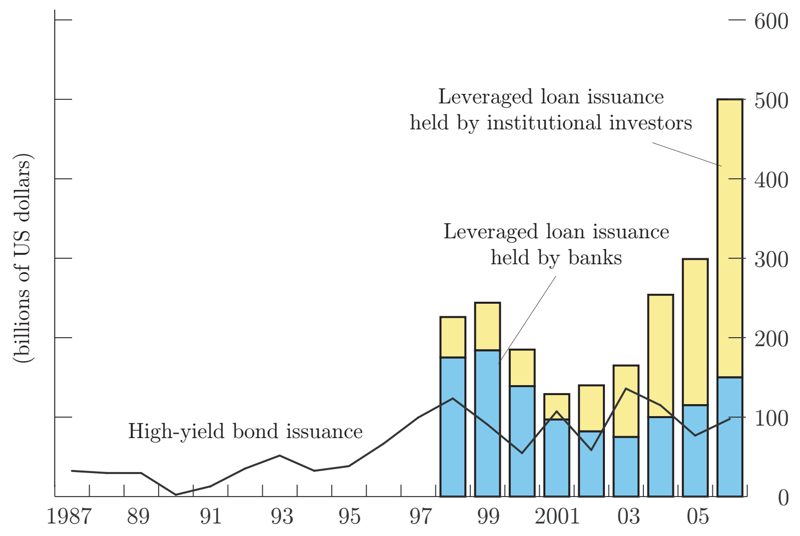
Still assuming that the transfer of credit risk occurs only through the outright sale of loans, suppose that the cost of selling loans diverges widely across the pool of loans that a bank originates. Then we would expect the bank to sell only those loans that provide the greatest benefit in terms of the reduction of capital requirements, net of the sale costs. The marginal loan sold is that for which the marginal benefit from the associated release of capital is equal to the marginal loan sale costs. The lemons premium and the moral hazard cost described above are typically related to the level of default risk. If the capital released from the sale of a loan does not depend on the quality of the loan, then the lowest-quality loans would be retained. Since a bank's chosen or mandated level of capital needs to be sensitive to the riskiness of the bank's loan portfolio, however, more capital is liberated by the sale of a high-risk loan than by the sale of a low-risk loan. Depending on the circumstances, it might be preferable to sell risky loans. Assuming that regulatory capital is binding, the Basel II capital accord is an improvement in this respect. Notably, high-risk loans are increasingly not held by traditional banks, as indicated in Graph 3. Loan syndication, which from the viewpoint of the lead bank has some of the same qualities as a loan sale, is also increasingly oriented towards speculative grade loans, as indicated in Graph 8.

Consistent with this cost-benefit trade-off, Drucker and Puri (2006) show that the loans sold by banks appear to have relatively low monitoring costs. For example, sold loans tend to have more restrictive covenant packages than unsold loans. Drucker and Puri (2006) also find that a covenant package tends to be more restrictive when rating agencies disagree on the borrower's rating, a signal of informational asymmetries. They note that covenant packages frequently appear to be designed to ease loan sales, given that over 60% of loan sales occur within a month of origination. More than half of sold loans are eventually resold – another indication that the intent is to create a loan instrument that will be liquid in the secondary market. Nearly 90% of sold loans have a credit rating compared with 40% of unsold loans. As for the incentive to sell loans that tie down a significant amount of capital, Drucker and Puri (2006) find that, after controlling for other relevant predictors, having a junk credit rating significantly increases the likelihood of sale.

Thus, banks often sell loans that are designed specifically for an intermediation profit

Graph 7

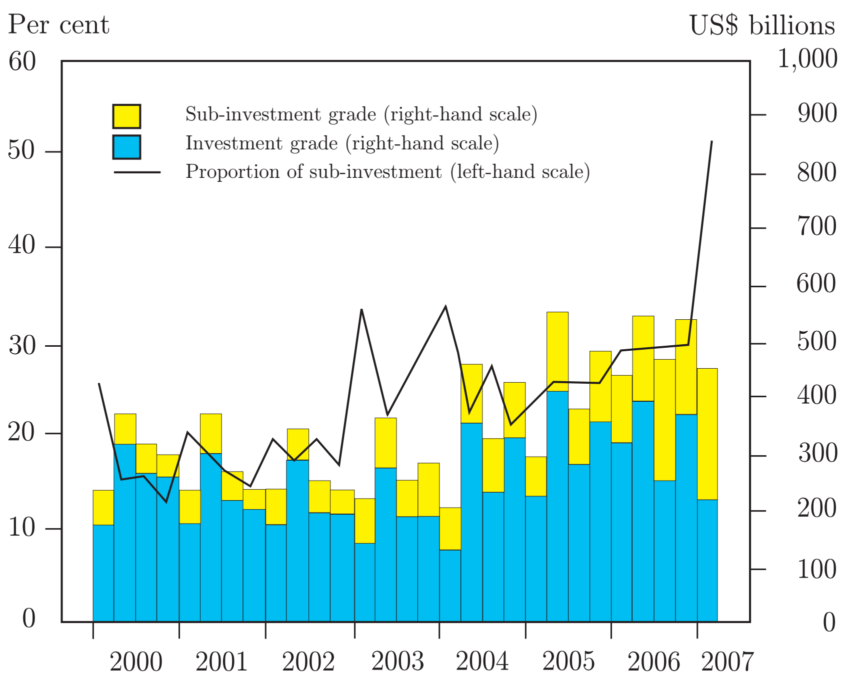
Bank and non-bank investment in leveraged loans



Source: IMF.

Graph 8

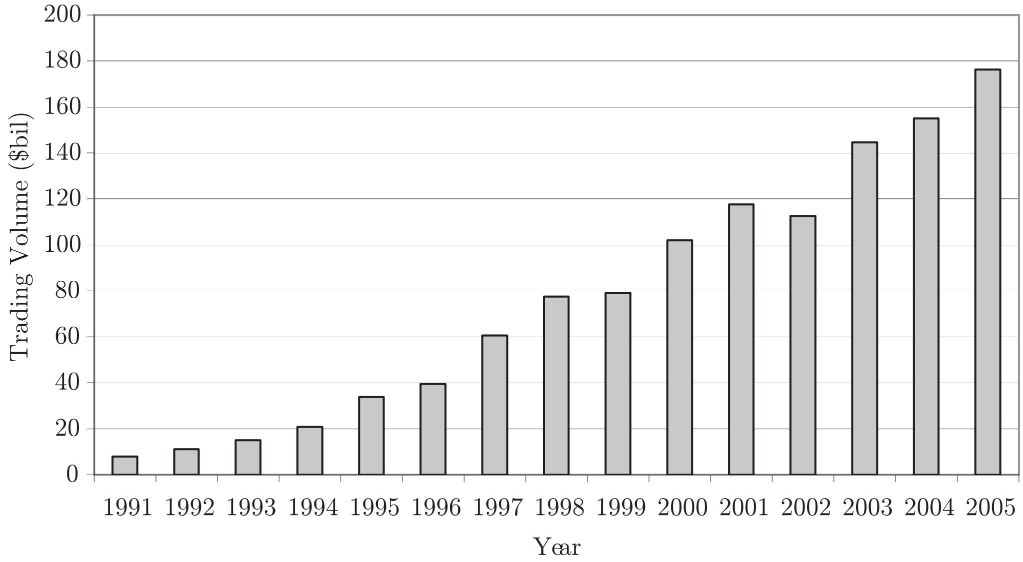
Decomposition of syndicated loan issuance by investment grade and sub-investment grade.



Source: Bank of England (2007), *Financial Stability Report*.

rather than for a long-run investment profit, using more restrictive covenant packages that mitigate selling costs. The riskier the loans, the likelier they are to be sold, controlling for other effects, perhaps because they tie down more bank capital.

Graph 9
Secondary market loan sales



Source: Drucker and Puri (2006).

