

Asset Cash Flow Generation

The first calculations to do are related to cash flowing into the structure, which is known as *asset cash flow generation*. Depending on the type of transaction, there can be wide variability as to how cash is generated. For most structured finance transactions, the asset cash flow generation is usually in the form of principal and interest from the assets. Some transactions, particularly those involving infrastructure, rely on consultant studies or simulations that project future cash flow. Regardless of the type of transaction, a cash flow model must have some type of assumption for the periodic inflow of cash.

With a structured framework, there are many intricate and distinct parts to creating the cash flows that assets produce such as interest calculations, default and prepayment assumptions, recoveries, and the like. Explaining in detail how each of these parts work is fundamental to accurate modeling and also beneficial to building a financial modeler's skill. Explaining the most basic concepts first, this chapter then focuses on creating a notional asset cash flow—that is, cash flows without giving affect to prepayments and defaults. Once this is complete, each detail will be introduced one at a time to create the actual asset cash flow.

Prior to explaining exactly how to model structured asset cash flows, the answers to two questions need to be taken into account: (1) How will the assets exist over time? (2) And what and how much data on the assets are there? Depending on the answers to those two questions two methodologies can be employed: loan level generation and representative line generation. Both methods produce a set of cash flows that can be used for modeling purposes, but each method used on the same assets can produce remarkably different results.

LOAN LEVEL VERSUS REPRESENTATIVE LINE AMORTIZATION

The answers to those questions asked in the previous section—about how assets exist over time and the amount and quality of data—determine which methodology to use for generating cash flow. So, how do assets exist over time? This concept can be a little cryptic to people new to structured finance. At the most basic level, the assets in a structured finance transaction can either remain the same in a definitive pool or they can revolve. A definitive pool means that the assets that the transaction

starts with are the only assets available to the transaction. If there were 10,000 mortgages in a pool, those specific mortgages would remain in the transaction through the deal's life. As the mortgages pay off, refinance, or default, no new mortgages are added. This is usually seen in buy and hold transactions or deals where investors buy into a specific pool.

With a definitive pool, the most preferred method of asset amortization is a *loan level analysis* where each individual asset is amortized based on the asset's individual characteristics. Each one of the 10,000 mortgages would have its own amortization schedule that would be aggregated to form one transaction amortization schedule. That aggregated amortization schedule would provide the cash flow generation for the transaction.

Whether a loan level analysis is possible depends on the answer to the second question: What type of information is available for the assets? Detailed data for each asset is required to complete a loan level analysis. At minimum, information for each loan's term, balances, and interest rate would be required. This is why it is extremely important for companies to track extensive data on their assets and be able to access and transmit such data.

If no such data exists, the other option is to use a *representative line analysis*. A representative line can be thought of as an aggregation of similar loan's attributes as a single loan or line of information. For instance, if there were only five similar loans in a pool and each loan's specific balance, term, and rate was unknown, a loan level analysis could not be completed. However, if information on the aggregate pool of the five loans was available, such as the sum of all the balances, the weighted average terms, and the weighted average rate, an amortization schedule using those figures could be created. In such a case enough information exists to create and amortize a fictitious loan that is representative of the five actual loans in the pool.

Many people find representative lines a difficult concept to grasp, so a basic example of taking a number of loans and making one representative line is the best way to get a feel for the concept. Assume the following loans shown in Figure 2.1.

	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							

<i>Individual Loans</i>			
Loan	Principal Balance	Rate	Term
1	1,000,000	4.00%	360
2	35,000	14.00%	240
3	500,000	5.50%	360
4	400,000	7.00%	280
5	750,000	5.00%	180

FIGURE 2.1 Each individual loan has a principal balance, rate, and term.

	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							

<i>Individual Loans</i>			
Loan	Principal Balance	Rate	Term
1	1,000,000	4.00%	360
2	35,000	14.00%	240
3	500,000	5.50%	360
4	400,000	7.00%	280
5	750,000	5.00%	180

<i>Representative Line</i>		
Sum	Weighted Average Rate	Weighted Average Term
2,685,000	5.14%	296

FIGURE 2.2 A representative line can be created from the individual loans by summing the principal balances and calculating the weighted average rate and term.

	I	J	K	L	M	N
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						

<i>Individual Loans</i>			
Loan	Principal Balance	Rate	Term
1	1,000,000	1.00%	360
2	35,000	20.00%	240
3	500	12.50%	360
4	5,000,000	3.00%	280
5	750,000	10.00%	180

<i>Representative Line</i>		
Sum	Weighted Average Rate	Weighted Average Term
6,795,500	3.57%	281

FIGURE 2.3 The five loans presented here have diverse principal balances, rates, and terms.

By summing the balances and calculating the weighted average rate and term, a single representative line could be made. This would create a single line of information that provides a relatively good summary of the pool of loans as shown in Figure 2.2.

This single line is much easier to create cash flows from than having to create five separate cash flows for each loan in the pool. However, subjective analysis is required when making representative lines because the more diverse a pool of assets is, the more distorted the cash flows are when making a single representative line. Imagine having the data tape shown in Figure 2.3.

