CHAPTER 32

Value Enhancement: Economic Value Added, Cash Flow Return on Investment, and Other Tools

The discounted cash flow model provides for a rich and thorough analysis of all the different ways in which a firm can increase value, but it can become complex as the number of inputs increases. It is also difficult to tie management compensation systems to a discounted cash flow model, since many of the inputs need to be estimated and can be manipulated to yield the results management wants.

If we assume that markets are efficient, we can replace the unobservable value from the discounted cash flow model with the observed market price and reward or punish managers based on the performance of the stock. Thus, a firm whose stock price has gone up is viewed as having created value, whereas one whose stock price has fallen has destroyed value. Compensation systems based on the stock price, including stock grants and warrants, have become a standard component of most management compensation packages.

While market prices have the advantage of being up-to-date and observable, they are also noisy. Even if markets are efficient, stock prices tend to fluctuate around the true value, and markets sometimes do make mistakes. Thus, a firm may see its stock price go up and its top management rewarded, even as it destroys value. Conversely, the managers of a firm may be penalized as its stock price drops, even though the managers may have taken actions that increase firm value. The other problem with stock prices as the basis for compensation is that they are available only for the entire firm. Thus stock prices cannot be used to analyze the managers of individual divisions of a firm, or for their relative performance.

In the past decade, while firms have become more focused on value creation, they have remained suspicious of financial markets. While they might understand the notion of discounted cash flow value, they are unwilling to tie compensation to a value that is based on dozens of estimates. In this environment, new mechanisms for measuring value that are simple to estimate and use, do not depend too heavily on market movements, and do not require a lot of estimation find a ready market. The two mechanisms that seem to have made the most impact are:

1. *Economic value added (EVA),* which measures the dollar surplus value created by a firm on its existing investment.
2. *Cash flow return on investment (CFROI),* which measures the percentage return made by a firm on its existing investments.

This chapter looks at how each is related to discounted cash flow valuation. It also looks at the conditions under which firms using these approaches to judge performance and evaluate managers may end up making decisions that destroy value rather than create it.

ECONOMIC VALUE ADDED

The economic value added (EVA) is a measure of the dollar surplus value created by an investment or a portfolio of investments. It is computed as the product of the excess return made on an investment or investments and the capital invested in that investment or investments.

$$\begin{aligned}\text{Economic value added} &= (\text{Return on capital invested} - \text{Cost of capital}) \\ &\quad \times (\text{Capital invested}) \\ &= \text{After-tax operating income} - (\text{Cost of capital} \\ &\quad \times \text{Capital invested})\end{aligned}$$

This section begins by looking at the measurement of economic value added, then considers its links to discounted cash flow valuation, and closes with a discussion of its limitations as a value enhancement tool.

Calculating EVA

The definition of EVA outlines three basic inputs we need for its computation—the return on capital earned on investments, the cost of capital for those investments, and the capital invested in them. In measuring each of these, we will make many of the same adjustments that were discussed in the context of discounted cash flow valuation.

How much capital is there invested in existing assets? One obvious answer is to use the market value of the firm, but market value includes capital invested not just in assets in place but in expected future growth.[1] Since we want to evaluate the quality of assets in place, we need a measure of the market value of just these assets. Given the difficulty of estimating market value of assets in place, it is not surprising that we turn to the book value of capital as a proxy for the market value of capital invested in assets in place. The book value, however, is a number that reflects not just the accounting choices made in the current period, but also accounting decisions made over time on how to depreciate assets, value inventory, and deal with acquisitions. At the minimum, the three adjustments we made to capital invested in the discounted cash flow valuation—converting operating leases into debt, capitalizing R&D expenses, and eliminating the effect of one-time or cosmetic charges—have to be made when computing EVA as well. The older the firm, the more extensive the adjustments that have to be made to book value of capital to get to a reasonable estimate of the market value of capital invested in assets in place. Since this requires that we know and take into account every accounting decision over time, there are cases where the book value of capital is too flawed to be fixable. Here, it is best to estimate the capital invested from the ground up, starting

[1]As an illustration, computing the return on capital at Microsoft using the market value of the firm, instead of book value, results in a return on capital of about 3 percent. It would be a mistake to view this as a sign of poor investments on the part of the firm's managers.

EVA COMPUTATION IN PRACTICE

During the 1990s, EVA was promoted most heavily by Stern Stewart, a New York–based consulting firm. The firm's founders, Joel Stern and Bennett Stewart, became the foremost evangelists for the measure. Their success spawned a whole host of imitators from other consulting firms, all of which were variants on the excess return measure.

In the process of applying this measure to real firms, Stern Stewart found that it had to modify accounting measures of earnings and capital to get more realistic estimates of surplus value. In his book *The Quest for Value* Bennett Stewart mentions some of the adjustments that should be made to capital invested, including adjusting for goodwill (recorded and unrecorded). He also suggests adjustments that need to be made to operating income, including the conversion of operating leases into financial expenses.

Many firms that adopted EVA during this period also based management compensation on measured EVA. Consequently, how it was defined and measured became a matter of significant concern to managers at every level.

with the assets owned by the firm, estimating the market value of these assets, and cumulating this market value.

To evaluate the return on this invested capital, we need an estimate of the after-tax operating income earned by a firm on these investments. Again, the accounting measure of operating income has to be adjusted for operating leases, R&D expenses, and one-time charges to compute the return on capital.

The third and final component needed to estimate the economic value added is the cost of capital. In keeping with our arguments both in the investment analysis and the discounted cash flow valuation sections, the cost of capital should be estimated based on the market values of debt and equity in the firm, rather than book value. There is no contradiction between using book value for purposes of estimating capital invested and using market value for estimating cost of capital, since a firm has to earn more than its market value cost of capital to generate value. From a practical standpoint, using the book value cost of capital will tend to understate cost of capital for most firms, and will understate it more for more highly levered firms than for lightly levered firms. Understating the cost of capital will lead to overstating the economic value added.

Economic Value Added, Net Present Value, and Discounted Cash Flow Valuation

One of the foundations of investment analysis in traditional corporate finance is the net present value rule. The net present value (NPV) of a project, which reflects the present value of expected cash flows on a project, netted against any investment needs, is a measure of dollar surplus value on the project. Thus, investing in projects with positive net present value will increase the value of the firm, while investing in projects with negative net present value will reduce value. Economic value added is a simple extension of the net present value rule. The net present value of the project is the present value of the economic value added by that project over its life.[2]

$$NPV = \sum_{t=1}^{t=n} \frac{EVA_t}{(1+k_c)^t}$$

where EVA_t is the economic value added by the project in year t, and the project has a life of n years.

