CHAPTER 1

Cash-Flow Structures

If I listened to my customers, I would have invented a very fast horse.

—Henry Ford

1.1 GETTING STARTED

A simplified “cash” structure, also known as a “true sale” structure, is illustrated in Figure 1.1. A seller sells assets into a trust from which bonds are issued to investors. The adjective “cash” is used to denote that real assets are purchased with cash collected from issued bonds. This is opposed to a synthetic structure where credit default swaps (CDSs) are entered into (discussed later in this chapter). The adjective “true sale” refers to the transfer of the assets into a trust or special-purpose vehicle (SPV) from the sellers. The transfer is a legal sale, isolating the assets from the seller.

The assets reside in the trust and generate interest and principal (I + P) cash flows. These collateral cash flows are routed to the various bonds that were issued as liabilities. The rationale behind this generic structure is to transform a group of assets with certain average credit risk into a set of bonds of distinct credit risks. These risks may be formalized by virtue of having a rating agency assign ratings (e.g., senior bonds are rated AAA).\(^1\) The bonds are partitioned in an attempt to meet investor demand for different risks. The structure satisfies various counterparties in different ways. Senior investors may gain the ability to invest in asset types that were previously unavailable to them because of their raw risk. Equity investors may exploit

\(^1\) Throughout this book, S&P ratings are given unless the distinction between the different agency ratings is relevant.
the excess spread “arbitrage” between asset yields and issued bond costs. Seller/securitizers, underwriters, guarantors, and the like look to earn fees.

The AAA senior bonds, for example, achieve their low risk and high rating because they are supported (at a higher priority than other bonds) by asset cash flows and they have various forms of credit enhancement. One type of credit enhancement is the subordinate bonds shown in Figure 1.1. These bonds absorb any losses before the seniors do—all the subordinates need to be written down before the seniors realize any loss. The alchemy of transforming collateral of one rating into a security of another rating is subtle. Do the senior bonds have the same credit risk as other securities rated AAA (perhaps backed by different collateral) by the same rating agency? Where does the similarity end, making the rating nonequivalent (Davies 2006)?

Both the assets and the liabilities have various characteristics that are glossed over in this figure. Structural complications are hidden. How are interest and principal allocated to each bond over time? Are there triggers that cause cash flows to be rerouted or even terminate the deal? Are there auxiliary accounts, and how do they operate? Consider that a prospectus can be 150 to 250 pages long. The main difficulty in accurately modeling the structure (i.e., estimating the value of the bonds) is not necessarily this complexity, although complexity does make such models intricate. No, the key difficulty is in making the right input assumptions: Will the assets prepay and at what rate? How heavy will losses be, and what is their timing? Will forward interest rates be used or another view of rates taken?
Table 1.1 sketches a possible cash flow for this structure. Assets consist of $100MM worth of what is known as “2/28 hybrid ARM” loans. For simplicity, all the loans are considered to be the same: They remain fixed at 8.6% for two years until they float at six-month LIBOR + 6.3%. The collateral cash flows are shown on the left and the bond cash flows on the right. There are no losses assumed, although there are voluntary prepayments made on the collateral. Senior and subordinate floating-rate bonds are issued for a total of $98MM, thus implying that the deal is initially over-collateralized by 2%. Annualized one-month LIBOR rates are listed—the two bonds are floating on this rate: the senior bond at a 25 bps spread and the subordinate at a 140 bps spread. There is enough “excess spread” between the assets and liabilities that even after bond interest and principal is paid, there is a residual (rightmost column in Table 1.1). Note that the seniors get paid down entirely before the subordinates are paid any principal. In this structure, O/C is held constant at $2MM until the bonds pay down entirely, at which point the O/C slowly releases to the residual.