In this example, the rates and terms between assets are very different, which means that the aggregate interest and periodic cash flows are distinctly different than

	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	EJ	BK	BL
1															
2		Aggregated Individual Loans						Representative Line							
3		Period	Beg Bal	PMT	Int	Prin	End Bal	Period	Beg Bal	PMT	Int	Prin	End Bal		
4		0	0	0	0	0	€ 785,600	0	€ 785,600	€ 35,666	€ 20,172	€ 15,494	€ 785,600		
5		1	€ 755,600	€ 36,728	€ 20,172	€ 15,666	€ 769,944	1	€ 755,600	€ 35,666	€ 20,172	€ 15,494	€ 770,076		
6		2	€ 730,944	€ 36,728	€ 20,124	€ 15,804	€ 752,240	2	€ 770,076	€ 35,666	€ 20,126	€ 15,530	€ 754,496		
7		3	€ 702,340	€ 36,728	€ 20,075	€ 15,862	€ 735,688	3	€ 754,496	€ 35,666	€ 20,030	€ 15,576	€ 738,910		
8		4	€ 675,688	€ 36,728	€ 20,027	€ 15,911	€ 719,987	4	€ 738,910	€ 35,666	€ 20,033	€ 15,622	€ 723,298		
9		5	€ 670,907	€ 36,728	€ 19,970	€ 15,950	€ 702,237	5	€ 723,298	€ 35,666	€ 19,907	€ 15,669	€ 707,619		
10		6	€ 670,237	€ 36,728	€ 19,929	€ 15,993	€ 685,439	6	€ 707,619	€ 35,666	€ 19,940	€ 15,715	€ 691,904		
11		7	€ 685,439	€ 36,728	€ 19,830	€ 16,048	€ 669,391	7	€ 691,904	€ 35,666	€ 19,834	€ 15,762	€ 676,142		
12		8	€ 688,531	€ 36,728	€ 19,831	€ 16,097	€ 651,694	8	€ 676,142	€ 35,666	€ 19,847	€ 15,809	€ 660,333		
13		9	€ 684,634	€ 36,728	€ 19,731	€ 16,147	€ 634,747	9	€ 660,333	€ 35,666	€ 19,810	€ 15,856	€ 644,477		
14		10	€ 634,747	€ 36,728	€ 19,731	€ 16,197	€ 617,750	10	€ 644,477	€ 35,666	€ 19,753	€ 15,903	€ 628,574		

FIGURE 2.4 Notice the slight differences in payment, interest, and principal when using a representative line versus aggregating individual loan schedules.

the cash flows generated by a representative line. Figure 2.4 presents the periodic cash flows of each method.

In the example, the two cash flows are different on a periodic basis and in aggregate. The periodic differences can be problematic for the upcoming liability structure in the transaction. There could be periods of liquidity shortfall or triggers tripped when using one of the methodologies versus the other. Also, the aggregate interest sum of the individual loans comes to \$2,926,259, while the interest sum of the representative line is \$3,233,736. The balance difference is small in this example, but if the principal balance were \$1 billion then the difference between the two methods could be in the tens of millions! For a detailed example of representative lines in Excel, see *Rep_Lines.xls* in Ch 02's Additional Files folder on the CD-ROM.

While it appears that loan level asset generation is ideal if the information is available, a representative line methodology is more appropriate when assets are revolving. A revolving structure is the other form in which assets can be financed. This means that assets can be added to a pool as the transaction continues throughout time. The deal might start with 10,000 mortgages; but some of those mortgages might pay off, refinance, or default over time and others can be added. There is no guarantee that the assets started with will be the assets in the transaction any time in the future. The key to this state of existence for assets is that there are *eligibility criteria* for the assets in the pool.

Eligibility criteria are a fixed set of rules that dictate what assets can be added to a revolving structure and are essential to modeling such a transaction. Typically transactions with revolving assets are modeled assuming the pool of assets is filled to the deal size limit with the absolute worst set of assets the eligibility criteria allows. For example, if the minimum asset yield the eligibility criteria allows is 7 percent, then a representative line created for this transaction should use 7 percent as the asset yield. The reason this is important is that there is no guarantee, other than the eligibility criteria, on the composition of the asset pool. It is also important because stress testing often involves creating a worst-case scenario and, in the case of a revolving transaction, the worst possible pool are the adverse limits of the eligibility

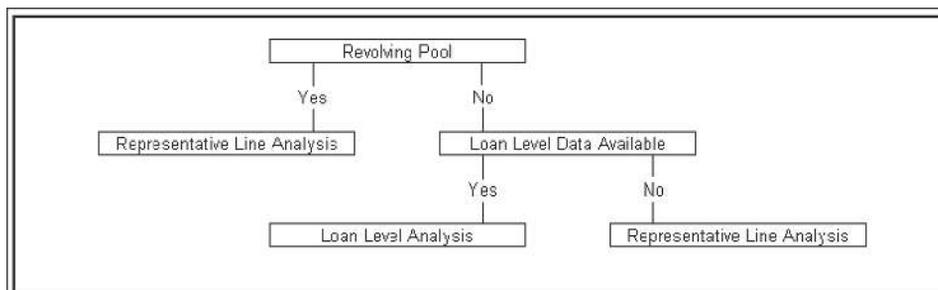


FIGURE 2.5 The type of analysis used to create cash flows depends on a number of factors.

criteria. See Figure 2.5 for a decision tree that summarizes whether loan level or representative line asset generation should be used.

HOW ASSET GENERATION IS DEMONSTRATED IN MODEL BUILDER

The easiest asset amortization to learn is a single loan or representative line created within Excel sheet formulas. This is a useful level at which to start because, as a more detailed asset generation tool is created, the basics can all be found in a single loan. This is why Project Model Builder that you started to create in Chapter 1 uses a single asset or single representative line. To create a more robust model that can handle multiple representative lines or tens of thousands of loans some type of computer code is required. Visual Basic for Applications (VBA) is perfect for such a task and is used frequently in more advanced models. A highly developed asset generation tool has the flexibility to accept any type of loan or amortize loans in groups based on many different criteria.