This connection between economic value added and NPV allows us to link the value of a firm to the economic value added by that firm. To see this, let us begin with a simple formulation of firm value in terms of the value of assets in place and expected future growth:

Firm value = Value of assets in place + Value of expected future growth

Note that in a discounted cash flow model, the values of both assets in place and expected future growth can be written in terms of the net present value created by each component:

$$\text{Firm value} = \text{Capital invested}_{\text{assets in place}} + NPV_{\text{assets in place}} + \sum_{t=1}^{t=\infty} NPV_{\text{future projects, t}}$$

Substituting the economic value added version of net present value into this equation, we get:

$$\text{Firm value} = \text{Capital invested}_{\text{assets in place}} + \sum_{t=1}^{t=\infty} \frac{EVA_{\text{t, assets in place}}}{(1+k_c)^t} + \sum_{t=1}^{t=\infty} \frac{EVA_{\text{t, future projects}}}{(1+k_c)^t}$$

Thus the value of a firm can be written as the sum of three components: the capital invested in assets in place, the present value of the economic value added by these assets, and the expected present value of the economic value that will be added by future investments.

[2]This is true, though, only if the expected present value of the cash flows from depreciation is assumed to be equal to the present value of the salvage of the capital invested in the project. A proof of this equality can be found in my paper on value enhancement in the *Contemporary Finance Digest* in 1999.

ILLUSTRATION 32.1: Discounted Cash Flow Value and Economic Value Added

Consider a firm that has existing assets in which it has capital invested of $100 million. Assume these additional facts about the firm:

- The after-tax operating income on assets in place is $15 million. This return on capital of 15% is expected to be sustained in the future, and the company has a cost of capital of 10%.
- At the beginning of each of the next five years, the firm is expected to make new investments of $10 million each. These investments are also expected to earn 15% as a return on capital, and the cost of capital is expected to remain 10%.
- After year 5, the company will continue to make investments, and earnings will grow 5% a year, but the new investments will have a return on capital of only 10%, which is also the cost of capital.
- All assets and investments are expected to have infinite lives.[3] Thus, the assets in place and the investments made in the first five years will make 15% a year in perpetuity, with no growth.

This firm can be valued using an economic value added approach, as follows:

Capital invested in assets in place	$100
+ EVA from assets in place = (.15 – .10)(100)/.10	$ 50
+ PV of EVA from new investments in year 1 = [(.15 – .10)(10)/.10]	$ 5
+ PV of EVA from new investments in year 2 = [(.15 – .10)(10)/.10]/1.1	$ 4.55
+ PV of EVA from new investments in year 3 = [(.15 – .10)(10)/.10]/1.1^2	$ 4.13
+ PV of EVA from new investments in year 4 = [(.15 – .10)(10)/.10]/1.1^3	$ 3.76
+ PV of EVA from new investments in year 5 = [(.15 – .10)(10)/.10]/1.1^4	$ 3.42
Value of firm	$170.85

Note that the present values are computed assuming that the cash flows on investments are perpetuities and that the investments are made at the beginning of each year. In addition, today value of the economic value added by the investments made in future years are discounted to today, using the cost of capital. To illustrate, the present value of the economic value added by investments made at the beginning of year 2 is discounted back one year. The value of the firm, which is $170.85 million, can be written using the earlier equation as follows:

$$\text{Firm value} = \text{Capital invested}_{\text{assets in place}} + \sum_{t=1}^{t=\infty} \frac{\text{EVA}_{t,\text{ assets in place}}}{(1+k_c)^t} + \sum_{t=1}^{t=\infty} \frac{\text{EVA}_{t,\text{ future projects}}}{(1+k_c)^t}$$

$$\$170.85 \text{ million} = \$100 \text{ million} + \$50 \text{ million} + \$20.85 \text{ million}$$

The value of existing assets is therefore $150 million, and the value of future growth opportunities is $20.85 million.

Another way of presenting these results is in terms of market value added (MVA). The market value added, in this case, is the difference between the firm value of $170.85 million and the capital invested of $100 million, which yields $70.85 million. This value will be positive only if the return on capital is greater than the cost of capital and will be an increasing function of the spread between the two numbers. The number will be negative if the return on capital is less than the cost of capital.

[3]Note that this assumption is purely for convenience, since it makes the net present value easier to compute. This also allows us to assume the depreciation is offset by capital maintenance expenditures.

Note that although the firm continues to grow operating income and makes new investments after the fifth year, these marginal investments create no additional value because they earn the cost of capital. A direct implication is that it is not growth that creates value, but growth in conjunction with excess returns. This provides a new perspective on the quality of growth. A firm can be increasing its operating income at a healthy rate, but if it is doing so by investing large amounts at or below the cost of capital, it will not be creating value and may actually be destroying it.

This firm could also have been valued using a discounted cash flow valuation, with free cash flows to the firm discounted at the cost of capital. The following table shows expected free cash flows and the firm value, using the cost of capital of 10% as the discount rate.

	0	*1*	*2*	*3*	*4*	*5*	*Terminal Year*
EBIT(1 – t) from assets in place	$ 0.00	$15.00	$15.00	$15.00	$15.00	$ 15.00	
EBIT(1 – t) from investments—Year 1		$ 1.50	$ 1.50	$ 1.50	$ 1.50	$ 1.50	
EBIT(1 – t) from investments—Year 2			$ 1.50	$ 1.50	$ 1.50	$ 1.50	
EBIT(1 – t) from investments—Year 3				$ 1.50	$ 1.50	$ 1.50	
EBIT(1 – t) from investments—Year 4					$ 1.50	$ 1.50	
EBIT(1 – t) from investments—Year 5						$ 1.50	
Total EBIT(1 – t)		$16.50	$18.00	$19.50	$21.00	$ 22.50	$23.63
– Net capital expenditures	$ 10.00	$10.00	$10.00	$10.00	$10.00	$ 11.25	$11.81
FCFF		$ 6.50	$ 8.00	$ 9.50	$11.00	$ 11.25	$11.81
PV of FCFF	($ 10)	$ 5.91	$ 6.61	$ 7.14	$ 7.51	$ 6.99	
Terminal value						$236.25	
PV of terminal value						$146.69	
Value of firm	$170.85						
Return on capital	15%	15%	15%	15%	15%	15%	10%
Cost of capital	10%	10%	10%	10%	10%	10%	10%

In looking at this valuation, note the following:

- The capital expenditures occur at the beginning of each year and thus are shown in the previous year. The investment of $10 million in year 1 is shown in period 0, the year 2 investment in year 1, and so on.
- In year 5, the net investment needed to sustain growth is computed by using two assumptions—that growth in operating income would be 5% a year beyond year 5, and that the return on capital on new investments starting in year 6 (which is shown in year 5) would be 10%.

$$\text{Net investment}_5 = [\text{EBIT}_6(1-t) - \text{EBIT}_5(1-t)]/\text{ROC}_6 = (\$23.625 - \$22.50)/.10 = \$11.25 \text{ million}$$

The value of the firm obtained by discounting free cash flows to the firm at the cost of capital is $170.85, which is identical to the value obtained using the economic value added approach.