An overly simple example with actual numbers is introduced to help the reader visualize the core of all cash flow models. There are assets generating cash fed to liabilities absorbing cash. Both sides are driven by market rates, perhaps unevenly. The collateral can be driven by several factors, including losses and prepayments. The bonds are managed by potentially complex payment priorities. If one were to invest in the residual of this deal, for example, then an accurate present valuation of the residual cash flow would be necessary, under alternative scenarios. The sensitivity of the residual to various factors would be important to ascertain (e.g., how does its value change with a change in prepayment rate?).

The details of collateral cash flows are discussed in Chapter 3. The intricacies of bond cash flow generation are discussed in Chapter 4. How the over-collateralization amount, as well as the bond allocations, is optimally chosen is discussed in Chapter 5. The trade-offs between over-collateralization and excess spread are discussed in Chapter 6.

1.2 SECURITIZATION

Collateralized mortgage obligations (CMOs) and, in general, mortgage-backed securities (MBSs) are investment vehicles that support bond issuance with an underlying pool of mortgage assets. In general, interest cash flows from the assets support interest paid to the bonds, and principal cash flows from the assets support amortization of the bonds. In actuality, the transfer of cash flows can be a complex priority of payments as described in what is known as a waterfall. In general, the asset and liability balances match more
### TABLE 1.1
Simplified Cash Securitization Structure: Cash Flows (x000). Monthly periods 1–12 and 45–60 shown. Rates are annualized (6m LIBOR not shown)

<table>
<thead>
<tr>
<th>Period</th>
<th>Int</th>
<th>Prin</th>
<th>Prepay</th>
<th>Collateral</th>
<th>Bonds 1m L</th>
<th>Senior Int</th>
<th>Sub Int</th>
<th>Prin Dist</th>
<th>Senior Prin</th>
<th>Sub Prin</th>
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Cash-Flow Structures

or less. When the asset balance exceeds the liability balance, the structure is over-collateralized. This is beneficial to the bond holders because the excess can absorb defaulted mortgages. Most structures require a certain amount of over-collateralization (O/C) and when the OC is less than the target, the structure is undercollateralized. In such a case, payment priorities are shifted to pay down more senior bonds, hence increasing the OC.

Let's look in more detail at a typical deal, jumping into the deep water. The reader may wish to skim the remainder of this chapter and return to it after reading subsequent chapters. However, it is important to understand how the securitization business works before appreciating why models are built as they are. Subsequent chapters describe many of the points introduced here in greater detail.

The phases of a typical “cash” mortgage securitization are:

1. The Seller buys assets (it is called the Seller because it sells these assets into a Trust).
2. Underwriters bid to do the bond underwriting (potentially the Seller does its own bond issuance, in which case it is an underwriter).
3. The Seller picks a syndicate of underwriters with a lead.
4. The Seller works with the syndicate lead and the rating agencies to size and rate the structure.
5. The syndicate starts to sell the deal (i.e., solicit interest from Investors).
6. On Trade Date, the Seller and syndicate lead price the deal with live market spreads and interest rates. The syndicate finalizes sales to Investors at these prices for settlement on the Settle Date. Usually, all bonds are sold at this time.
7. The Seller books a sale of the assets on the Trade Date but retains certain risks until the Settle Date (around one month later). For example, should a loan entirely prepay, that loan must be replaced by the Seller. If the loan was purchased at a premium, since it prepayments at par, there will be a loss to the Seller.
8. On settlement, the Seller sells the assets into the Trust.
9. The syndicate issues bonds supported by the Trust to Investors.
10. After settlement the Seller may be required to supply additional assets within some short period of time (called the prefunding period).
11. The Seller may also be allowed to trade assets during a period of time (called the reinvestment period).