ASSET GENERATION ON THE INPUTS SHEET

Whether a loan level or representative line methodology is used, the asset generation should be easily manipulated from the Inputs sheet. In a loan level type approach there would need to be a sensitivity selector that changes calculation variables or switches between cash flows calculated and imported from another model. For Project Model Builder, a single representative line methodology will be used and controlled from the Inputs sheet.

The single representative line input for Project Model Builder is based on a pool of assets that pay principal and interest and therefore needs to include, at minimum, the following information: the original balance, the current balance, the interest rate, the original term, and the remaining term. Additional information is required, particularly if the assets are generating yield off of a floating rate. Since

floating rate assets are certainly a possibility in many structured transactions, this text will explain and implement the option of floating rate asset amortization in Project Model Builder.

Fixed Rate Amortization Inputs

A fixed rate amortization with a level payment is very straightforward. The periodic cash flows are created by first calculating the level payment using the PMT function, next calculating the interest for the period depending on the period's beginning balance, then subtracting the interest from the payment to get the periodic principal, and finally subtracting the periodic principal from the beginning balance to get the end balance. Doing this process for each period until the balance is 0 produces a series of principal and interest cash flows.

Floating Rate Amortization Inputs

While most deals are modeled with a fixed rate, there are a number of deals that have floating rate assets, which are more complex to model correctly. A floating rate asset can have a number of additional attributes that could alter the cash flow:

- Rate index
- Rate margin
- Lifetime rate cap
- Lifetime rate floor
- Periodic rate cap
- Periodic rate floor
- Rate reset frequency
- First reset date

The forward projecting assumption for the underlying index primarily drives the interest calculation. This assumption is typically a vector such as a forward curve or rating agency stressed curve. The margin is added to the periodic rate. A *lifetime cap* is a hedge that prevents the index rate from exceeding a defined level over the lifetime of the deal. Conversely, a *lifetime floor* is a hedge that prevents the index rate from decreasing below a defined level over the lifetime of the deal. Closely related is a *periodic rate cap* and *floor*. Instead of preventing the index rate from going beyond a defined level over the lifetime of the deal, a periodic cap prevents breaching certain levels during any given period. Lastly, the *rate reset frequency* is how often the rate resets and changes.

A more general concept to consider when working with a floating rate amortization is how the cash flow is affected as the rate changes. One of two things can happen when the rate changes: the payment changes or the term of the loan changes. Many assets have payments that change as interest rates change. This is the source of payment shock that is often witnessed with variable rate products. Other assets

are set up to keep a fixed payment, so when the rate changes the same payment is made, but the term is affected. If rates increase beyond expectations then less principal will be paid each period and the term will have to be extended. Likewise, if rates decrease below expectations, more principal will be paid each period and the term will have to be decreased.

Another point to consider when working with floating rate assets is that the index the assets are based off of becomes yet another attribute that could cause the need for multiple representative lines. Some pools may have floating rate assets based off of different indexes, which would require the use of a separate representative line for each index.

Organizing the different indexes is the final point to take into account. Each index is a projected vector of rates that is as long as the number of periods. In the example model, there is a possibility of 360 periods, so a single projected interest rate vector such as one-month LIBOR (London Interbank Offered Rate), will take up 360 cells. Storing the indexes on the Inputs sheet would be inefficient since there will be other rate vectors encountered later in the model (e.g., default rates, prepayment rates, etc.) all taking up a large amount of cells. For this reason, a separate sheet for the vectors is created.

MODEL BUILDER 2.1: INPUTS SHEET ASSET ASSUMPTIONS AND THE VECTORS SHEET

This section starts at the Inputs sheet, where the relevant data for a representative line is entered and stored. The inputs used for asset generation create the notional amortization schedule. After this is complete, the asset generation is further developed to account for prepayment, default, and recovery assumptions. Figure 2.6 glimpses at the Inputs assumptions that are created.

To create the inputs necessary for a notional amortization, perform the following steps:

1. In cell B10 create a label for this section of the Inputs sheet by entering **ASSET INPUTS**.

Project Model Builder													
DETAILS & TIMING													
4	Closing Date	2/1/2007											
5	First Payment Date	3/1/2007											
6	Day-Count System	30 / 360											
7	Int. Frequency	Monthly											
ASSET INPUTS													
Description	Original Principal Balance	Current Principal Balance	Asset Amort Type	Y2F Paid Rate	Original Term	Remaining Term	Seasoning	Floating Rate Curve	Weight	Periodic Cap/Floor	Lifetime Cap	Lifetime Floor	Risk Rating
Asset Pool 1	100,000,000	100,000,000	Fixed	5.00%	360	360	0			100.00%	100.00%	0.00%	1

FIGURE 2.6 The section of the Inputs sheet that controls the asset assumptions.