ILLUSTRATION 32.2: An EVA Valuation of Boeing—1998

The equivalence of traditional DCF valuation and EVA valuation can be illustrated for Boeing. We begin with a discounted cash flow valuation of Boeing and summarize the inputs used:

	High-Growth Phase	*Stable-Growth Phase*
Length	*10 years*	*Forever after year 10*
Growth inputs		
Reinvestment rate	65.98%	59.36%
Return on capital	6.59%	8.42%
Expected growth rate	4.35%	5.00%
Cost of capital inputs		
Beta	1.01	1.00
Cost of debt	5.50%	5.50%
Debt ratio	19.92%	30.00%
Cost of capital	9.18%	8.42%
General information		
Tax rate	35%	35%

The current after-tax operating income for the firm is $1,651 million. With these inputs, the free cash flows to the firm can be estimated:

Year	*EBIT(1 – t)*	*Reinvestment*	*FCFF*	*Present Value at 9.18 Percent*
Current	$1,651			
1	$1,723	$1,137	$ 586	$537
2	$1,798	$1,186	$ 612	$513
3	$1,876	$1,238	$ 638	$490
4	$1,958	$1,292	$ 666	$469
5	$2,043	$1,348	$ 695	$448
6	$2,132	$1,407	$ 725	$428
7	$2,225	$1,468	$ 757	$409
8	$2,321	$1,532	$ 790	$391
9	$2,422	$1,598	$ 824	$374
10	$2,528	$1,668	$ 860	$357
Terminal year	$2,654	$1,576	$1,078	

The sum of the present value of the cash flows over the growth period is $4,416 million. The terminal value can be estimated based on the cash flow in the terminal year and the cost of capital of 8.42%:

$$\text{Terminal value} = \$1{,}078/(.0842 - .05) = \$31{,}529 \text{ million}$$

The discounted cash flow estimate of the value is:

$$\text{Value of Boeing's operating assets} = 4{,}416 + 31{,}529/1.0918^{10} = \$17{,}506 \text{ million}$$

The following table estimates the EVA for Boeing each year for the next 10 years, and the present value of the EVA. To make these estimates, we begin with the current capital invested in the firm of $26,149 million and add the reinvestment each year from the preceding table to it to obtain the capital invested in the following year.

Year	Capital Invested at Beginning of Year	Return on Capital	Cost of Capital	EVA	PV of EVA
1	$26,149	6.59%	9.18%	($678)	($621)
2	$27,286	6.59%	9.18%	($707)	($593)
3	$28,472	6.59%	9.18%	($738)	($567)
4	$29,710	6.59%	9.18%	($770)	($542)
5	$31,002	6.59%	9.18%	($804)	($518)
6	$32,350	6.59%	9.18%	($839)	($495)
7	$33,757	6.59%	9.18%	($875)	($473)
8	$35,225	6.59%	9.18%	($913)	($452)
9	$36,756	6.59%	9.18%	($953)	($432)
10	$38,354	6.59%	9.18%	($994)	($413)
11	$40,022	Present value of EVA over 10 years			($5,107)

The sum of the present values of the EVA is –$5,107 million. To get to the value of the operating assets of the firm, we add two more components:

1. The capital invested in assets in place at the beginning of year 1 (current), which is $26,149 million.
2. The present value of the EVA in perpetuity on assets in place in year 10, which is computed as follows:

$$\frac{[\text{EBIT}_{11}(1-t) - \text{Capital invested}_{11} \times \text{Cost of capital}_{11}]/\text{Cost of capital}_{11}}{(1 + \text{Current cost of capital})^{10}}$$

$$= [(2{,}653.93 - 40{,}022 \times .0842)/.0842]/(1.0918)^{10}$$

$$= -\$3{,}536 \text{ million}$$

Note that while the marginal return on capital on new investments is equal to the cost of capital after year 10, the existing investments continue to make 6.59%, which is lower than the cost of capital of 8.42%, in perpetuity.

The total value of the firm can then be computed as follows:

Capital invested in assets in place	$26,149 million
PV of EVA from assets in place	–$ 8,643 million
Value of operating assets	$17,506 million

fcffeva.xls: **This spreadsheet allows you to convert a discounted cash flow valuation into an EVA valuation, and vice versa.**

EVA VALUATION VERSUS DCF VALUATION: WHEN THEY WILL DISAGREE

To get the same value from discounted cash flow and EVA valuations, you have to ensure that the following conditions hold:

- The after-tax operating income that you use to estimate free cash flows to the firm should be equal to the after-tax operating income you use to compute Economic Value Added. Thus, if you decide to adjust the operating income for operating leases and research and development expenses when doing discounted cash flow valuation, you have to adjust it for computing EVA as well.
- The growth rate you use to estimate after-tax operating income in future periods should be estimated from fundamentals when doing discounted cash flow valuation. In other words, it should be set to:

$$\text{Growth rate} = \text{Reinvestment rate} \times \text{Return on capital}$$

If growth is an exogenous input into a DCF model and the relationship between growth rates, reinvestments, and return on capital outlined above does not hold, you will get different values from DCF and EVA valuations.

- The capital invested that is used to compute EVA in future periods should be estimated by adding the reinvestment in each period to the capital invested at the beginning of the period. The EVA in each period should be computed as follows:

$$\text{EVA}_t = \text{After-tax operating income}_t - \text{Cost of capital} \times \text{Capital invested}_{t-1}$$

- You have to make consistent assumptions about terminal value in your discounted cash flow and EVA valuations. In the special case, where the return on capital on all investments—existing and new—is equal to the cost of capital after your terminal year, this is simple to do. The terminal value will be equal to your capital invested at the beginning of your terminal year. In the more general case, you will have to ensure that the capital invested at the beginning of your terminal year is consistent with your assumption about return on capital in perpetuity. In other words, if your after-tax operating income in your terminal year is 1.2 billion and you are assuming a return on capital of 10 percent in perpetuity, you will have to set your capital invested at the beginning of your terminal year to be $12 billion.

EVA and Firm Value: Potential Conflicts

Assume that a firm adopts economic value added as its measure of value and decides to judge managers on their capacity to generate greater-than-expected economic value added. What is the potential for abuse? Is it possible for a manager to deliver greater than expected economic value added, while destroying firm value at the same time? If so, how can we protect stockholders against these practices?

To answer these questions, let us go back to the earlier equation where we decomposed firm value into capital invested, the present value of economic value added by assets in place, and the present value of economic value added by future growth.

$$\text{Firm value} = \text{Capital invested}_{\text{assets in place}} + \sum_{t=1}^{t=\infty} \frac{\text{EVA}_{t,\ \text{assets in place}}}{(1+k_c)^t} + \sum_{t=1}^{t=\infty} \frac{\text{EVA}_{t,\ \text{future projects}}}{(1+k_c)^t}$$

The Capital Invested Game The first two terms in the preceding equation, the capital invested and the present value of economic value added by these investments, are both sensitive to the measurement of capital invested. If capital invested is reduced, keeping the operating income constant, the first term in the equation will drop but the present value of economic value added will increase proportionately. To illustrate, consider the firm valued in Illustration 32.1. Assume that the capital invested is estimated to be $50 million rather than $100 million, and that the operating income on these investments stays at $15 million. This will increase the return on capital on existing assets to 30 percent. The assumptions about future investments remain unchanged. The firm value can then be written as shown in Table 32.1.