3.1 Fractional retention as a signal of commitment

If a fraction of a loan can be sold, that fraction optimally trades off capital relief against selling costs. Leland and Pyle (1977) use a signalling equilibrium to model the partial sale of an asset by an informed owner. The loan seller signals a higher-quality borrower through the costly retention of a larger fraction of the loan. Whether a bank can credibly commit not to sell the retained portion of the loan later may depend on the development of a reputation for retention. There is clearly scope for further theory in this area.

Alternatively, one can consider the case of selling costs associated with moral hazard with regard to costly efforts by a bank to control the default risk of the borrower, in the spirit of Gorton and Pennachi (1995).

We can consider a simple illustrative theoretical framework that will be extended when we consider the design of CLOs. Suppose that a bank is indifferent between having one dollar of additional assets, against which capital must be retained, and having b dollars of additional capital. For example, if $b = 0.99$, there is a shadow price of 1% for holding assets on the balance sheet. Unless the cash to be liberated by the loan sale is large relative to the bank's capital, the marginal value of each dollar of capital liberated by the loan sale would not depend on the fraction of the loan sold. Consider the sale by the bank of some fraction f of a loan whose market value would be par if market participants assumed a minimally acceptable effort by the bank to control default losses. The bank's total value for what is sold and what is retained is thus

$$U(f, x) = f(1 + x) + b(1 - f)(1 + x) - C(x), \tag{1}$$

where x is a candidate for the improved value of the loan that could be achieved through efforts by the bank to lower the borrower's default risk, and where $C(x)$ is the bank's cost of achieving this additional loan value x.

The buyer of the loan understands that the bank, when choosing an effort level, focuses only on the value of the retained fraction of the loan net of monitoring costs, therefore solving

$$\max_{x} \; (1 - f)b(1 + x) - C(x). \qquad (2)$$

Letting $X(f)$ be the optimal effort for a sold fraction f, the bank thus faces the loan sale decision

$$\max_{f} \; U(f, X(f)). \qquad (3)$$

For example, suppose that the effort necessary for a fractional increase in the loan value of x has a proportionate cost to the bank of $C(x) = kx^2$, for some coefficient k. Then, from the first-order condition[6] for (2), we have $X(f) = (1 - f)b/(2k)$. Substituting $X(f)$ into (3), the optimal fraction of the loan to sell[7] is

$$f^* = \frac{k}{b} \frac{\left(1 + \frac{b}{2k}\right)(1 - b)}{1 - \frac{b}{2}}. \qquad (4)$$

For the anticipated case of b near 1, we have $f^* \simeq 2k(1 - b)$. For example, at $k = 25$ and $b = 0.99$, the optimal fraction to sell is about $f^* = 50\%$. Relative to the value of the loan if it were sold in its entirety, the bank chooses to protect its investment in the retained portion of the loan by efforts that lower the market value of total loan default losses by about $X(f^*) = 1\%$, at a monitoring cost $C(0.01)$ of about 25 basis points of the loan value. Net of the cost of tying down capital in the retained portion, $1 - b = 1\%$ of the 50% retained, the bank achieves a net improvement in value for the loan of about 25 basis points.

Consistent with the role of monitoring in explaining the incentive to sell a particular loan, Sufi (2007) finds that the fraction of a syndicated loan retained by the lead arranger is about 38% for a private firm borrower, about 35% for a public but unrated borrower, and about 20% for a public and rated borrower, as illustrated in Graph 10. The fraction retained is lower for more reputable lead arranging banks. By studying the relationship over time between the borrower and the lead arranger, Sufi finds more support for the moral hazard motive for loan retention than for the lemons premium motive. A longer borrower-lender relationship implies a greater lemons premium but presumably lowers monitoring costs. Sufi's data do not support greater loan retention with a prior lender-borrower relationship.

Lenders seeking to transfer credit risk can buy default swap protection instead of selling a loan. If the maturity of the loan is identical to that of the default swap, buying CDS protection is essentially equivalent to selling the loan, setting aside the risk of default swap counterparty performance. Loan sales are currently somewhat superior to buying CDS protection from the viewpoint of regulatory capital and accounting disclosure requirements. A cross-jurisdictional review of regulatory capital and disclosure treatment of CDS protection of bank loans is provided in the Joint Forum

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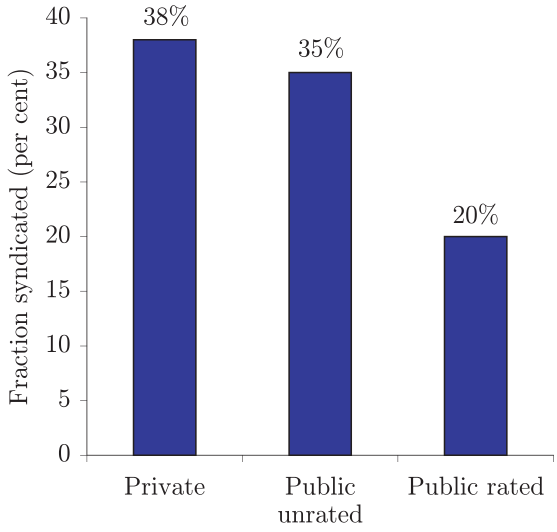
6 The first-order condition for optimal effort x^* by the bank implies that $C'(x^*) = (1 - f)b$.

7 This is the first-order condition. The second-order condition for a maximum is always satisfied. One should restrict attention to cases with $f^* < 1$.

Graph 10

Estimates of syndicated loan retention by lead arranger



Source: Sufi (2007).

report on credit risk transfer BIS (2005). Typically, a CDS-protected loan is treated for regulatory capital purposes as though it is a loan guaranteed by a counterparty of the quality of the CDS protection seller, subject to maturity-matching and other provisions.[8] Basel II will provide a more uniform regulatory capital framework.

Duffee and Zhou (2001) theorise that CDS protection of loans with default swaps of shorter maturities than those of the loans can be effective if the default risk is concentrated near or at the maturity of the loan. Arping (2004) further shows that CDS protection buying by lenders can be more effective without a maturity match when balancing the costs of moral hazard to the lender against the benefits of the borrower's free-riding on the lender's incentive to bail out the borrower.

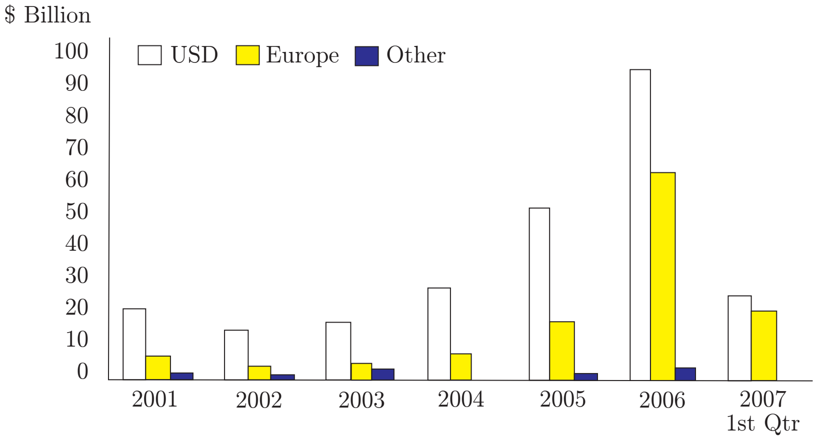
4. Collateralised debt obligations

A CDO is a debt security whose underlying collateral is typically a portfolio of bonds (corporate or sovereign) or bank loans. The collateral is held by a special purpose vehicle (SPV), a corporation or trust whose only purpose is to collect collateral cash flows and pass them to CDO investors. CDOs backed by consumer loans, such as mortgages or credit card debt, are often called asset-backed securities (ABSs). Those backed by corporate loans are usually called collateralised loan obligations. CDOs allocate interest income and principal repayments from the asset collateral pool to prioritised CDO securities, often called *tranches*. While there are many variations, a standard prioritisation scheme is simple subordination: senior CDO notes are paid before mezzanine and lower-subordinated notes, with any residual cash flow paid to an equity piece. A typical contractual framework for CDOs is pictured in Graph 4.