2. Range B11:O11 contains the labels for the variables that will be entered below on row 12. Enter the following text into each labeled cell:
 - B11: **Description**
 - C11: **Original Principal Balance**
 - D11: **Current Principal Balance**
 - E11: **Asset Amort Type**
 - F11: **WA Fixed Rate**
 - G11: **Original Term**
 - H11: **Remaining Term**
 - I11: **Seasoning**
 - J11: **Floating Rate Curve**
 - K11: **Margin**
 - L11: **Periodic Cap/Floor**
 - M11: **Lifetime Cap**
 - N11: **Lifetime Floor**
 - O11: **Rate Reset Freq**
3. It is much easier to work with values for the assumptions, even if they will be changed later. Beginning with cell B12, enter the label **Asset Pool 1**. This variable is self-explanatory; it is a description of the asset representative pool. For this cell and all of the following, make sure that the font format is blue and bold because they are variables that may change. Also, name this cell **AssetDes1**.
4. In cell C12, enter the value **100,000,000**. This is the original principal balance of the pool. It is important to know the original principal balance because the payments are calculated off of it. Name this cell **AssetOrgBal1**.
5. In cell D12, enter the value **100,000,000**. This is the current principal balance of the pool and can be different from the original balance because some loans in the pool may have been partially amortized. For simplicity, it is easier to assume that all of the assets are new and the current balance is the same as the original balance. Name this cell **AssetCurBal1**.
6. Cell E12 contains the amortization type (whether it is fixed interest, floating interest, or custom) and has a value from a data validation list. To do this, go back to the Hidden sheet and enter **Asset Amortization Type** in cell A16, **Fixed** in cell A17, **Floating** in cell A18, and **Custom** in cell A19. While still on the Hidden sheet, name the range A17:A19 **lstIntType**. Go back to the Inputs sheet and create a data validation list for cell E12 using **lstIntType** as the name reference. Cell E12 will be a reference for cells that depend on the type of amortization. Finally, name cell E12 **AssetIntType1**.
7. If the asset pool is going to be amortized on a fixed rate basis, an assumption is needed for that fixed rate. In cell F12 enter **9.00%** for now as a placeholder. Name this cell **AssetFxdRate1**.
8. Cell G12 contains the original term assumption of the pool. Remember that the maximum number of periods the model has been designed for is 360, so this value needs to be less than or equal to that. For now, assume that the original term is 360 and enter **360** in cell G12. Name this cell **OrgTerm1**.

9. Cell H12 is for the remaining term of the pool. This value can be equal to the original term if all of the assets are new but is typically less than the original term. As a starting variable assume that the remaining term is 360 and enter **360** in cell H12. Name this cell **RemTerm1**.
10. The next cell, seasoning (I12), is actually a calculation derived from the original term and the remaining term. The formula that should be entered is:

$$= \text{OrgTerm1} - \text{RemTerm1}$$

While extremely easy, the seasoning should not be underestimated in terms of importance. Prepayment and loss amounts will heavily rely on the seasoning to determine accurate projections. Name this cell **Age1**.

11. Cell J12 contains the name of the curve (synonymous with *vector*) that will be used to calculate interest if the asset is based on a floating rate. This value will be a validation list similar to those done before, but with a twist. The names of the rates make up the range that is being referenced for the list, but they will not be contained on the Hidden sheet. Instead, the names of the curves will be created on a new sheet named *Vectors*.
To create the Vectors sheet, insert a new worksheet and name the sheet **Vectors**. The vectors will be over time, so time labels are needed. In cell A4 on the Vectors sheet, reference cell A4 of the Cash Flow sheet by entering = and then clicking on cell A4 of the Cash Flow sheet. Copy the reference over the range A4:C366. The formatting is most likely incorrect, so copy and paste special the formatting for those three columns from the Cash Flow sheet. Also, there will probably be zero values for cells A5, B5, and C5, which can be deleted since they are unnecessary.
12. In cell E4 enter the first vector name which is **1-month LIBOR**, in cell F4 enter **3-month LIBOR**, in cell G4 enter **6-month LIBOR**, in cell H4 enter **Prime**, in cell I4 enter **Custom 1**, in cell J4 enter **Custom 2**, in cell K4 enter **Custom 3**. Now name the range E4:K4 **lstInterestRates**. The area should look like Figure 2.7.
13. Back on the Inputs sheet, create the data validation list using **lstInterestRates** as the named range reference. Name cell J12 **AssetFltIndx1**. The full utility of creating the data validation list in this manner will become clear later, when the formulas that need to select between the floating rates are explained.
14. The amount that is earned in addition to the floating rate, the margin, is stored in cell K12. For now assume this amount is 1.50 percent. Name this cell **AssetMarg1**.
15. The Periodic Rate Cap/Floor is the amount that the rate can go up or down each period and will be stored in cell L12. For now assume that there is essentially no Cap/Floor by entering **100%**. (It would be extraordinarily rare to have a rate increase or decrease by 100 percent in one month.) Name this cell **AssetPdCapFl1**.

	A	B	C	D	E	F	G	H	I	J	K
1	Vectors										
2											
3				Interest Rates							
4	Period	Date	Day Factor	1-Month LIBOR	3-Month LIBOR	6-Month LIBOR	Prime	Custom 1	Custom 2	Custom 3	
5											
6	0	2/1/2007	-								
7	1	3/1/2007	0.083								
8	2	4/1/2007	0.083								
9	3	5/1/2007	0.083								
10	4	6/1/2007	0.083								
11	5	7/1/2007	0.083								
12	6	8/1/2007	0.083								
13	7	9/1/2007	0.083								
14	8	10/1/2007	0.083								
15	9	11/1/2007	0.083								
16	10	12/1/2007	0.083								

FIGURE 2.7 The new Vectors sheet should include basic timing and rate information at this point.