The value of the firm is unchanged, but it is redistributed to the economic value added component. When managers are judged on the economic value added, there will be strong incentives to reduce the capital invested, at least as measured for EVA computations.

There are some actions managers can take to reduce capital invested that truly create value. Thus, in the example, if the reduction in capital invested came from closing down a plant that does not (and is not expected to) generate any operating income, the cash flow generated by liquidating the plant's assets will increase value. Some actions, however, are purely cosmetic in terms of their effects on capital invested and thus do not create and may even destroy value. For instance, firms can take one-time restructuring charges that reduce capital, or lease assets rather than buy them because the capital impact of leasing may be smaller.

To illustrate the potential destructiveness of these actions, assume that the managers of the firm in Illustration 32.1 are able to replace half their assets with leased assets. Assume further that the estimated capital invested in these leased as-

TABLE 32.1 EVA Valuation of Firm: EVA and Assets in Place

Capital invested in assets in place	$ 50.00
+ EVA from assets in place = (.30 – .10)(50)/.10	$100.00
+ PV of EVA from new investments in year 1 = [(.15 – .10)(10)/.10]	$ 5.00
+ PV of EVA from new investments in year 2 = [(.15 – .10)(10)/.10]/1.1	$ 4.55
+ PV of EVA from new investments in year 3 = [(.15 – .10)(10)/.10]/1.1^2	$ 4.13
+ PV of EVA from new investments in year 4 = [(.15 – .10)(10)/.10]/1.1^3	$ 3.76
+ PV of EVA from new investments in year 5 = [(.15 – .10)(10)/.10]/1.1^4	$ 3.42
Value of firm	$170.85

sets is only $40 million, which is lower than the capital invested in the replaced assets of $50 million. In addition, assume that the action actually reduces the adjusted annual operating income from these assets from $15 million to $14.8 million. The value of the firm can now be written in Table 32.2. Note that the firm value declines by $2 million, but the economic value added increases by $8 million.

When economic value added is estimated for divisions, the capital invested at the divisional level is a function of a number of allocation decisions made by the firm, with the allocation based on prespecified criteria (such as revenues or number of employees). While we would like these rules to be objective and unbiased, they are often subjective and overallocate capital to some divisions and underallocate it to others. If this misallocation were purely random, we could accept it as error and use changes in economic value added to measure success. Given the natural competition that exists among divisions in a firm for the marginal investment dollar, however, these allocations are also likely to reflect the power of individual divisions to influence the process. Thus, the economic value added will be overestimated for those divisions that are underallocated capital, and underestimated for divisions that are overallocated capital.

The Future Growth Game The value of a firm is the value of its existing assets and the value of its future growth prospects. When managers are judged on the basis of economic value added in the current year, or on year-to-year changes, the economic value added that is being measured is just that from assets in place. Thus, managers may trade off the economic value added from future growth for higher economic value added from assets in place.

Again, this point can be illustrated simply using the firm in Illustration 32.1. The firm earned a return on capital of 15 percent on both assets in place and future investments. Assume that there are actions the firm can take to increase the return on capital on assets in place to 16 percent, but that this action reduces the return on

TABLE 32.2 Value Reduction with Higher EVA

Capital invested in assets in place	$ 90.00
+ EVA from assets in place = (.1644 – .10)(90)/.10	$ 58.00
+ PV of EVA from new investments in year 1 = [(.15 – .10)(10)/.10]	$ 5.00
+ PV of EVA from new investments in year 2 = [(.15 – .10)(10)/.10]/1.1	$ 4.55
+ PV of EVA from new investments in year 3 = [(.15 – .10)(10)/.10]/1.1^2	$ 4.13
+ PV of EVA from new investments in year 4 = [(.15 – .10)(10)/.10]/1.1^3	$ 3.76
+ PV of EVA from new investments in year 5 = [(.15 – .10)(10)/.10]/1.1^4	$ 3.42
Value of firm	$168.85

TABLE 32.3 Trading Off Future Growth for Higher EVA

Capital invested in assets in place	$100.00
+ EVA from assets in place = (.16 – .10)(100)/.10	$ 60.00
+ PV of EVA from new investments in year 1 = [(.12 – .10)(10)/.10]	$ 2.00
+ PV of EVA from new investments in year 2 = [(.12 – .10)(10)/.10]/1.1	$ 1.82
+ PV of EVA from new investments in year 3 = [(.12 – .10)(10)/.10]/1.1^2	$ 1.65
+ PV of EVA from new investments in year 4 = [(.12 – .10)(10)/.10]/1.1^3	$ 1.50
+ PV of EVA from new investments in year 5 = [(.12 – .10)(10)/.10]/1.1^4	$ 1.37
Value of firm	$168.34

capital on future investments to 12 percent. The value of this firm can then be estimated in Table 32.3. Note that the value of the firm has decreased, but the economic value added in year 1 is higher now than it was before. In fact, the economic value added at this firm for each of the next five years is graphed in Figure 32.1 for both the original firm and this one. The growth trade-off, while leading to a lower firm value, results in economic value added in each of the first three years that is larger than it would have been without the trade-off.

Compensation mechanisms based on EVA are sometimes designed to punish managers who give up future growth for current EVA. Managers are partly compensated based on the economic value added this year, but another part is held back in a compensation bank and is available to the manager only after a period (say three or four years). There are significant limitations with these approaches. First, the limited tenure that managers have with firms implies that this measure can at best look at economic value added only over the next three or four years. The real costs of the growth trade-off are unlikely to show up until much later. Second, these approaches are really designed to punish managers who increase economic value added in the current period while reducing economic value added in future periods. In the more subtle case, where the economic value added continues to increase but at a rate lower than it otherwise would have, it is difficult to devise a punishment for managers who trade off future growth. In the preceding example, for instance, the economic value added with the growth trade-off increases over time. The increases are smaller than they would have been without the trade-off, but that number would not have been observed, anyway.