Mortgage assets are sold in pools of loans by Originators who underwrite the individual loans. The pools are sold at auction. The first step above, buying assets, involves the following steps:

1. The Seller models the loan collateral to estimate a price.
2. The Seller wins its bid for the pool.
3. The Seller conducts due diligence on pool, potentially kicking out non-compliant loans.
4. The Trustee verifies that the collateral is compliant, issuing a Trust Receipt to the Seller.
5. The pool is now settled, that is, owned by the Seller.
6. The Seller monitors Servicer reports and reconciles invoices with cash receipts.
7. The Seller updates the loan balances and paid-through dates.
8. Within some short period of time after settling the pool, the Seller can put back noncompliant loans to the Originator.

Figure 1.2 summarizes a typical “cash” structure just at the point of settlement. Investors in the structure (also called Certificate Holders) pay cash to buy various bonds or tranches of the Trust (1). The Trustee is potentially paid up-front fees (2). The Trust buys the loans from the Seller (3). Previously, the loans were analyzed and bid, and due diligence was conducted by a third party (the Trustee). The final loan portfolio is passed into the Trust. Swap counterparties (“Basis Risk Cap Provider” and “NIM Cap Provider” in the diagram) may provide interest rate swaps and/or caps to the Trusts. Here, caps are assumed, requiring up-front fees (4,5). The caps reduce Trust exposure to any fixed-floating-rate mismatch. Servicing rights are sold to the Seller along with the loan portfolio. The Seller may sell these rights to a new Servicer, receiving cash (6).
The Net Interest Margin (NIM) Trust is a monetized portion of the residual (equity) tranche of the structure. Potentially, three cash flows can be placed into the NIM Trust (7). Class X is residual interest, and class P is prepayment penalties. The NIM “corridor” is the flows from optional interest rate caps (the “NIM Cap Provider”). Class N is the NIM outflows, perhaps sold to Investors (8). The cash paid by NIM Investors flows through to the Seller (8,9) and into the original Trust in purchase of Classes X and P. This flow is implicitly netted against (3). A “post” NIM piece (OTE, or “Owner’s Trust Equity”) is the residual after Class N is paid. This may be retained by the Seller or sold to a counterparty (9). This example has one NIM, although a chain of NIMs is possible. Class R is constructed for tax purposes and related to real estate mortgage investment conduits (REMICs), a topic beyond the scope of this text. For one explanation of how this type of structure is taxed, see Morgan Stanley (2004a).

Figure 1.3 shows the structure in the steady state. The assets in the Trusts pay interest and principal to the Investors (1,6). These payments are supported by the Basis Risk Cap (BRC) paid by the Cap Provider should interest rates exceed the strike (2,3). These payments are also supported by the Servicer should any assets miss payments due to delinquency or default (4). Should recoveries be made on defaulted assets, the servicer is repaid any advances from recoveries (4). The Trustee distributes payments from the Cap Providers and Servicers to the Trusts (2,5). The assets also make payments to the Trustee: ongoing Trustee fees and Class X, P, and R cash flows (2). The Class X and P flows are paid to the NIM Trust (5). The post-NIM residual is paid back to the Trustee (7) and ultimately to its owner.

**FIGURE 1.3** Typical Trust Structure: Steady State Cash Flows
The first phase of syndication (bidding on an asset pool) is illustrated in Figure 1.4. These actions occur within a few days and are repeated throughout the period when assets are warehoused, leading to a securitization takeout. Collateral data, arriving from an originator, are scrubbed and entered into a collateral management system. The system then produces stratification reports for traders to ascertain pricing assumptions for the pool, perhaps by comparing to similar pools. Loss distribution models are run (rating agencies may have their own proprietary models), producing loss severity and foreclosure frequency reports. A repline file (describing the collateral) is generated for structurers to lay out a tentative structure (what tranches at what ratings) that is then fleshed out (how large each tranche is) in the sizing model. The sizing model requires market inputs for curves and spreads, as well as rating agency constraints. The sizing model generates a final structure that can then be priced with the pricing model. Over time, if the model price drifts from other bids in the market, the model inputs should be reconsidered. For instance, one might ask: Are the assumed market spreads still correct?