8 An important distinction across jurisdictions is whether the default swap must cover restructuring to qualify for regulatory capital reduction, as in Europe.

Graph 11

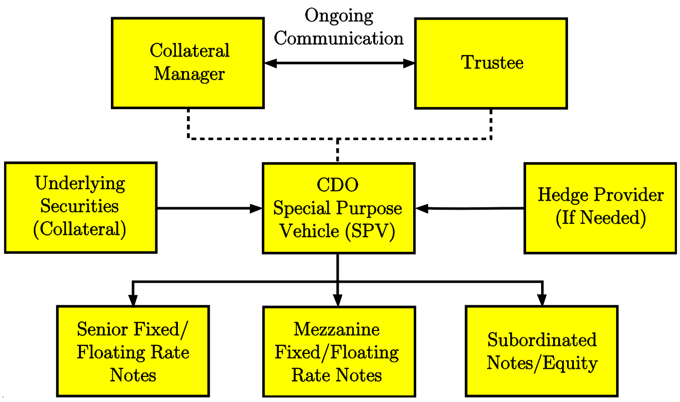
Issuance of CLOs by year and region



Source: Morgan Stanley (Data from Thomson Financial show that total issuance of CDOs backed by high-yield bonds reached $164 billion in 2006, roughly consistent with the Morgan Stanley data. Fitch data indicate that European CLOs totalled approximately 30 trillion euros in 2006. SIFMA reports balance-sheet CDO issuance in 2006 of about $70 billion, based on Thomson Financial data.

Graph 12

Typical CDO contractual relationships



Source: Morgan Stanley.

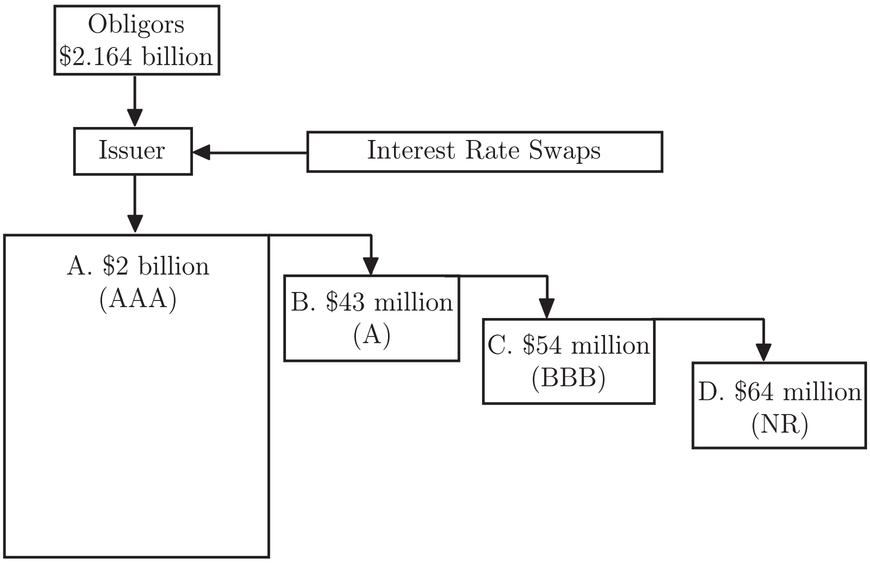
The first generation of CDOs, which appeared in about 1980, were collateralised mortgage obligations (CMOs). Prioritising the cash flows of a mortgage portfolio into relatively low-risk and high-risk tranches led to improved liquidity for mortgages and lower borrowing costs for homeowners. Notably, the CMO market collapsed in 1994 with dramatic changes in the term structure of interest rates and the failure of the Granite Fund, which had depended on unreliable valuation and risk management methodology. After a year-on-year decline of 95% in CMO issuance, the market subsequently recovered.

In 1997, NationsBank issued one of the earliest major examples of a collateralised loan obligation (CLO), illustrated in Graph 4. A senior tranche of $2 billion in face value had priority over successively lower-subordination tranches. The ratings assigned by Fitch are also illustrated. The underlying pool of collateralising assets consisted of roughly 900 loans previously made by NationsBank to various firms, most of which were rated

BBB or BB. Most of these loans had floating interest rates. Any fixed-rate loans in the collateral pool were significantly hedged against interest rate risk by having the SPV enter into payer (fixed to floating) interest rate swaps. Most of the (unrated) lowest tranche was retained by NationsBank, presumably based on the adverse selection and moral hazard costs of selling that we have explained in the context of outright loan sales.[9]

Graph 13

NationsBank CLO tranches 1997 Q1



Source: Fitch.

4.1 Theories of CDO design

We have discussed moral hazard and adverse selection as motives for retention by a lender in the case of an outright loan sale. The story is essentially the same for retention of CDOs by issuers. Moral hazard and adverse selection also play a role becuase lenders have the opportunity to select the loans for the pool of CDO collateral. The problem in CDO design is to develop an algorithm for assigning cash flows from the collateral pool to each CDO tranche so as to maximise the sum of the market value of what is sold and the effective value of what is retained.

An additional incentive for the creation of CDOs is the demand by certain investors for debt instruments of a given credit quality. Those developing structured credit products have pointed to such clientele effects, with limited if any support from academic research. In perfect capital markets, the pricing of risk is identical across all assets. Issuing-high quality debt and retaining the residual has no benefit over the converse issuance strategy, along the lines described in Modigliani and Miller (1958). If, however,

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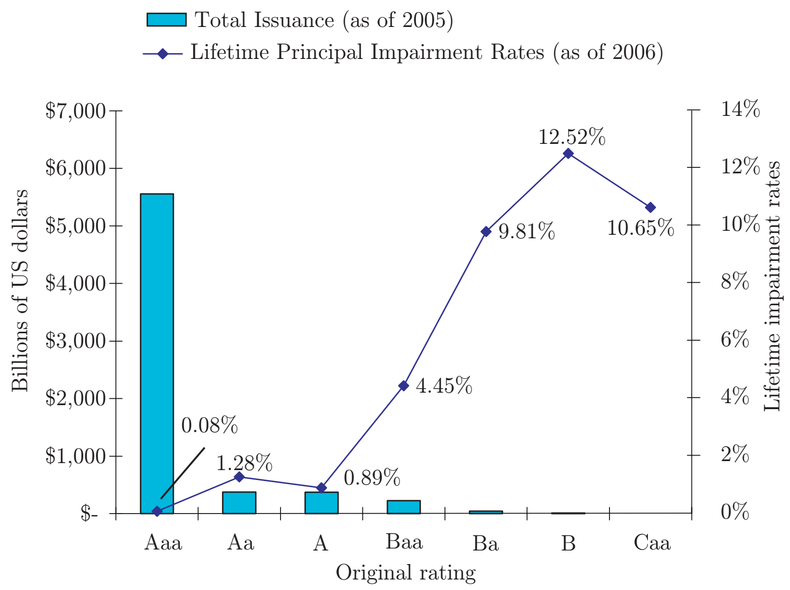
[9] A *cash flow* CDO is one for which the collateral portfolio is not actively traded by the CDO manager, implying that the uncertainty regarding interest and principal payments to the CDO tranches is determined mainly by the number and timing of defaults of the collateral securities. The NationsBank CLO illustrated in Graph 4 is an example of a cash flow CDO. A *market value* CDO is one for which the CDO tranches receive payments based essentially on the mark to market returns of the collateral pool, which depend on the trading performance of the CDO asset manager.