The Risk Shifting Game The value of a firm is the sum of the capital invested and the present value of the economic value added. The latter term is therefore a function not just of the dollar economic value added but also of the cost of capital. A

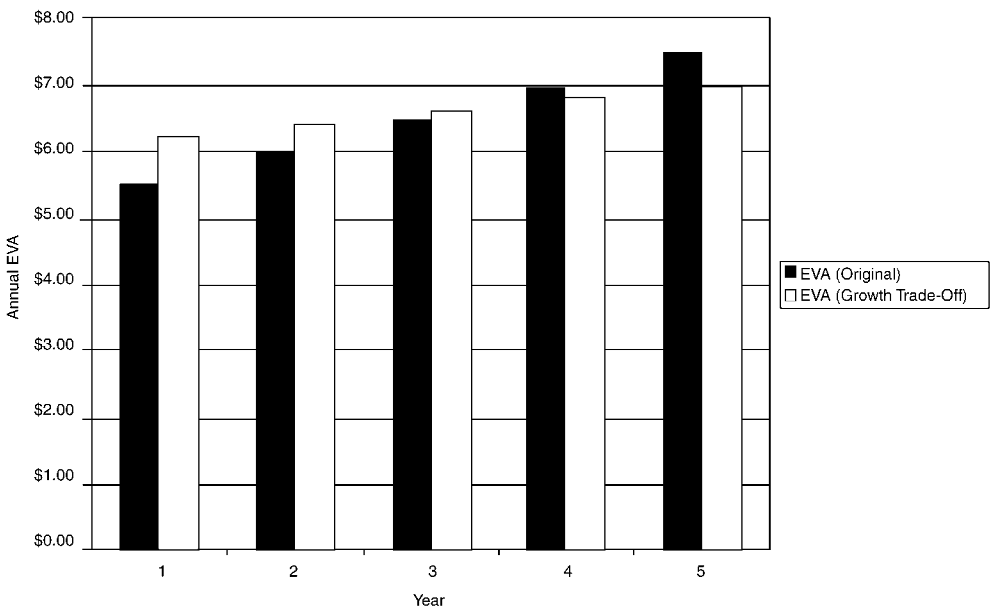


FIGURE 32.1 Annual EVA: With and Without Growth Trade-Off

firm can invest in projects to increase its economic value added but still end up with a lower value, if these investments increase its operating risk and cost of capital.

Again, using the firm in Illustration 32.1, assume that the firm is able to increase its return on capital on both assets in place and future investments from 15 percent to 16.25 percent and from 10 percent to 11 percent after year 5. Simultaneously, assume that the cost of capital increases to 11 percent. The economic value added in each year for the next five years is contrasted with the original economic value added in each year in Figure 32.2. While the economic value added in each year is higher with the high-risk strategy, the value of the firm is shown in Table 32.4. Note that the risk effect dominates the higher excess dollar returns, and the value of the firm decreases.

This risk shifting can be dangerous for firms that adopt economic value added based on objective functions. When managers are judged based on year-to-year economic value added changes, there will be a tendency to shift into riskier investments. This tendency will be exaggerated if the measured cost of capital does not reflect the changes in risk or lags it.[4]

In closing, economic value added is an approach skewed toward assets in place and away from future growth. It should not be surprising, therefore, that when economic value added is computed at the divisional level of a firm, the higher-growth divisions end up with the lowest economic value added, and in some cases with negative economic value added. Again, while these divisional managers may still be judged based on changes in economic value added from year to year, the temptation

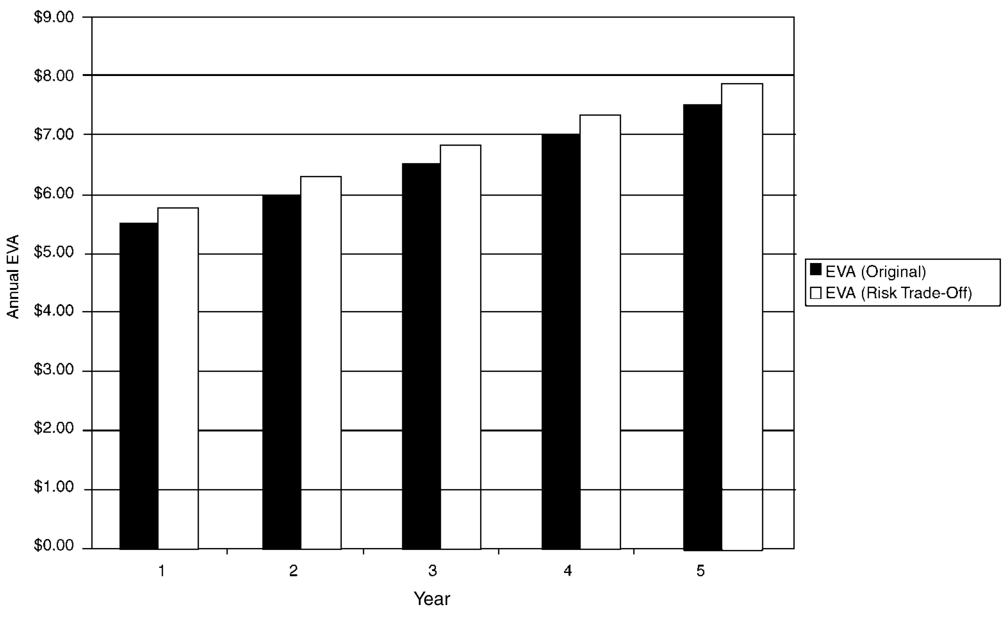


FIGURE 32.2 EVA: Higher Risk and Return

[4]In fact, beta estimates that are based on historical returns will lag changes in risk. With a five-year return estimation period, for instance, the lag might be as long as three years and the full effect will not show up for five years after the change.

TABLE 32.4 EVA with High-Risk Strategy

Capital invested in assets in place	\$100.00
+ EVA from assets in place = (.1625 – .11) (100)/.11	\$ 47.73
+ PV of EVA from investments in year 1 = [(.1625 – .11)(10)/.11]	\$ 4.77
+ PV of EVA from investments in year 2 = [(.1625 – .10)(10)/.11]/1.11	\$ 4.30
+ PV of EVA from investments in year 3 = [(.1625 – .11)(10)/.11]/1.11^2	\$ 3.87
+ PV of EVA from investments in year 4 = [(.1625 – .11)(10)/.11]/1.11^3	\$ 3.49
+ PV of EVA from investments in year 5 = [(.1625 – .11)(10)/.11]/1.11^4	\$ 3.14
Value of firm	\$167.31

at the firm level to reduce or eliminate capital invested in these divisions will be strong, since it will make the firm's overall economic value added look much better.

EVA and Market Value

Will increasing economic value added cause market value to increase? While an increase in economic value added will generally lead to an increase in firm value, barring the growth and risk games described earlier, it may or may not increase the stock price. This is so because the market value has built into it expectations of future economic value added. Thus a firm like Microsoft is priced on the assumption that it will earn large and increasing economic value added over time. Whether a firm's market value increases or decreases on the announcement of higher economic value added will depend in large part on what the expected change in economic value added was. For mature firms, where the market might have expected no increase or even a decrease in economic value added, the announcement of an increase will be good news and cause the market value to increase. For firms that are perceived to have good growth opportunities and are expected to report an increase in economic value added, the market value will decline if the announced increase in economic value added does not measure up to expectations. This should be no surprise to investors, who have recognized this phenomenon with earnings per share for decades; the earnings announcements of firms are judged against expectations, and the earnings surprise is what drives prices.