	D	E	F	G	H	I	J
1							
2							
3	Notional Amort Schedule						
4	Beginning Balance	Interest Rate	Payment	Interest	Principal	Ending Balance	
5							
6						100,000,000	
7	100,000,000	9.00%	804,623	750,000	54,623	99,945,377	
8	99,945,377	9.00%	804,623	749,590	55,032	99,890,345	
9	99,890,345	9.00%	804,623	749,178	55,445	99,834,900	
10	99,834,900	9.00%	804,623	748,762	55,861	99,779,039	
11	99,779,039	9.00%	804,623	748,343	56,280	99,722,759	
12	99,722,759	9.00%	804,623	747,921	56,702	99,666,057	
13	99,666,057	9.00%	804,623	747,495	57,127	99,608,930	
14	99,608,930	9.00%	804,623	747,067	57,556	99,551,375	
15	99,551,375	9.00%	804,623	746,636	57,987	99,493,387	

FIGURE 2.8 The Notional Amortization schedule is created on the Cash Flow sheet.

16. Cell M12 contains the Lifetime Cap, which is the absolute maximum that the interest rate can increase to. Just as the Periodic Rate Cap/Floor enter 100% for now so it is basically deactivated. Name this cell **AssetLifeCap1**.
17. Cell N12 contains the Lifetime Floor, which is the absolute maximum that the interest rate can decrease to. This will be deactivated now by entering 0%. Name this cell **AssetLifeFloor1**.
18. The last cell of this section, cell O12, contains a numeric value that represents the frequency that the rate changes or resets. Depending on the type of rate, there

can be any frequency of rate reset. If the rate resets every period, then this value is one. If it resets every three periods, then it is three, etc. For now assume that the rate can reset every period by entering 1. Name this cell **AssetRateReset1**.

ASSET GENERATION ON THE CASH FLOW SHEET

As the name suggests, the Cash Flow sheet is where the calculations for the asset cash flow generation take place. When using a representative line methodology, a notional schedule of amortization needs to be created. The schedule is called *notional* because it is a hypothetical amortization that does not take into account prepayments, defaults, and recoveries. Later, prepayments, defaults, and recoveries will use the notional schedule to calculate the actual amortization schedule.

The notional asset amortization schedule uses six columns, one for each of the following: Beginning Balance, Payment, Periodic Interest Rate, Interest, Principal, and Ending Balance. Most models, including Project Model Builder, assume a level (mortgage style) payment system, making the calculations very straightforward. The only confusing part can be interest, particularly if a floating rate is desired; otherwise the periodic rate is fixed every period.

MODEL BUILDER 2.2: NOTIONAL ASSET AMORTIZATION ON THE CASH FLOW SHEET

1. As in prior Model Builder sections, the first step is to create labels for the calculations. On the Cash Flow sheet, in cell E3, enter **Notional Amort Schedule**. This will be a title for the next six columns that make up the schedule.
2. In cell E4 enter **Beginning Balance**, in cell F4 enter **Interest Rate**, in cell G4 enter **Payment**, in cell H4 enter **Interest**, in cell I4 enter **Principal**, and finally, in cell J4, enter **Ending Balance**.
3. It may seem a bit counterintuitive, but the next step is to start creating the calculations for the ending balance in column J. This is due to the fact that period 0 does not have a beginning balance. The purpose of having a period 0 is to track when the deal closed and funded. Period 0 has no beginning, it is merely a reference point to begin the deal and any values that correspond to period 0 are considered to be at the end of the period. As will be seen later, period 1 will begin where period 0 leaves off. When working with other models it is important to see whether calculations are based off of *end of period* (EOP) or *beginning of period* (BOP). Often times the difference can have a noticeable impact on results.
4. Since period 0 is an exception, an IF statement that inputs the initial asset balance is needed in column J. Otherwise the ending balance is just the beginning

balance minus the principal that has been paid in that period. In cell J6, enter the following formula and copy it down to cell J366:

$$= \text{IF}(A6=0, \text{AssetCurBal1}, E6 - I6)$$

This formula reads: If the period is 0 then the value of cell J6 is the asset current balance off the Inputs sheet, otherwise it is the asset balance at the beginning of the period, minus the principal paid during that period.

5. The next calculation to complete is the beginning balance. This is extraordinarily easy because the beginning balance of any period is always the ending balance of the period prior. In cell E7 enter:

$$= J6$$

Copy the cell down to row 366. If there is confusion to why this calculation and the next few begin on row 7 recall that period 0 starts with an ending balance only.

6. The next calculation is the periodic interest rate, which is the most intricate formula in this section and possibly the entire model. The numeric value of the interest rate is what needs to be returned in this section, and depends on many factors. The foremost factor is what interest rate vector the user selects on the Inputs sheet. Therefore the formula needs to reference the Inputs sheet to see the vector selection and the Vectors sheet to reference the projected periodic rate. Also, if the rate is a floating rate there is the possibility of caps, floors, and reset periodicity. All of these factors need to be taken into account to return an accurate interest rate for the period.
7. Before the rate formula is constructed, placeholder vectors should be entered on the Vectors sheet. The typical interest rate vector will be a projected curve of some type and can be obtained a number of ways. Usually a forward curve analysis from Bloomberg or any other financial information program is sufficient. To meet ratings criteria, a stressed curve constructed by the ratings agencies should be used. To be able to precisely follow the example calculations going forward, go to the completed Model Builder 2.2 example and in the Vectors sheet copy the curve for 1-month LIBOR (E6:E366). Paste that curve into the same location in the model in progress.
8. With placeholder rates stored, return to the Cash Flow sheet. Cell F7 is where the formula will be entered. The first part of the formula focuses on selecting a rate depending if the assets are paying fixed or floating. This calls for a simple IF statement referencing cell E12 of the Inputs sheet. If cell E12 is set to fixed, then the periodic rate will be the WA Fixed rate in cell F12 of the Inputs sheet, if not then it must be a floating rate and should be the interest rate from the Vectors sheet that corresponds to the correct period and curve selected. The fixed rate selection of the IF statement is simple:

$$= \text{IF}(\text{AssetIntType1} = \text{"Fixed"}, \text{AssetFxdRate1},$$

9. Getting the false value of the formula, in this case the floating rate, requires referencing two pieces of information: the period and the curve selected. A glance at the Vectors sheet reveals that both of those pieces of information are there. All that needs to be made is a connection between the period that the cell corresponds to and the rate curve that the user selected on the Inputs sheet. This can be accomplished using a powerful lookup combination of the OFFSET and MATCH functions. Using these functions in tandem is better than using specific lookup functions such as VLOOKUP because the specific lookup functions typically require lookup values to be in order. OFFSET and MATCH have no such requirements. If you are unfamiliar with either of these functions, refer to the Toolbox section at the end of this chapter.

To help understand how this method works, it is useful to think about the Vector sheet as a table with curve names on the x axis and the periods on the y axis. The OFFSET function is going to locate the correct cell on that table depending on the curve selected and the period. Since OFFSET is essentially a grid lookup tool that starts with a reference point and uses numerical values to find a cell, it starts to become clearer that there needs to be numerical values to represent the period and the curve. Given that the period is already in numeric format, the only difficult variable to conceive of as a number is the curve that is selected. However, since there is a list of the curves on the Vectors sheet (recall that the range E4:K4 was named *lstInterestRates*), there is an implied ordering to the list. Specifically in the named range 1-Month LIBOR (E4) comes first, 3-Month LIBOR (F4) comes second, etc. See Figure 2.9 for more detail.

Looking at Figure 2.9 it makes sense then that a grid reference using D6 as a starting point, to 1-Month LIBOR, one period out (2.60 percent) should be (1,1). This method of grid referencing can be used within the context of the

	A	B	C	D	E	F	G	H	I	J	K	
1	Vectors											
2												
3					Interest Rates							
4	Period	Date	Day Factor		1-Month LIBOR	3-Month LIBOR	6-Month LIBOR	Prime	Custom 1	Custom 2	Custom 3	
5												
6	0	2/1/2007	-									
7	1	3/1/2007	0.083		2.60%							
8	2	4/1/2007	0.083		2.81%							
9	3	5/1/2007	0.083		2.87%							
10	4	6/1/2007	0.083		2.94%							
11	5	7/1/2007	0.083		3.00%							
12	6	8/1/2007	0.083		3.06%							
13	7	9/1/2007	0.083		3.12%							
14	8	10/1/2007	0.083		3.19%							
15	9	11/1/2007	0.083		3.25%							
16	10	12/1/2007	0.083		3.31%							

FIGURE 2.9 The Vectors sheet contains the list for the interest rate, which can be referenced to determine the correct periodic interest rate.

OFFSET function. If cell D6 was offset one cell to the right and one cell down, the active cell would be cell E6. This is synonymous with the formula:

$$= \text{OFFSET}(\$D\$6,1,1)$$

That formula reads: offset cell D6 one cell to the right and one cell down. It would return the value in cell E7, 2.60 percent. Note that cell D6 is an absolute—or fixed—cell reference with \$, so the reference never changes. Once it is clear that cell \$D\$6 is the focal point of the OFFSET, a function needs to be implemented to translate the text variable that selects the interest rate curve into a numerical value.

The function that accomplishes this for the interest rate curve variable is the MATCH function. The MATCH function works very well for lists with any value and any order. Conveniently, a list for the interest rate curve was created (lstInterestRates). If one were given the interest rate curve text variable of 1-Month LIBOR, it could be matched exactly against the list lstInterestRate. The MATCH function returns a numerical value for the placement of the matching value in the list. In this case, the label 1-Month LIBOR is the first value in lstInterestRate, and therefore a MATCH of the text 1-Month LIBOR returns a 1.

Since the periods are already in a numeric value, they do not need to be looked up using the MATCH function. If the offset originates in the cell above the first period, offsetting that cell one period down would require a numeric value of one. Notice that the period value for that corresponding cell is 1. Likewise to offset the cell two periods down, the corresponding period value is 2, and so on. If all of this seems confusing do not worry, the combined formula should start to make sense:

$$= \text{IF}(\text{AssetIntType1} = \text{"Fixed"}, \text{AssetFxdRate1}, \\ \text{OFFSET}(\text{Vectors!}\$D\$6, \text{A7}, \text{MATCH}(\text{AssetFltIdx1}, \text{lstInterestRates}, 0)))$$

This addition to the formula reads, offset cell D6 on the Vectors sheet by one cell down and by one cell to the right. Determining that the offset should go one cell down is done by the period value. Determining that the offset should go one cell to the right is done by matching the selected interest rate curve from the inputs sheet with the list of interest rates. Since 1-Month LIBOR is the first value on the list, the offset goes one cell to the right. Notice that if 3-Month LIBOR was selected on the Inputs sheet, this is second on the list and the offset would go two cells over to cell F7.