Graph 14

Structured finance: outstanding issuance and impairment rates by rating

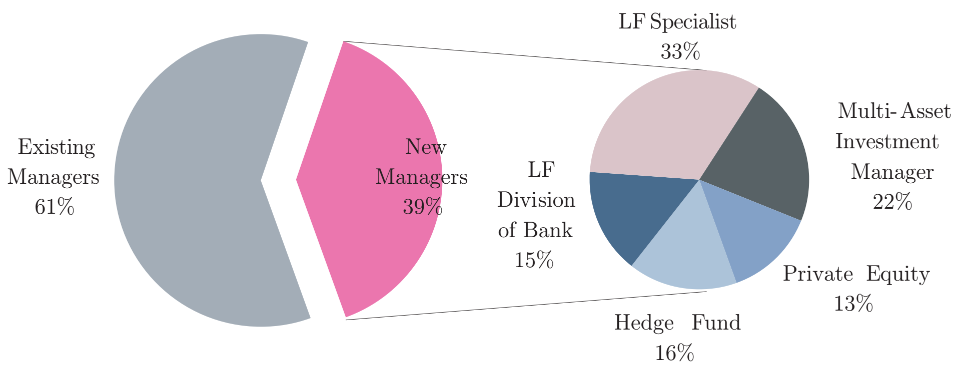


Source: Moody's.

there is a pool of investor capital that is dedicated to relatively high-quality debt instruments, the supply of such instruments to the market can lag demand, and, in the meantime, an issuer of ABSs can earn attractive rents. As illustrated in Graph 4, the structured finance industry has indeed created a very large supply of high-quality fixed income assets out of a pool of lower-quality assets by concentrating the credit risk in a small amount of highly risky assets.

Graph 15

New European CLO issuers in 2006



Source: Fitch.

The fact that a typical CDO structure incorporates multiple classes of relatively senior tranches that are all sold out is evidence that some of the impetus for collateralised debt obligations stems from demand for certain classes of securities. If moral hazard or lemons premia were the only incentives, the intermediate tranches would be retained in different proportions by the issuer.

Just as has long been claimed by CDO asset managers, it is likely that the sold-out tranches add value to the CDO structure by feeding clienteles with assets they value highly and that are in relatively short supply. Coval, Jurek and Stafford (2007) propose that investors in senior CDOs are simply unaware that these instruments are exposed to significant levels of systemic risk, given that only a significant economic downturn would generate sufficient losses to impair relatively senior tranches. The degree to which the issuance of CDOs is driven by "behavioural" demand or is based on a shortage of assets with similar risk and return characteristics is an open question. In any case, it is my presumption that sub-tranching of the unretained portions of CDOs is not explained by traditional theories of security design that are based on adverse selection and moral hazard.

Incidentally, the latest available data regarding returns on the equity pieces of CDOs are rather discouraging. In 59 deals terminated in time for Moody's January 2007 report on CDO equity returns, the mean internal rate of return (IRR) on the equity pieces of CLOs was estimated by Moody's to be 2.35%, with a standard deviation of 21.14%. For collateralised bond obligations, the mean IRR of the equity tranches across 36 terminated deals was -14.2%, with a standard deviation of 43.5%.

In general, an issuer has an incentive to design a CDO that enables it to sell most or all of the senior tranches while retaining a significant portion of one or more subordinate tranches that would be among the first to suffer losses stemming from poor monitoring, servicing or asset selection.[10] The goal is to demonstrate to investors a degree of confidence in, or commitment of effort for, low default losses. In the light of retention by the issuer, investors may be willing to pay more for the tranches in which they invest, and the total valuation is higher than it would be for an unprioritised structure, such as a straight-equity pass-through security. Innes (1990) has a model supporting this motive for the issuance of a standard-debt senior security and retention of the equity residual in a case where the effort to improve the cash flow performance of the underlying assets is costly for the issuer. DeMarzo and Duffie (1999) show the optimality of the same security design in a setting of adverse selection.[11]

DeMarzo (2005) further shows natural conditions under which a lender prefers not to sell a pass through security, prefering instead to first pool and then issue standard debt (a senior tranche) backed by pooled loans about which the lender has private information. I am not aware of any research that has addressed the motives for pooling and tranching designs in the case of moral hazard on the part of the issuer.

Franke and Krahnen (2007) analyse the implications of CLO issuance and reinvestment of the sale proceeds for a bank's aggregate default loss distribution. They also indicate that securitisation activity by a bank is associated with an increase in the systematic component of the bank's stock return, in terms of beta (second moment). Presumably, however, higher-moment systematic risk is reduced by securitisation, because the senior tranches that are sold transfer to other investors the loan portfolio losses associated with dramatic recessions.

Curiously, banks seem to have begun selling even the equity residuals of CLOs, or similar synthetic forms of first-loss exposure possibly driven in part by accounting

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[10] Likewise, a significant portion of the management fees for arbitrage CDOs may be subordinated to the issued tranches.

[11] For further work in this direction, see Nicolò and Pelizzon (2005) and Nicolò and Pelizzon (2006).

standards for equity residuals and by other investors' demand for higher-yielding assets.[12]

4.2 Specialty finance companies

Going beyond CDOs, credit derivative product companies (CDPCs) are special purpose structured finance operating companies whose only permitted line of business is to sell credit protection. Strict contractual risk limits, when breached, force either an immediate liquidation or a freezing of the CDPC portfolio, which essentially converts the CDPC into a CDO. Often cited CDPCs include Primus Financial Products and Athilon Asset Acceptance Corporation. Remeza (2007) reports that, in early 2007, Moody's had proposals for ratings for 24 new CDPCs, about 75% of which are US-based. About one third of the CDPC sponsors are banks; the remainder are other asset managers and insurance companies. A CPDC can serve as a flexible and ongoing financing conduit for a sponsor with a pipeline of loan risk. The capital structures of CDPCs are designed for Aaa ratings to enable these companies to sell protection without posting collateral.

A related type of specialty finance company focuses on more structured products, particularly CDOs. Some companies of this type have proposed going public – for example, Highland Financial Partners and Everquest Financial. Everquest's objective, according to the prospectus of its initial public offering in May 2007, "is to create, structure and own CDOs and other structured finance assets that will provide attractive risk-adjusted returns to us and our shareholders. We generate earnings primarily through a diversified portfolio of CDOs in which we beneficially own all or a majority of the equity".

Many niche specialty finance companies now provide services that combine traditional lending with securitisation. For example, in 2005, CB Richard Ellis announced the formation of a new specialty finance company that focuses on originating, purchasing, financing and managing a diversified portfolio of commercial real estate-related loans and securities. In another example, Consumer Portfolio Services, Inc., according to its own publicity, "is a specialty finance company that provides indirect automobile financing to individual borrowers with past credit problems, low incomes, or limited credit histories. The Company purchases retail installment sales contracts primarily from factory franchised automobile dealers. The contracts are secured by late model used cars and to a lesser extent, new cars. The Company accumulates the contracts into pools, and finances the pooled contracts through the issuance of 'AAA' rated asset-backed securities".

Consistent with the remarks of Geithner (2007), the development of the markets for default swaps and collateralised debt obligations may have enabled specialty finance companies to take on some of the roles of banks in providing both intermediation and financing of credit. The implications for the banking system and banking regulation are not clear.

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[12] See Michael Marray, "First-loss frenzy," in *ThomsonŠs International Securitisation Report,* 1 October 2006, and Paul Davies, "Getting rid of unwanted leftovers", *Financial Times,* 15 December 2005. Marray writes, "With wide variations caused by deal structure as well as type and quality of collateral, expected returns on equity pieces may be down from perhaps 13% or 14% 18 months ago to more like 10% to 11% today. That is bringing the investor base more in line with bank originators who wish to sell first-loss pieces in order to avoid the onerous dollar-for-dollar capital deductions under new accounting regulations."

4.3 Default correlation: roadblock ahead?

Default correlation across a pool of loans that constitute the collateral of a CDO can have a significant impact on the risks and market value of individual CDO tranches. As default correlation increases, so does the volatility of the cash flows from the collateral pool. At one extreme, if defaults are perfectly correlated, then either all loans default or none default. At the other extreme, if defaults are independent across a relatively large homogeneous collateral pool, according to the law of large numbers, the default rate would be close to the average expected default rate.