We would therefore not expect any correlation between the magnitude of the economic value added and stock returns, or even between the change in economic value added and stock returns. Stocks that report the biggest increases in economic value added should not necessarily earn high returns for their stockholders.[5] These priors are confirmed by a study done by Richard Bernstein at Merrill Lynch, who examined the relationship between EVA and stock returns, and concluded that:

- A portfolio of the 50 firms which had the highest absolute levels[6] of economic value added earned an annual return on 12.9% between February 1987 and February 1997, while the S&P index returned 13.1% a year over the same period.

[5]A study by Kramer and Pushner found that differences in operating income (NOPAT) explained differences in market value better than differences in EVA. O'Byrne (1996), however, finds that changes in EVA explain more than 55 percent of changes in market value over five-year periods.

[6]See Quantitative Viewpoint, Merrill Lynch, December 19, 1997.

EVA FOR HIGH-GROWTH FIRMS

The fact that the value of a firm is a function of the capital invested in assets in place, the present value of economic value added by those assets, and the economic value added by future investments points to some of the dangers of using it as a measure of success or failure for high-growth and especially high-growth technology firms. In particular, there are three problems:

1. We have already noted many of the problems associated with how accountants measure capital invested at technology firms. Given the centrality of capital invested to economic value added, these problems have a much bigger effect when firms use EVA than when you use discounted cash flow valuation.
2. When 80 percent to 90 percent of your value comes from future growth potential, the risks of managers trading off future growth for current EVA are magnified. It is also very difficult to monitor these trade-offs at young firms.
3. The constant change that these firms go through also makes them much better candidates for risk shifting. In this case, the negative effect (of a higher discount rate) can more than offset the positive effect of a higher economic value added.

Finally, it is unlikely that there will be much correlation between actual changes in economic value added at technology firms and changes in market value. The market value is based on expectations of economic value added in future periods, and investors expect an economic value added that grows substantially each year. Thus if the economic value added increases, but by less than expected, you could see its market value drop on the report.

eva.xls: **This dataset on the Web summarizes economic value added by industry group for the United States.**

- A portfolio of the 50 firms that had the highest growth rates[7] in economic value added over the previous year earned an annual return of 12.8% over the same time period.

Equity Economic Value Added

While EVA is usually calculated using total capital, it can easily be modified to be an equity measure:

$$\text{Equity EVA} = (\text{Return on equity} - \text{Cost of equity})(\text{Equity invested in project or firm})$$
$$= \text{Net income} - \text{Cost of equity}(\text{Equity invested})$$

Again, a firm that earns a positive equity EVA is creating value for its stockholders while a firm with a negative equity EVA is destroying value for its stockholders.

[7]See Quantitative Viewpoint, Merrill Lynch, February 3, 1998.

Why might a firm use this measure rather than the traditional measure? Chapter 21, when looking at financial service firms, noted that defining debt (and therefore capital) may open you open to measurement problems, since so much of the firm could potentially be categorized as debt. Consequently, it was argued that financial service firms should be valued using equity valuation models and multiples. Extending that argument to economic value added holds that equity EVA is a much better measure of performance for financial service firms than the traditional EVA measure.

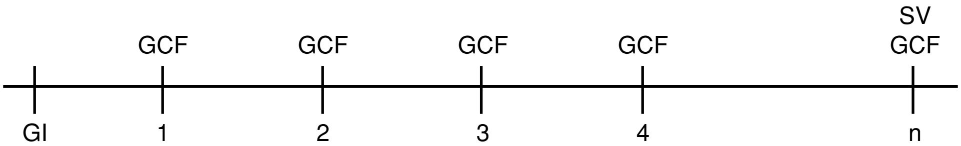
It must be added that much or all of the issues raised in the context of the traditional EVA measure affect the equity EVA measure as well. Banks and insurance companies can play the capital invested, growth, and risk games to increase equity EVA just as other firms can with traditional EVA.

CASH FLOW RETURN ON INVESTMENT

The cash flow return on investment (CFROI) for a firm is the internal rate of return on existing investments, based on real cash flows. Generally, it should be compared to the real cost of capital to make judgments about the quality of these investments.

Calculating CFROI

The cash flow return on investment for a firm is calculated using four inputs. The first is the gross investment (GI) the firm has in its existing assets, obtained by adding back cumulated depreciation and inflation adjustments to the book value. The second input is the gross cash flow (GCF) earned in the current year on that asset, which is usually defined as the sum of the after-tax operating income of a firm and the noncharges against earnings, such as depreciation and amortization. The third input is the expected life of the assets (n) in place at the time of the original investment, which varies from sector to sector but reflects the earning life of the investments in question. The expected salvage value (SV) of the assets at the end of this life, in current dollars, is the final input. This is usually assumed to be the portion of the initial investment, such as land and building, that is not depreciable, adjusted to current dollar terms. The CFROI is the internal rate of return of these cash flows (i.e., the discount rate that makes the net present value of the gross cash flows and salvage value equal to the gross investment), and it can thus be viewed as a composite internal rate of return in current dollar terms.



n = Life of the asset at time of original purchase
CFROI is the internal rate of return that makes the PV of GCF + SV = GI

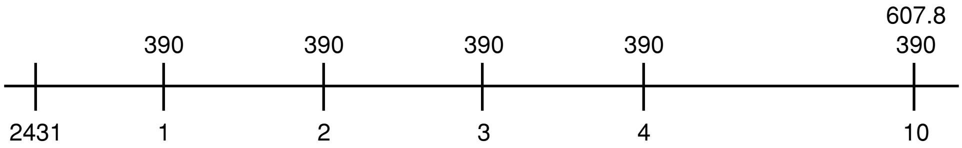
An alternative formulation of the CFROI allows for setting aside an annuity to cover the expected replacement cost of the asset at the end of the project life. This annuity is called the economic depreciation and is computed as follows:

$$\text{Economic depreciation} = \frac{\text{Replacement cost in current dollars}(k_c)}{\left[(1+k_c)^n - 1\right]}$$

where n is the expected life of the asset, k_c is the cost of capital, and the expected replacement cost of the asset is defined in current dollar terms to be the difference between the gross investment and the salvage value. The CFROI for a firm or a division can then be written as follows:

$$\text{CFROI} = \frac{\text{Gross cash flow} - \text{Economic depreciation}}{\text{Gross investment}}$$

For instance, assume that you have existing assets with a book value of \$2,431 million, a gross cash flow of \$390 million, an expected salvage value (in today's dollar terms) of \$607.8 million, and a life of 10 years.