10. The next step in constructing the formula is to take care of instances when there is a cap. A cap is a hedge that is purchased to prevent the rate from going above a desired limit. With floating rate financing, there can be either a periodic cap that prevents the rate from going above a fixed amount each period or a lifetime cap that prevents the rate from going above a fixed amount over the lifetime of

the deal. The perfect function to take care of this is MIN. If a floating rate is being used the rate each period should be the minimum of the projected rate or the capped rate. The MIN statement (shown in bold) should be inserted into the formula as shown:

$$= \text{IF}(\text{AssetIntType1} = \text{"Fixed"}, \text{AssetFxdRate1}, \text{MIN}(\text{OFFSET}(\text{Vectors!}\$D\$6, \text{A7}, \text{MATCH}(\text{AssetFltIdx1}, \text{lstInterestRates}, 0)), (\text{F6} - \text{AssetMarg1}) + \text{AssetPdCapFl1}, \text{AssetLifeCap1}))$$

The new section of the formula reads: return the minimum of the projected rate on the Vectors sheet or the previous rate plus the periodic cap or the lifetime cap. Notice that the margin is subtracted out of the previous month's rate. This is because at the end of the formula the margin will be added and any comparison for a cap must be of solely the projected rate. The previous month's rate already has the margin added. So, for comparison purposes, it must be subtracted out.

11. An opposite approach must be taken for floors. Floors are the opposite of caps and are hedges that prevent the rate from going below a certain amount. Given that the hedge is the opposite it makes sense that an opposite function should be used; the MAX function. The MAX function (shown in bold) should be added right before the MIN function. The periodic floor should be included, but the floor should be subtracted instead of added:

$$= \text{IF}(\text{AssetIntType1} = \text{"Fixed"}, \text{AssetFxdRate1}, \text{MAX}(\text{MIN}(\text{OFFSET}(\text{Vectors!}\$D\$6, \text{A7}, \text{MATCH}(\text{AssetFltIdx1}, \text{lstInterestRates}, 0)), (\text{F6} - \text{AssetMarg1}) + \text{AssetPdCapFl1}, \text{AssetLifeCap1}), (\text{F6} - \text{AssetMarg1}) - \text{AssetPdCapFl1}, \text{AssetLifeFloor1}))$$

12. The next part of the formula must figure out if the floating rate should be changed depending on the reset frequency. Some floating rates only change quarterly or semiannually. The Inputs sheet anticipated this with cell M12 (AssetRateReset). The ideal function for determining when to do something according to timing is the MOD function. If unfamiliar with MOD, consult the Toolbox section for detail. Essentially MOD (shown in bold) is used to see if the current period is perfectly divisible with the rate reset frequency established on the Inputs sheet.¹ If it is then the rate needs to be looked up, otherwise the rate remains the same as last month. The wording of the last sentence should be a sign that an IF statement should also be used:

$$= \text{IF}(\text{AssetIntType1} = \text{"Fixed"}, \text{AssetFxdRate1}, \text{IF}(\text{MOD}(\$A7, \text{AssetRateReset1}) = 0, \text{MAX}(\text{MIN}(\text{OFFSET}(\text{Vectors!}\$D\$6, \text{A7},$$

¹Public Securities Association, *Standard Formulas for the Analysis of Mortgage-Backed Securities and Other Related Securities*, 1 June 1990, p. SF-5.

$$\begin{aligned} & \text{MATCH}(\text{AssetFltIdx1}, \text{lstInterestRates}, 0)), (\text{F6} - \text{AssetMarg1}) \\ & + \text{AssetPdCapFl1}, \text{AssetLifeCap1}), (\text{F6} - \text{AssetMarg1}) - \text{AssetPdCapFl1}, \\ & \text{AssetLifeFloor1}), \text{F6}) \end{aligned}$$

This addition to the formula reads, if the current period divides by the given reset frequency perfectly then look up the rate on the Vectors sheet, otherwise use the previous month's rate (F6).

13. The last section is primarily clean up to take into account the first period not having a previous month's rate. If the first period is a floating rate, it should simply reference the starting floating rate. This can easily be done with an IF statement referencing the current period and the TRUE value being the same rate lookup method we used earlier (i.e., the OFFSET MATCH combination). Insert the IF statement (shown in bold) and copy and paste the OFFSET MATCH combination (shown in bold) to produce the following:

$$\begin{aligned} = & \text{IF}(\text{AssetIntType1} = \text{"Fixed"}, \text{AssetFxdRate1}, \text{IF}(\text{A7} = 1, \text{OFFSET}(\text{Vectors!}\$D\$6, \\ & \text{A7}, \text{MATCH}(\text{AssetFltIdx1}, \text{lstInterestRates}, 0)), \text{IF}(\text{MOD}(\$A7, \\ & \text{AssetRateReset1}) = 0, \text{MAX}(\text{MIN}(\text{OFFSET}(\text{Vectors!}\$D\$6, \text{A7}, \\ & \text{MATCH}(\text{AssetFltIdx1}, \text{lstInterestRates}, 0)), (\text{F6} - \text{AssetMarg1}) \\ & + \text{AssetPdCapFl1}, \text{AssetLifeCap1}), (\text{F6} - \text{AssetMarg1}) \\ & - \text{AssetPdCapFl1}, \text{AssetLifeFloor1}), \text{F6})) \end{aligned}$$