To summarize, for each asset pool of interest, the models outlined take the best available input assumptions at the time and generate a bid price. This price is an estimate of pool value assuming eventual securitization takeout. The pool can be viewed on its own (as if the securitization were supported only by these assets) or in conjunction with what is already owned.

In reality, securitization is more complex than previously described. Figure 1.5 illustrates the purchase of assets over time. Starting on the left of the timeline, an ongoing operation is to bid and purchase loan pools. These loans are added to the overall open position of the Desk. A securitization “closes” on the Settle Date. One month prior to this, the bonds are structured, priced, and sold vis-à-vis a Prosup (short for Prospectus Supplement) pool. This pool has the required collateral size and characteristics for closing. The rating agencies bless this pool and certain stressed performance results are published in the Prosup for sales purposes. One week prior to settlement, the initial settlement pool is selected. This pool must adhere to the Prosup pool characteristics within very tight bands. The rating agencies again need to bless this pool. Loans originally in the Prosup pool that have settled and pass all performance constraints can be removed from the initial settlement pool and substituted with other loans, as long as the overall profile is acceptable. After closing, the prefunding account is used to buy additional loans to complete the collateral. These loans are usually selected in three phases, one per month, each reviewed by the rating agencies.

Figure 1.4 also summarizes daily mark-to-market of the bonds. Every day, the current aggregated assets are run through the pricing model. The only inputs that should change are market curves and (less frequently) market
FIGURE 1.4  Modeling Procedure for Assets Not Yet Securitized
spreads. The pricing model generates a price estimate for the loan portfolio. In the next chapters, the pricing and sizing models in this diagram are described.

Once a portfolio of loans gets securitized and the deal has settled, commercial models can be used, for example, Intex (www.intex.com). Industry standard has evolved to use the Intex CMO Description Information (CDI) meta-language for describing a deal and its waterfalls. The models outlined in this book are not CDI interpreters, nor do they produce CDI to run on the Intex interpreter. The models described here take a different approach.

The securitizations described above involve “cash” structures involving actual or real collateral (loans or bonds). “Synthetic” deals are structured with swaps that mimic bond cash flows. Among securitizations over the past few years, synthetic and hybrid (synthetic and cash) deals outnumbered cash deals. Synthetics are introduced next and revisited in section 7.5.

1.3 SYNTHETIC STRUCTURES

A “synthetic” structure uses credit default swaps (CDSs) or, in the case of mortgages, asset-backed credit default swaps (ABCDSs) instead of real assets. In a CDS transaction one party pays a periodic fixed premium to buy protection on a given name or credit (a reference bond). The counterparty receives these premiums. Should the reference bond miss interest or principal payments, the counterparty pays some related compensation to the insurance buyer. Hence, the counterparty is selling protection. This is a gross overview of the swap—there are several other details concerning how the counterparty pays given certain events, and how the swap is terminated.

Even with this simple description, we can see how the swap can be used as a hedge for a cash deal. If the reference credit starts to deteriorate (e.g., its spread widens), then the protection buyer sees an increase in the swap value. A securitizer might enter into a swap to hedge the value of an underlying real asset warehoused prior to securitization settlement. It is painful if a separate swap is required for every name in the portfolio. To facilitate this, it is possible to swap on an index of names. For example, ABX is an index
FIGURE 1.6 Cash vs. Synthetic Structures (Funded)

of 20 mortgage deals, each with various rated tranches (Lehman Brothers 2005, 2006; Credit Suisse 2006). If your asset portfolio has the same general characteristics as the ABX, it can be hedged by entering into an ABX swap as the protection buyer. For example, you can buy protection on the ABX BBB subindex, which means that you pay a premium and receive a contingency payment should the ABX BBB tranches miss a payment of some sort.