CFROI = Internal rate of return = 11.71%

The conventional measure of CFROI is 11.71%, and the real cost of capital is 8%. The estimate using the alternative approach is computed as follows:

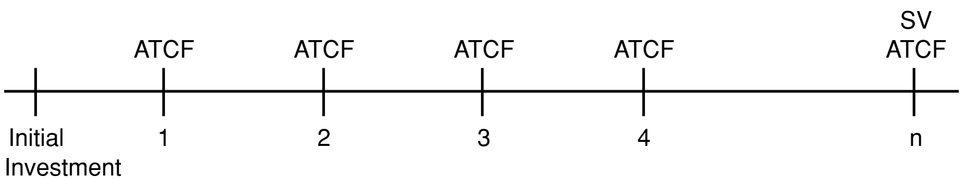
$$\text{Economic depreciation} = \frac{(\$2.431 \text{ billion} - \$0.6078 \text{ billion})(.08)}{(1.08^{10} - 1)} = \$125.86 \text{ million}$$

$$\text{CFROI} = (\$390.00 \text{ million} - \$125.86 \text{ million})/\$2{,}431 \text{ million}$$
$$= 10.87\%$$

The difference in the reinvestment rate assumption accounts for the difference in CFROI estimated using the two methods. In the first approach, intermediate cash flows get reinvested at the internal rate of return, while in the second, at least the portion of the cash flows that are set aside for replacement get reinvested at the cost of capital. In fact, if we estimated that the economic depreciation using the internal rate of return of 11.71 percent, the two approaches would yield identical results.[8]

Cash Flow Return on Investment, Internal Rate of Return, and Discounted Cash Flow Value

If net present value provides the genesis for the economic value added approach to value enhancement, the internal rate of return is the basis for the CFROI approach. In investment analysis, the internal rate of return on a project is computed using the initial investment on the project and all cash flows over the project's life:



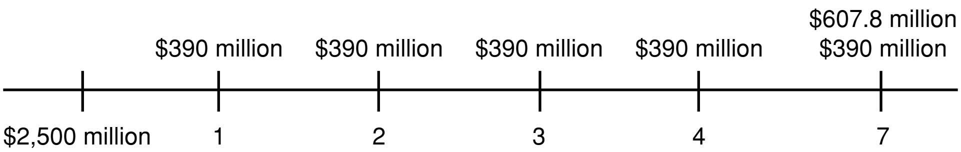
[8]With an 11.71 percent rate, the economic depreciation works out to \$105.37 million, and the CFROI to 11.71 percent.

where the ATCF is the after-tax cash flow on the project, and SV is the expected salvage value of the project assets. This analysis can be done entirely in nominal terms, in which case the internal rate of return is a nominal IRR and is compared to the nominal cost of capital, or in real terms, in which case it is a real IRR and is compared to the real cost of capital.

At first sight, the CFROI seems to do the same thing. It uses the gross investment in the project (in current dollars) as the equivalent of the initial investment, assumes that the gross current-dollar cash flow is maintained over the project life and computes a real internal rate of return. There are, however, some significant differences.

The internal rate of return does not require the after-tax cash flows to be constant over a project's life, even in real terms. The CFROI approach assumes that real cash flows on assets do not increase over time. This may be a reasonable assumption for investments in mature sectors, but will understate project returns if there is real growth. Note, however, that the CFROI approach can be modified to allow for real growth.

The second difference is that the internal rate of return on a project or asset is based on incremental future cash flows. It does not consider cash flows that have occurred already, since these are viewed as "sunk." The CFROI, on the other hand, tries to reconstruct a project or asset, using both cash flows that have occurred already and cash flows that are yet to occur. To illustrate, consider the project described in the previous section. At the time of the original investment, assuming that the inputs for initial investment, after-tax cash flows, and salvage value are unchanged, both the internal rate of return and the CFROI of this project would have been 11.71 percent. The CFROI is, however, being computed three years into the project life and remains at 11.71 percent since none of the original inputs have changed. The IRR of this project will change, though. It will now be based on the current market value of the asset, the expected cash flows over the remaining life of the asset, and a life of seven years. Thus, if the market value of the asset has increased to $2.5 billion, the internal rate of return on this project would be computed to be only 6.80 percent.



Given the real cost of capital of 8 percent, this would mean that the CFROI is greater than the cost of capital, while the internal rate of return is lower. Why is there a difference between the two measures, and what are the implications? The reason for the difference is that IRR is based entirely on expected future cash flows, whereas the CFROI is not. A CFROI that exceeds the cost of capital is viewed as a sign that a firm is deploying its assets well. If the IRR is less than the cost of capital, that interpretation is false, because the owners of the firm would be better off selling the asset and getting the market value for it rather than continuing its operation.

To link the cash flow return on investment with firm value, let us begin with a simple discounted cash flow model for a firm in stable growth:

$$\text{Firm value} = \frac{\text{FCFF}_1}{(k_c - g_n)}$$

where FCFF is the expected free cash flow to the firm k_c is the cost of capital, and g_n is the stable growth rate. Note that this can be rewritten, approximately, in terms of the CFROI as follows:

$$\text{Firm value} = \frac{[(\text{CFROI} \times \text{GI} - \text{DA})(1 - t) - (\text{CX} - \text{DA}) - \Delta\text{WC}]}{(k_c - g_n)}$$

where CFROI is the cash flow return on investment, GI is the gross investment, DA is the depreciation and amortization, CX is the capital expenditure and ΔWC is the change in working capital. To illustrate, consider a firm with a CFROI of 30%, a gross investment of $100 million, capital expenditures of $15 million, depreciation of $10 million, and no working capital requirements. If we assume a 10% cost of capital, a 40% tax rate, and a 5% stable growth rate, it would be valued as follows:

$$\text{Firm value} = \frac{[(.30 \times 100 - 10)(1 - .4) - (15 - 10) - 0]}{(.10 - .05)} = \$140 \text{ million}$$

More important than the mechanics, however, is the fact that firm value, while a function of the CFROI, is also a function of the other variables in the equation—the gross investment, the tax rate, the growth rate, the cost of capital, and the firm's reinvestment needs.

Again, sophisticated users of CFROI do recognize the fact that value comes from the CFROI not just on assets in place but also on future investments. In fact, Holt Associates, one of CFROI's leading proponents, allows for a fade factor in CFROI, where the current CFROI fades toward the real cost of capital over time. The fade factor is estimated empirically by looking at firms in different CFROI classes and tracking them over time. Thus, a firm that has a current CFROI of 20 percent and real cost of capital of 8 percent will be projected to have lower CFROI over time. The value of the firm, in this more complex format, can then be written as a sum of the following:

- The present value of the cash flows from assets in place over their remaining life, which can be written as:

$$\sum_{t=1}^{t=n} \frac{\text{CFROI}_{aip} \times \text{GI}_{aip}}{(1 + k_c)^t}$$

  where CFROI_{aip} is the CFROI on assets in place, GI_{aip} is the gross investment in assets in place, and k_c is the real cost of capital.

- The present value of the excess cash flows from future investments, which can be written in real terms as

$$\sum_{t=1}^{t=\infty} \frac{\text{CFROI}_{t,NI} \times \Delta\text{GI}_t}{(1 + k_c)^t} - \Delta\text{GI}_t$$

  where $\text{CFROI}_{t,NI}$ is the CFROI on new investments made in year t and ΔGI_t is the new investment made in year t. Note that if $\text{CFROI}_{t,NI} = k_c$, this present value is equal to zero.