A senior CDO tranche is effectively "short a call option" on the cash-flow performance of the underlying collateral pool. The market value of a senior tranche therefore decreases with risk neutral default correlation. The value of the equity piece, which resembles a call option on the collateral pool cash flows, increases with default correlation. Optionality does not have a clear effect on the valuation of intermediate tranches, however. Each of the intermediate tranches has given up an option to the tranches with less priority and taken an option from the tranches above it. The overcollateralisation of a tranche is the principal amount of debt below it. With sufficient overcollateralisation, the option given to the lower tranches dominates, but it is the other way around for sufficiently low levels of overcollateralisation.

Currently, the weakest link in the risk measurement and pricing of CDOs is the modelling of default correlation. In practice, there is relatively little emphasis on data or analysis bearing on default correlation. When valuing CDOs, somewhat arbitrary copula default correlation models are typically calibrated to the observed prices of CDS-index tranches, a class of derivatives that behave much like CDOs, as explained in the Appendix. Some of the industry-standard calibrated correlation models are internally inconsistent, as we shall see by example, in that the correlation model that matches the price of one tranche of a CDO structure is typically very different from that of another tranche of the same structure. Although these differences are sometimes eliminated in practice with proprietary copula models that have a richer set of parameters, the additional parametric details are usually not based on realistic information about default correlation. A model with enough flexibility can be made to match market prices without necessarily capturing reality in any significant way. Risk managing the mark to market valuation of CDOs, moreover, is not treated directly by the current copula approach to valuation, which has no place in its modelling framework for uncertain changes in credit spreads.

The market's dependence on CDO valuation methodology is particularly weak in the case of bespoke CDOs – CDOs based on a customised portfolio of names. Bespoke CDO correlation assumptions tend to be based on extremely slender analysis – largely, extrapolation of CDS index tranche-implied correlation parameters – with little evidence or analysis of the degree to which common risk factors are present in the actual bespoke portfolio.

Institutional investors tend to rely on the ratings of structured credit products, including CDOs, when making investment decisions. Methodologies for rating CDOs, however, are still at a relatively crude stage of development. Correlation parameters used in ratings models tend to be based on rudimentary assumptions – for example, treating all pairs of names within a given industrial sector as though they have the same default correlation, and treating all pairs of names not within the same industrial sector as though they have the same default correlation. In contrast with valuation models often used for dealing, investment and hedging decisions, rating decisions place at least some emphasis on data bearing directly on correlation.

The Appendix reviews the current valuation methodology for CDS index tranches, and some of its pitfalls, discussing the impact of the May 2005 General Morots downgrade on the CDX index tranche market as an illustrative example.

4.4 CLO design illustration

To illustrate the implications of moral hazard for CLO design and retention, I present an example showing how the credit quality of the borrowers can deteriorate if efforts to control their default risks are costly for issuers. These results are from forthcoming research by the author and Andreas Eckner.

Assuming that the cash flows to be issued from a collateral pool increase with the pool-level cash flows, under technical regularity conditions the optimal security to retain is pure equity, according to the results in Innes (1990). The main questions concern the equilibrium level of equity to retain, the effort made by the issuer to control credit quality, and the market spread on the issued CLO.

We consider a basic CLO design for a collateralising pool of loans of equal amounts to each of 125 obligors, whose modelled default correlations are calibrated to the corporations underlying the CDX.NA.IG4 default swap index, in that the risk neutral stochastic default intensity dynamics are calibrated to fit one-year and five-year CDS, as well as five-year CDX tranche spreads as of 5 December 2005.

The CLO issue is a five-year note whose principal is a fraction $1 - q$ of the total principal of the 125-loan collateral pool. The note pays investors a coupon at a contractual yield with some spread S over the risk-free rate on the current principal. Any default recoveries are paid to note investors, with a corresponding reduction in principal, as defaults occur. We assume that S is chosen so as to price the note at par (that is, giving the note a market value equal to its initial principal). The remaining cash flows go to an equity tranche retained by the issuer. The issuer's design problem therefore consists in choosing the retention fraction q and the effort level x so as to maximise the market value of what is sold plus the value of what is retained, net of the costs of reducing borrowers' default risks and of pinning down capital to support the retained portion of the structure.[13]

Adopting the portfolio default process model proposed by Duffie and Gârleanu (2001), we assume that any surviving borrower's default intensity (risk neutral conditional mean arrival rate of default) is of the form, for borrower i at time t,

$$\lambda_{it}^{\mathbb{Q}} = 0.5^{x} \left(X_{it} + a_i Y_t \right), \qquad (5)$$

for an idiosyncratic component X_i and systematic (common to all borrowers) component

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[13] We assume a default recovery rate for each borrower of 40% of principal. As for the CLO "waterfall" that allocates loan cash flows to the note issued and the retained equity tranche, we assume no reserve account – that is, all excess interest payments from the collateral pool are immediately paid to the equity tranche (with no interest coverage or overcollateralisation tests). Risk-free interest rates are assumed for the sake of simplicity to be independent of default risk and determined by market yields as of December 2005.

Y. Here, x can be viewed as the proportional reduction in default intensity that is achieved through effort by the issuer. The processes $X_1, \ldots, X_n, Y$ are assumed to be, risk neutrally, independent basic affine jump diffusions, a class of jump diffusion processes that provides a significant amount of analytical tractability. For any two issuers i and j, the common-factor weighting coefficients a_i and a_j determine the structure of default correlation between issuers i and j. The parameterisation of basic affine processes is provided in Duffie and Gârleanu (2001). We exploit the results of Mortensen (2006) and Eckner (2007), who provide Fourier transform methods for computing portfolio loss distributions and pricing CDS index tranches in this framework.

To model the issuer's incentive to sell assets in exchange for cash or to achieve a reduction in regulatory capital, we assume that retained cash flows are discounted more heavily than they would be in the market, at an extra spread of $\delta > 0$.

We assume for notational simplicity a total collateral principal of 1. For a given retention fraction q and spread s, the issuer chooses an effort level x that maximises

$$U(q, x) = W(q, x, S(q, x)) - \pi x, \tag{6}$$

where π is the assumed cost per unit of effort and $W(q, x, s)$ is the market value of the equity residual, assuming effort level x, and assuming that the note issued has a contractual spread of s and an initial principal of $1 - q$. Here, $S(q, x)$ is the par spread, given q and x. One notes that the issuer's effort level x influences the contractual coupon of the security that is issued.

Investors in the note understand that, given the retention fraction q, the issuer's effort level $X(q)$ is that solving $\max_x U(q, x)$. The design problem is therefore to choose some retention fraction q^* solving