Furthermore, synthetic structures can be built entirely out of CDSs rather than real assets. Cash and synthetic deals are contrasted in Figure 1.6. In a typical cash deal, the investors pay cash that is used to buy real assets in the collateral portfolio. The assets throw off interest and principal payments (I + P). These are paid through a waterfall to the investors. The issued bonds amortize at the natural rate of the collateral amortization.

This description is simplified in many areas. No prior funding of assets is assumed—it is as if all the assets were purchased at settlement. In reality, most assets are purchased beforehand, and this requires funding. There is some counterparty off to the left that funds the deal at some funding rate, and is paid off on settlement date by the investor’s cash. Also, on settlement, all assets are assumed to have been purchased—in reality, there may be a prefunding period. There may also be a reinvestment period, which is assumed here to be absent. Finally, termination conditions are ignored. These same simplifications are assumed when considering the synthetic deal next.
In a typical (funded) synthetic deal, the investors pay cash to buy bonds. This cash is invested in relatively risk-free securities (reserve account) that pays a floating rate (London Interbank Offered Rate [LIBOR]). A portfolio of (AB)CDS is entered into. These swaps pay fixed premiums. Supposing the issued bonds are floaters, the premium (from swaps) plus LIBOR (from the reserve account) combine to form the interest payment to the bonds. Any excess interest goes into the reserve account. During amortization, cash from the reserve account is paid out as principal to the bonds. The amortization rate tracks the amortization rate of the (AB)CDS reference bonds. Should losses be taken in the reference bonds, the reserve account makes a contingency payment to the swap counterparty. Finally, any cash remaining in the reserve upon termination is distributed to the residual.

This type of synthetic structure is called a “funded” deal because bonds are issued for cash. The trust has been created to ensure that the assets in the reserve account are bankruptcy remote. It is possible to issue an unfunded tranche if the investor is so highly rated that it can be trusted to make contingency payments. Such a tranche is usually (but not always) the seniormost, called the “super senior,” that is, effectively rated even higher than AAA. The super senior is supported directly by entering into a CDS; that is, the investor pays no initial cash.

What are the advantages of a synthetic structure? Primarily, it should allow optimal asset selection without having to bid on newly issued asset portfolios or bonds. Assets on the secondary market can be evaluated, compared, and selected prior to execution. A cash portfolio organically grown over time is perhaps less optimal. Also, synthetics enable cheaper funding. CDSs can be cheaper than their corresponding cash assets. In addition, unfunded “super seniors” have lower spreads than funded seniors (hence are cheaper to the issuer). What is the main disadvantage? (AB)CDS counterparties to buy protection must be found, which may not be easy.

A bespoke tranche (also called a single-tranche CDO or STCDO) is a synthetic structure consisting of a single tranche. It is simpler than a traditional synthetic structure (above), and can be optimized to an investor’s preferences. The investor can specify the collateral, the amount of credit enhancement, and the tranche width. If there is only one investor, then there can be no conflicts of interest with other investors, for example, the seller/structurer who often retains the equity. This can result in increased spread to the investor for equivalent risk. One investor also implies that the deal can be closed even faster than a traditional synthetic deal. Unlike a structure in which the seller has sold all tranches and hence holds no risk position, if the seller sells a bespoke to an investor, then the seller is short risk (i.e., it has bought protection). To hedge this, the seller may choose to sell protection in the right ratio (more about this in section 7.5.3). Either the entire index, a sector within
the index, a subset of individual names in the index, or a combination of these can be sold as the hedge. A seller retaining the equity tranche of a cash structure has a similar hedging problem, as does any investor in any tranche.

Synthetic structures are a topic worthy of an entire book (e.g., Chaplin 2005). The reader interested in learning more about synthetics is also referred to Tavakoli (2003), Cifuentes and Lancaster (2004), Lucas (2006), Mahadevan (2006a, 2006b), Whetten and Adelson (2004a, 2004c, 2004d), and Bank of America (2004).