14. The final bit to add is the margin. No matter what rate is returned, fixed or floating, the margin needs to be added at the end. The only caveat is that the lifetime floor and cap can be exceeded by the margin. To take this into account the margin (shown in bold) needs to be subtracted from the lifetime cap and floor. The final formula should look as follows:

$$\begin{aligned} = & \text{IF}(\text{AssetIntType1} = \text{"Fixed"}, \text{AssetFxdRate1}, \text{IF}(\text{A7} = 1, \text{OFFSET}(\text{Vectors!}\$D\$6, \\ & \text{A7}, \text{MATCH}(\text{AssetFltIdx1}, \text{lstInterestRates}, 0)), \text{IF}(\text{MOD}(\$A7, \\ & \text{AssetRateReset1}) = 0, \text{MAX}(\text{MIN}(\text{OFFSET}(\text{Vectors!}\$D\$6, \text{A7}, \\ & \text{MATCH}(\text{AssetFltIdx1}, \text{lstInterestRates}, 0)), (\text{F6} - \text{AssetMarg1}) \\ & + \text{AssetPdCapFl1}, \text{AssetLifeCap1} - \text{AssetMarg1}), (\text{F6} - \text{AssetMarg1}) \\ & - \text{AssetPdCapFl1}, \text{AssetLifeFloor1} - \text{AssetMarg1}), \text{F6})) \\ & + \text{AssetMarg1} \end{aligned}$$

15. The next formula calculates the total payment that is due each period. The PMT function in Excel is specifically designed for this purpose. The PMT function

uses balance, term, and rate information to provide a periodic payment. In Project Model Builder, the payment is level in fixed rate scenarios and variable when the rate is floating. This is accomplished by making sure the payment formula references the rate vector, which will be the same rate for each period in a fixed rate system and a differing rate each period for a floating rate system.

Another consideration for the payment formula is that in a floating rate system the payment can be higher than the balance of the assets. To take care of this, an IF statement needs to be inserted to check whether the balance is less than the payment and, if so, calculate the payment as the sum of the balance and the interest due that period. In cell G7 enter the following formula and copy it down to cell G366:

$$= \text{IF}(J6 \leq G6, H7 + E7, -\text{PMT}(\$F\$7 * \$C\$7, \text{AssetTerm1}, \text{AssetOrgBal1}))$$

One final note on the formula is that there is a negative sign in front of the PMT function. This is because PMT will return a payment as a negative value and for consistency all numbers in the model will be positive.

16. Once the payment formula is done, the next formula to create is the interest calculation. This is very simple since the periodic interest rate is available in column F. The interest per period is the beginning balance multiplied by the interest rate. Remember that the periodic interest rate is still an annual rate and must be calculated as a periodic rate by multiplying by the day factor. The final formula to enter in cell H7 (and copy down to cell H366) is:

$$= F7 * C7 * E7$$

17. The last column in this section is the principal payment. Given that the total payment and the current period's interest have already been calculated, the principal for that period is the subtraction of the interest from the total payment. In cell I7 enter and copy down to cell I366 the following formula:

$$= G7 - H7$$

18. The notional amortization schedule is now complete. Try changing the variables on the Inputs sheet to see how the amortization schedule is affected. Make sure this section is well understood since the cash that will flow through the rest of the model is completely dependent on the notional amortization schedule.

TOOLBOX

OFFSET

Perhaps one of the most useful types of functions in financial modeling is one that can reference other cells. The OFFSET function takes a selected cell and references

a different cell depending on the parameters given. The OFFSET function needs the following information:

= OFFSET(starting point cell, number of rows to move up or down,
number of columns to move back or forth)

For example, if the following cells and values were used with the function

= OFFSET(A1,1,1)

the return value would be the value in cell B2 since the OFFSET function started with cell A1 and offset the cell by 1 row and 1 column.

MATCH

The MATCH function is often overlooked, but it is an incredibly powerful function. The concept is to compare a given value against an array or list of values that may contain the given value. If there is a match, the function returns a numerical value that represents the order that the matched value is in the array or list. MATCH takes the following parameters:

= MATCH(selected cell for matching, array to be matched against,
accuracy of search)

In Figure 2.10, there is a list of groceries in range C5:C7. If the location of the word “Pear” on the list was required the MATCH function could be used to find it. The last parameter, 0 in this example, is how accurate the search should be. A 0 indicates that the word “Pear” needs to be found exactly, if not a #N/A error will be returned. The other two options, 1 and -1, are mainly for matches involving numbers. A 1 indicates that MATCH should find the largest value that is less than or equal to the given value. A -1 indicates that MATCH should find the smallest

E6		=MATCH(E5,C5:C7,0)				
	A	B	C	D	E	F
1						
2						
3						
4			Groceries		Position On List	
5			Apple		Pear	
6			Pear		2	
7			Banana			
8						

FIGURE 2.10 An example of MATCH using a grocery list and an item from it.

value that is greater than or equal to the lookup value. Using 1 or -1 requires the array or list to be placed in order, so try to use 0 if possible.

MOD

The MOD function is a mathematical function that returns the remainder after a number has been divided by a divisor. There are only two parameters for MOD, the number that is to be divided and the divisor.

PMT

A useful function for finance is the PMT function. This function takes a rate, a term, and a principal amount and returns the payment necessary to amortize the principal amount within the term given. The specific parameters include:

$$= \text{PMT}(\text{rate}, \text{term}, \text{principal balance})$$

Always be certain that the rate corresponds to the term. For example, if the term is on a monthly basis the rate needs to be adjusted so that it is a monthly rate. Also, the PMT function's default setting is to return the payment as a negative value, so either a negative needs to be put in front of the formula or other formulas have to work with a negative payment value. Project Model Builder assumes all positive values and requires the negative to be in front of the function.