$$V(q) = \sup_q \{U(q, X(q)) + 1 - q\}, \tag{7}$$

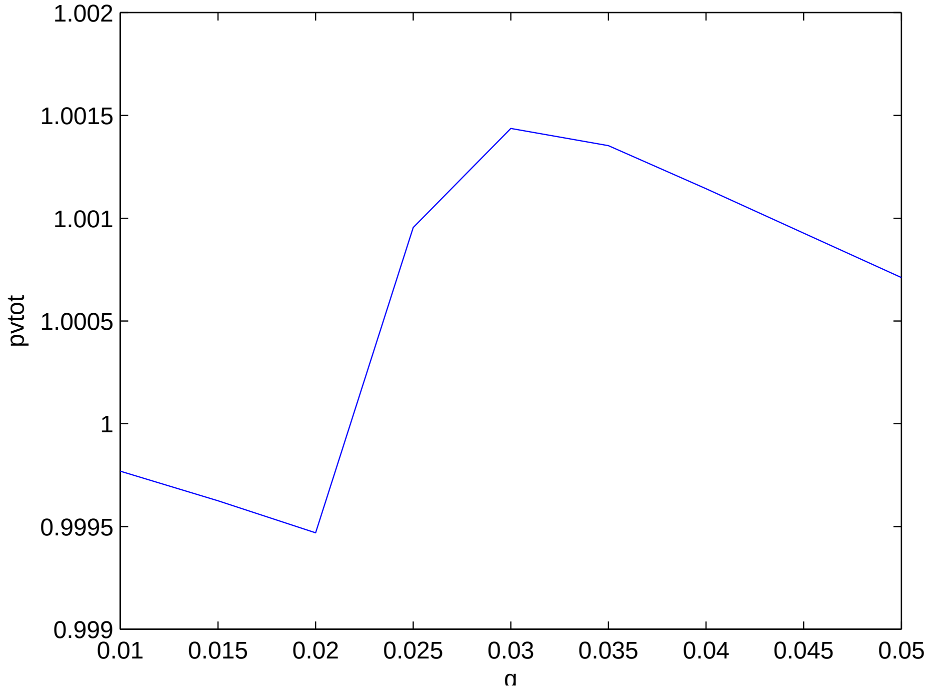
which is the value to the issuer of the equity residual, less the cost of effort, plus the par value $1 - q$ of the note issued. For a given CLO structure, we calculate the value of the equity residual and senior note using Fourier transform techniques developed by Mortensen (2006) and Eckner (2007). We then solve for the optimal CLO structure by using a search algorithm over the set of all possible CLO structures.

For a base case numerical example, we take $\delta = 0.01$ and $\pi = 0.001$. As shown in Graph 4.4, the optimal retention fraction is $q^* = 3\%$. The associated par spread $S(q^*, X(q^*))$ is 5 basis points, and the optimal effort level $X(q^*)$ is 0.75, corresponding to a proportional reduction in risk neutral default intensity, from the base case of no effort, of approximately 40%.

Graph 4.4 shows how the optimal effort level $X(q)$ depends on the retention fraction q. Table 2 shows how the optimal retention fraction q^* varies with the excess discount rate δ associated with retained assets and the cost π per unit of effort. The response to increasing δ is, of course, for the issuer to retain less. The response to increasing the cost π of effort is, at first, for the issuer to retain more risk to demonstrate to investors that the issuer has enough at stake to make the effort worthwhile, thereby narrowing the spread necessary to price the note issued at par. After the cost of effort becomes sufficiently high, however, Annex Tables 2 and 3 show that it becomes so costly to demonstrate a commitment to controlling the borrowers' default risks that the

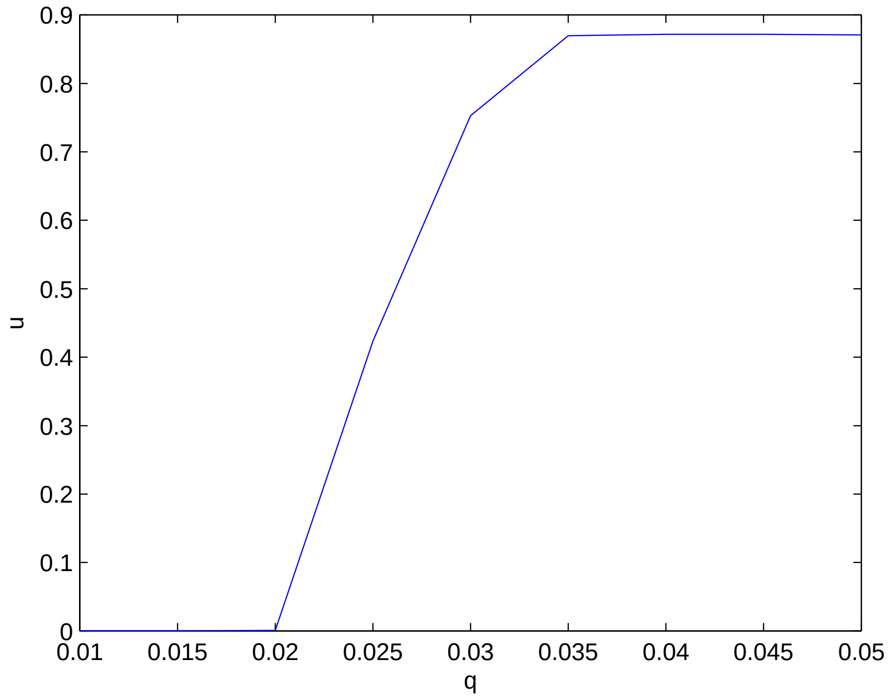
Graph 16

Total value $V(q)$ of the CLO structure to the issuer (retained and issued), net of effort costs



Graph 17

Optimal effort level $X(q)$ as it varies with retention fraction q



issuer simply sells the entire loan portfolio, making minimal effort. Indeed, banks have recently been selling equity residuals of CLOs to speciality finance companies.

[h]

Table 2

Optimal retention fraction q^* for various combinations of excess discount rate δ and unit cost π of effort

q^*	π = 0.0008	π = 0.001	π = 0.0012	π = 0.0014
δ = 0.5%	3.2%	3.4%	4.5%	0.0%
δ = 1%	2.8%	3.1%	3.2%	0.0%
δ = 1.5%	2.3%	2.8%	0.0%	0.0%

[t]

Table 3

Optimal effort level $X(q^*)$ for various combinations of excess discount rate δ and unit price π of effort

u^*	π = 0.0008	π = 0.001	π = 0.0012	π = 0.0014
δ = 0.5%	1.09	0.83	0.69	0.00
δ = 1%	0.96	0.76	0.41	0.00
δ = 1.5%	0.71	0.71	0.00	0.00

Appendix: CDS index tranches

Much of the growth in credit derivative trading volumes in recent years has been in default swap index products. An example is the CDX class of products. The most popular of these is the CDX.NA.IG (North American high-grade index) five-year, which is essentially a portfolio of 125 five-year default swaps covering equal principal amounts of debt of each of 125 named North American investment-grade issuers. A new index is constructed every six months. Each new series of 125 issuers is selected by polling a consortium of dealers that make markets in this product. Similar index products exist for alternative maturities and credit qualities and various issuer domiciles, including North America, Europe, Asia and certain emerging markets.

A family of tranched index products also exists. As illustrated in Graph 18, the seller of protection on each such tranche product is responsible for all default losses on an underlying index portfolio of default swaps in excess of a stipulated "attachment point" up to a stipulated "detachment point". Thus, a tranched index product has essentially the same risk characteristics as a collateralised debt obligation.

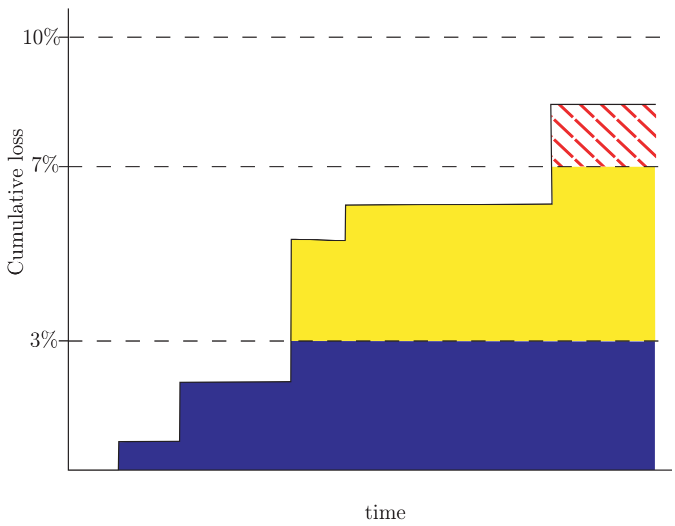
Consider, for example, tranches on a notional $250 million dollar position in the CDX.NA.IG five-year index, covering $2 million on each of the 125 firms. The seller of protection on the 0–3% tranche, known as the equity tranche, pays all default losses for five years up to $7.5 million (0.03 × $250 million) that result from sale of protection on the underlying $250 million portfolio of default swaps. Consider, for example, a scenario in which three of the named 125 firms default within the five-year maturity, with respective losses-given-default of 50%, 40% and 70%. In this scenario, the seller of protection on the equity tranche will make three successive protection payments of $1 million, $0.8 million and $1.4 million, for a total of $3.2 million. The mezzanine tranche, covering all losses above 3% ($7.5 million) up to 7% ($17.5 million) on the underlying $250 million principal, does not suffer any losses in this scenario. In another scenario in which total default losses on the $250 million position reach $10.5 million, then the equity-tranche protection seller pays $7.5 million of these losses. The 3–7% (mezzanine) tranche protection seller would pay the remaining $3 million of losses in this scenario.