1.4 PUTTING IT ALL TOGETHER

In this chapter, cash and synthetic structures have been introduced. The taxonomy of securitizations goes beyond this one dimension. Other key dimensions include type of asset and type of analysis, as illustrated in Figure 1.7. Only a sample of links is shown here. Hybrid deals are structures where both the assets and liabilities are constructed with both cash and synthetic assets. In addition to the asset-backed securities (ABS) and residential mortgage-backed securities (RMBS) emphasized in this book, there are also commercial mortgage (CMBS), corporate (investment grade and high yield), and emerging market (EM) deals.

All these assets are valued primarily based on interest, default, and recovery rates. For assets such as corporate bonds, credit spreads are translated

![Figure 1.7](image-url)
STRUCTURED FINANCE MODELING

into default probabilities (see Chapter 7). Mortgages and some ABS loans have the additional stochastic variable of prepayment rate. Each deal can be analyzed either statically or dynamically. Static analysis involves valuing a relatively small set of stressed economic scenarios as represented by interest, default, and prepayment curves. Dynamic analysis represents an unlimited number of scenarios by interest, default, and prepayment probability distributions. Finally, dynamic analysis can be implemented in various ways. Monte Carlo simulation evaluates thousands of scenarios sampled from the (marginal) probability distributions to construct empirical (joint) value distributions. In rare cases, the mathematics of the dynamic input distributions are sufficiently simple to allow semianalytical solutions to the output value distributions.

Not all of the combinations in this taxonomy are used in practice. Let’s trace some of the popular combinations. This book concentrates on ABS/MBS cash deals with static analysis (Chapters 3 through 6). Static analysis has been used by rating agencies to rate deals (i.e., assign ratings to tranches). Dynamic analysis with Monte Carlo simulation is introduced in Chapter 7, in the context of both cash deals and synthetic deals. In general, dynamic analysis is used by sellers/securitizers to get a more detailed view of risk versus return, and has recently been adopted by rating agencies.

Mortgage taxonomy is quite rich. MBSs can be split between residential (RMBS) and commercial (CMBS). RMBSs can be split between government-guaranteed and nonguaranteed mortgages. The three agencies (Ginnie Mae, Fannie Mae, and Freddie Mac) issue “conforming” collateral, and nonagency originators issue “nonconforming” collateral. RMBSs can also be split between pass-throughs and collateralized mortgage obligations (CMOs). The latter have tranchéd bonds in their liability structure. Nonagency CMOs are also called “whole loan” CMOs or CDOs because the collateral is raw mortgage loans. Other types of CDOs often have bonds for collateral, for example, pass-through mortgage bonds, corporates, and so on. Nonagency RMBSs, by virtue of not being guaranteed by the government, need other types of credit enhancement, as discussed in later chapters. Their collateral is split along a credit dimension: prime (“A” rated), midprime (“alt-A” rated), and subprime (“B” and “C” rated). “Home equity” is a term commonly used for subprime mortgages. However, technically it refers to second-lien mortgages of any quality. To avoid this ambiguity, the term will be avoided when possible.

Synthetic ABS deals with static analysis were touched upon in the previous section. Although the construction of synthetic deals is radically different

2 Throughout the book, “agency” refers to rating agency, not government mortgage agency, unless otherwise noted.
than cash deals, the analysis for ABS/MBS/CMBS is similar. These asset types require detailed cash flow analysis for accurate valuation; that is, picking an optimal portfolio requires understanding cash flows. Thus, the techniques described in this book apply also to synthetic ABS deals. Synthetic deals based on corporate credits differ in that cash flow analysis is simpler because premiums are fixed and assets do not amortize. Synthetic deals based on indexes differ in that the portfolio is fixed. The waterfalls in such structures are usually quite simple. As a result, dynamic analysis is practical for this market, as discussed in section 7.5 in the context of Monte Carlo simulation. Semianalytical solution of such structures is used by the market as a de facto “street model” for pricing such indexes.