In return for covering these losses, protection sellers receive fees from protection buyers. The fees are quoted in two parts, an up-front fee and a running spread. Both of these are quoted as a fraction of the maximum amount of loss for that tranche. For example, in the previous example, the maximum loss for the mezzanine tranche is $10 million. A running spread of 100 basis points means that the buyer of protection would begin paying $100,000 per 360-day year (in quarterly payments of roughly $25,000 each, based on the actual/360 day-count convention for dollars). Once defaults occur, however, the notional amount on which the running spread is charged is reduced, dollar for dollar, with losses. For instance, if the cumulative default losses paid on the mezzanine tranche reach $4 million, the running spread of 100 basis points is paid on the remaining $6 million, for a payment rate of $60,000 per year.

For the CDX.NA.IG series of tranche products, all tranches have an assigned running spread, but only the equity tranche also has an up-front fee. In fact, the equity tranche has a contractually set running spread of 500 basis points and an up-front fee that is negotiated in the market. For the other tranches of the CDX.NA.IG, there is no up-front fee; quotation is in terms of running spreads only.

Graph 18

Tranching total default losses on a portfolio



The first-loss tranche absorbs the first 3% of default losses on the underlying CDS portfolio. The next tranche absorbs the next 4% of default losses, and so on.

Table 4 indicates pricing for the latest series (known as Series 7) of the CDX.NA.IG five-year tranches, in terms of up-front fees and running spreads as a fraction of maximum loss on each tranche. The table also shows how the total risk neutral expected loss rate of 31 basis points on this CDX index was allocated to the sellers of protection of each of the tranches. The equity tranche bears about 85% of the risk neutral expected losses. The mezzanine tranche is estimated to bear 8.2% of the 31 basis points of risk neutral loss rate, or 2.54 basis points. The running spread of 64 = 2.54/0.04 basis points on the mezzanine tranche is represented as a fraction of the maximum loss on that tranche, which is 7% – 3% = 4% of the notional amount on the index.

Table 4

CDX.NA.IG five-year Series 7 tranche premia

Tranche (per cent)	Up-front fee (per cent)	Running (bp)spread	Fraction of total loss (per cent)	hedge (Δ)	Base corr.(per cent)
0–3	19.25	500	84.9	23.8	14
3–7	0	64	8.2	4.6	27
7–10	0	12	1.2	1.1	35
10–15	0	5	0.9	0.5	46
15–30	0	2	1.8	0.2	71
30–100	0	1	3.1	0.1	na
CDX	0	31.0	100	1.0	na

Fraction of risk neutral expected total loss rate borne by each tranche, and base Gaussian copula correlations to the respective detachment points. Source: Morgan Stanley data for 19 February 2007.

The predominant industry approach to pricing and hedging CDOs and tranched index products is known as the copula. A key parameter for the Gaussian copula model, the version most commonly used for quotation purposes, is knows as the base correlation. Table 4 shows the base correlations implied by the market pricing of the respective detachment points 3%, 7%, 10%, 15% and 30%. For a particular detachment point, say 7%, the base correlation of 27% reported in the table is the Gaussian copula correlation for pairs of firms in the underlying pool of 125 firms. The correlation parameter of 27% is chosen to match the copula model's valuation of default losses between 0 and 7% of the notional underlying pool of debt with the market valuation of these losses. The fact that the base correlation varies dramatically across the detachment points makes it clear that the Gaussian copula model does not provide consistent pricing across the various tranches. The copula correlation parameter is, in theory, a property of the underlying pool of debt, and is not a property of the tranches. if the pool correlation parameter necessary to price one set of tranches is not close to the pool correlation parameter necessary to price another set of tranches, then the model is not appropriate. In practice, firms use proprietary variants of the Gaussian copula model that are sufficiently flexible to fit most of the tranche prices. As explained in the main text, however, these more flexible models are not necessarily effective, since they are typically not based on information bearing directly on default correlation, other than the CDO prices to which they are calibrated.

Because hedging depends on accurate pricing, the lack of reliable industry models for CDO pricing is especially problematic for dealers in tranche products, or leveraged hedge funds, which tend to hedge their mark to market exposures to certain tranche products with positions in other products. The deltas shown in Table 4 are based on the same Gaussian copula model that is calibrated with the base correlation estimates shown for each tranche. The weaknesses of this copula model from the viewpoint of pricing are likewise a source of concern from the viewpoint of hedging. The current lack of reliable default correlation models also leaves significant doubt about the quality of pricing of bespoke tranches – those based on a pool of collateralising debt tailored to the specifications of investors. (Bespoke means custom made.) The tranche pricing implications of default correlation within bespoke collateral pools is difficult to infer by reference to CDX or other benchmark tranche pricing because of the often limited overlap of the sets of firms underlying bespoke and index products.

A notorious example of the ineffectiveness of delta hedging of tranches occurred with the rating downgrade of General Motors (GM) debt in May 2005. Theoretically, the loss incurred by a seller of protection on the equity CDX tranche should have been offset largely by the seller's buying protection with a mezzanine tranche position sized to offset the delta exposure of one tranche with the delta exposure of the other. For example, the deltas shown in Table 4 would have implied buying mezzanine protection for 71.4/18.4 = 3.9 times the total CDX debt principal underlying the equity tranche position. Some market participants that took this delta-based approach to hedging equity tranche positions with mezzanine tranche positions suffered significant losses when the mezzanine tranche price did not respond to the GM downgrade as suggested by the delta estimates used at the time of the downgrade. Indeed, the mezzanine tranche prices responded much less vigorously than predicted by the copula-based delta models available at the time and, in fact, responded in the *opposite* direction to that suggested by standard models. Instead of reducing their losses, hedgers following this approach slightly *increased* their losses! In mid-2007, a hedge fund managed by Bear Stearns suffered significant losses on CDOs Backed, in part,by subprime mortgages.

Even when theoretically correct, delta hedging may not be especially effective in the face of sudden large price changes. In the case of the GM downgrade, standard copula-based delta models were inadequate to the task. Reporters also questioned whether efficient market pricing was a reliable approach during the GM downgrade, given the limited amount of capital available for taking advantage of tranche price distortions caused by some market participants rushing to exit their losing positions.

The situation was further exacerbated by the fact that the rating downgrade moved GM debt from investment grade to speculative grade. Investors specialising in investment-grade debt (by design or by contractual limitation) would have needed to sell an exceptionally large amount of GM debt relative to the entire size of the speculative-grade bond market. The associated price impact, or at least traders' anticipation of the potential price impact, could have further pushed market prices away from their efficient-market levels.

Some believe, however, that the large pool of capital now dedicated to CDO trading will mitigate future market disruptions. In "Tranches of trepidation", (Risk, May 2007), Navroz Patel writes, "Dealers are correct in their assertion that they have a much broader base of clients to whom they can lay off equity correlation risk, says BlueMountain [Capital Management president Stephen] Siderow. But in his opinion, there remains a big open question over this evolution: 'How many of these newer players truly understand correlation risk, and will they stay in the market at a time of great stress?' If newer, perhaps less savvy, players do bolt for the exit door at a time of market stress, some of the major players are waiting in the wings to snap up equity tranches when correlation levels bottom out. As one correlation trader puts it, a number of major hedge funds are 'still kicking themselves' for not buying cheap equity tranches during the correlation crisis of 2005. 'I know for a fact that they would dive in and put their capital to work massively if we see that kind of dramatic price action again,' he says.

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Remarks on "Innovations in credit risk transfer: implications for financial stability"

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Introduction

It is a real pleasure and honour to be with you today. I would like to thank Malcolm Knight, Bill White, Claudio Borio and BIS colleagues for inviting me to this interesting conference.

I have been asked to comment on Professor Duffie's well written paper. The paper explores the "design, prevalence and effectiveness of credit risk transfer" with a view to assessing "the costs and benefits for the efficiency and stability of the financial system". It elegantly and comprehensively documents the proliferation of credit risk transfer (CRT) technology and analyses the potential implications for the operation of the financial system.

My objective in commenting briefly on the paper is twofold:

- First, to reinforce the view that the proliferation of CRT instruments represents the equivalent of a major "technological shock" for the financial industry. This shock is consequential, permanent and likely to spread to balance sheets well beyond the banking system. Indeed, we are in the midst of a structural change that has far-reaching implications.
- Second, to extend Professor Duffie's analysis to consider not only the evolving characteristics of the future "steady state" but also the manner in which we are likely to get there. In this context, and because this involves addressing markets that are not yet complete, my remarks will identify a series of analytical challenges for participants in international finance in general, and for supervisors/regulators in particular.

Points of emphasis

I agree with Professor Duffie's robust characterisation of the depth of the structural change associated with innovation in CRT technology. This phenomenon is well documented – particularly with respect to its magnitude and speed – in the paper's insightful charts and analysis. Moreover, Professor Duffie's paper highlights the degree to which CRT proliferation is still in its relative infancy. Its prevalence in the banking system is, as Professor Duffie shows, concentrated among a few large institutions. And, perhaps more important for the future, the technology underlying the unbundling and repackaging of risk components has potential (and likely) application to many more balance sheets in both the private and the public sectors.

At the heart of the CRT phenomenon is CRT's role in significantly reducing barriers to entry into, and exit from, many markets. CRT significantly expands the ability of existing market participants to reposition their portfolios and allows new participants to enter markets

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formerly closed to them. As a result, the eventual steady-state destination is likely to prove welfare-enhancing, since it involves the completion of markets, a broadening toolkit of risk-mitigating instruments and deeper market liquidity.

Given these dynamics, the credit markets will inevitably experience changes in valuations, liquidity, correlations and the velocity of capital that some observers will view as unusual. And the reaction to the proliferation of CRT – like reactions to virtually all technological shocks – will involve both short-term overshoots with potentially disruptive elements and changes that prove to be longer-lasting.

Secular changes inevitably raise questions about operational and systemic risk, for example:

- Can (and will) current supporting functions and infrastructures accommodate new investor behaviours made possible by innovations in CRT?
- Will this shock be disruptive, realigning the institutional framework, with important implications for the dominant players?
- How prepared is the regulatory/supervisory regime to support the potential welfare-enhancing efficiency gains of CRT innovations while mitigating the new systemic risks?

The transitional dimension

The analysis of these important questions is complicated by a basic reality: the markets that will be affected by the shock of proliferating CRT technology are different from each other in such determining characteristics as completeness, information imperfections and institutional robustness. In addition, the reaction functions of individual participants in international finance, and of the groups they form through their market interactions, will inevitably adjust to the shock at different speeds.

These transitional issues can be seen more clearly if one looks closely at examples of the types of risks being transferred from the balance sheets of banks to the balance sheets of new market participants.

As Professor Duffie demonstrates, by influencing the fundamentals of balance sheet management by dominant players, the proliferation of CRT technology generates efficiency gains for pre-existing market activities. It also places enormous pressure on banks to shift to greater reliance on an "originate and distribute" model. As a result, the detailed evaluation and structuring of individual loans gradually gives way to the mass production of composite products, causing the emphasis in risk assessment to move from the credit characteristics of individual borrowers to the extent of correlation within the composite products being originated, warehoused and distributed.

Professor Duffie's analysis captures the shift well. As he notes, "banks often sell loans that are designed specifically for an intermediation profit rather than a long-run investment profit". This shift entails an interesting challenge for banks, since it forces them to abandon the two extremes of the hedging spectrum – no hedging and perfect hedging – for the world of imperfect hedging with significant basis risk. The potential for periodic investor dislocations was demonstrated by the market disruptions of March 2005, May–June 2006 and February–March 2007.

The shift is encouraged by investor demand, turbocharged by an important market imperfection – investor segmentation. As the paper argues, much of the demand is coming from participants previously unable to enter credit markets. Indeed, in noting that the super senior tranches of collateralised debt obligations (CDOs) are persistently sold out, Professor Duffie points to the clientele effect associated with "the demand by certain investors for debt instruments of a *given* credit quality" (my emphasis). Specifically, if "there is a pool of investor capital that is dedicated to relatively high-quality debt instruments, the supply of such instruments can lag demand, and, in the meantime, an issuer of asset-backed securities can earn attractive rents".

Interestingly, these enthusiastic new buyers – state pension funds, insurance companies, etc – do not fall within the purview of supervisors and regulators possessing, in both absolute and relative terms, the technical sophistication required to understand CRT instruments. It is not that they are not regulated but that they are regulated by entities that have had little exposure to CRT technology.

This observation highlights a more general phenomenon. We are in the midst of a large-scale migration of risk out of the strongest regulatory/supervisory regimes to regimes that historically have lacked the necessary sophistication. The consequences for systemic risk are heightened by the growing probability of some type of political backlash that could lead to an ad hoc regulatory response. Activities related to the subprime loan debacle are worth monitoring in this regard.

The growing involvement of new buyers also raises issues with respect to self-regulation and the robustness of internal due diligence. Typically, these buyers outsource risk assessment through their heavy reliance on credit rating agencies – at a time when these agencies appear to have significant problems.

There is no doubt that credit rating agencies have adjusted their business models to respond to the significant pickup in demand for ratings of new products that tranche and bundle risk components. But the question is whether the credit rating agencies, given their ability to influence the allocation of capital by the new players, have made sufficient progress in understanding and modelling the dynamics of CRT instruments in different states of the world.

The key issue in this context is succinctly stated by Professor Duffie: "Currently, the weakest link in the risk measurement and pricing of CDOs is the modelling of default correlation. In practice, there is relatively little emphasis on data or analysis bearing on default correlation." Rating agency behaviour during the US subprime loan debacle has done little to allay concerns in this area.

This specific discussion is indicative of a broader phenomenon affecting many firms in the financial industry. The spread of derivative products highlights significant differences in the reaction functions of the front office on the one hand, and the middle and back offices on the other. And the tensions could lead to greater operational risks in the system as a whole.

The recent credit default swap (CDS) initiative spearheaded by the Federal Reserve Bank of New York speaks to this point. Significant progress has been made, essentially through moral suasion, in dealing with the large backlog of incomplete CDS confirms. This is a good indication of the type of measures needed to ensure that the "plumbing" of the financial system keeps up with market innovations. And the challenges involve such basic functions as risk modelling (including sensitivity and scenario analyses), valuation and accounting treatment.

Bottom line

So where does all this leave us? Professor Duffie's paper documents well a major technological shock affecting the financial industry. Specifically, the paper makes an important case for treating innovations in CRT technology as consequential and permanent, and for anticipating the rapid spread of their influence to a growing number of balance sheets both inside and outside the bank sector. Both existing and new market participants will feel the impact of these innovations. The completion of markets that will be achieved in the steady state will be welfare-enhancing, although it may entail fatter tails at both ends of the risk distribution.

Professor Duffie's paper also highlights the importance of complementing ongoing research on the eventual steady state with greater coverage of transition issues. Specifically, interesting systemic effects appear to be associated with the differences in the initial conditions of old and new participants, the speed of adjustment and access to contingent capital. A better understanding of these transition issues would add to Professor Duffie's interesting discussion of the costs and benefits of CRT for the efficiency and stability of the financial system.

Thank you.