Thus, a firm's value will depend on the CFROI it earns on assets in place and both the abruptness and the speed with which this CFROI fades toward the cost of capital. Thus, a firm can therefore potentially increase its value by doing either of the following:

- Increasing the CFROI from assets in place for a given gross investment.
- Reducing the speed at which the CFROI fades toward the real cost of capital.

Note that this is no different from our earlier analysis of firm value in the discounted cash flow approach in Chapter 31, in terms of cash flows from existing investments (increase current CFROI), the length of the high growth period (reduce fade speed), and the growth rate during the growth period (keep excess returns from falling as steeply).

cfroi.xls: **This spreadsheet allows you to estimate the cash flow return on investment for a firm or project.**

CFROI and Firm Value: Potential Conflicts

The relationship between CFROI and firm value is less intuitive than the relationship between EVA and firm value, partly because it is a percentage return. Notwithstanding this fundamental weakness, managers can take actions that increase CFROI while reducing firm value.

- *Reduce gross investment.* If the gross investment in existing assets is reduced, the CFROI may be increased. Since it is the product of CFROI and gross investment that determines value, it is possible for a firm to increase CFROI and end up with a lower value.

CFROI INNOVATIONS: THE FADE FACTOR AND IMPLIED COST OF CAPITAL

The biggest contribution made by practitioners who use CFROI has been the work that they have done on how returns on capital fade over time toward the cost of capital. Madden (1999) makes the argument that not only is this phenomenon widespread but it is at least partially predictable. He presents evidence done by Holt Associates, a leading proponent of CFROI, which sorted the largest 1,000 firms by CFROI from highest to lowest, and tracked them over time to find a convergence toward an average. It should be noted that this book has used fade factors, without referring to them as such, in the chapters on discounted cash flow valuation. The fade to a lower return on capital occurred either precipitously in the terminal year or over a transition period. It was mentioned that the return on capital could converge to the cost of capital or to the industry average.

To compute the cost of capital, CFROI practitioners look to the market instead of the risk and return models that we have used to compute DCF value. Using the current market values of stocks and their estimates of expected aggregate cash flows, they compute internal rates of return that they use as the cost of capital in analysis. Chapter 7 used a very similar approach to estimate an implied risk premium, though this premium was used as an input into traditional risk and return models.

- *Sacrifice future growth*. CFROI, even more than EVA, is focused on existing assets and does not look at future growth. To the extent that managers increase CFROI at the expense of future growth, the value can decrease while CFROI goes up.
- *Trade off risk*. While the CFROI is compared to the real cost of capital to pass judgment on whether a firm is creating or destroying value, it represents only a partial correction for risk. The value of a firm is still the present value of expected future cash flows. Thus a firm can increase its spread between the CFROI and cost of capital but still end up losing value if the present value effect of having a higher cost of capital dominates the higher CFROI.

In general, then, an increase in CFROI does not, by itself, indicate that the firm value has increased, since it might have come at the expense of lower growth and/or higher risk.

CFROI and Market Value

There is a relationship between CFROI and market value. Firms with high CFROI generally have high market value. This is not surprising, since it mirrors what we noted earlier about economic value added. However, it is *changes* in market value that create returns, not market value per se. When it comes to market value changes, the relationship between CFROI and value changes tends to be much weaker. Since market values reflect expectations, there is no reason to believe that firms that have high CFROI will earn excess returns.

The relationship between changes in CFROI and excess returns is more intriguing. To the extent that any increase in CFROI is viewed as a positive surprise, firms with the biggest increases in CFROI should earn excess returns. In reality, however, the actual change in CFROI has to be measured against expectations; if CFROI increases, but less than expected, the market value should drop; if CFROI drops but by less than expected, the market value should increase.

A POSTSCRIPT ON VALUE ENHANCEMENT

The value of a firm has three components. The first is its capacity to generate cash flows from existing assets, with higher cash flows translating into higher value. The second is its willingness to reinvest to create future growth, and the quality of these reinvestments. Other things remaining equal, firms that reinvest well and earn significant excess returns on these investments will have higher value. The final component of value is the cost of capital, with higher costs or capital resulting in lower firm values. To create value, then, a firm has to:

- Generate higher cash flows from existing assets, without affecting its growth prospects or its risk profile.
- Reinvest more and with higher excess returns, without increasing the riskiness of its assets.
- Reduce the cost of financing its assets in place or future growth, without lowering the returns made on these investments.

All value enhancement measures are variants on these simple themes. Whether these approaches measure dollar excess returns, as does economic value added, or percentage excess returns, like CFROI, they have acquired followers because they seem simpler and less subjective than discounted cash flow valuation. This simplicity comes at a cost, since these approaches make subtle assumptions about other components of value that are often not visible or not recognized by many users. Approaches that emphasize economic value added and reward managers for increasing the same often assume that increases in economic value added are not being accomplished at the expense of future growth or by increasing risk. Practitioners who judge performance based on the cash flow return on investment make similar assumptions.

Is there something of value in the new value enhancement measures? Absolutely, but only in the larger context of valuation. One of the inputs we need for traditional valuation models is the return on capital (to get expected growth). Making the adjustments to operating income suggested by those who use economic value added and augmenting it with a cash flow return, with CFROI, may help us come up with a better estimate of this number. The terminal value computation in traditional valuation models, where small changes in assumptions can lead to large changes in value, becomes much more tractable if we think in terms of excess returns on investments rather than just growth and discount rates. Finally, the empirical evidence that has been collected by practitioners who use CFROI on fade factors can be invaluable in traditional valuation models, where practitioners sometimes make the mistake of assuming that current returns will continue forever.

CONCLUSION

This chapter considers two widely used value enhancement measures. Economic value added measures the dollar excess return on existing assets. The cash flow return on investment is the internal rate of return on existing assets, based on the original investment in these assets and the expected future cash flows. While both approaches can lead to conclusions consistent with traditional discounted cash flow valuation, their simplicity comes at a cost. Managers can take advantage of measurement limitations in both approaches to make their firms look better with either approach while reducing firm value. In particular, they can trade off less growth in the future for higher economic value added today and shift to riskier investments.

As we look at various approaches to value enhancement, we should consider a few facts. The first is that no value enhancement mechanism will work at generating value unless there is a commitment on the part of managers to making value maximization their primary objective. If managers put other goals first, then no value enhancement mechanism will work. Conversely, if managers truly care about value maximization, they can make almost any mechanism work in their favor. The second is that while it is sensible to connect whatever value enhancement measure we have chosen to management compensation, there is a downside. Managers, over time, will tend to focus their attention on making themselves look better on that measure even if that can be accomplished only by reducing firm value. Finally, there are no magic bullets that create value. Value creation is hard work in competitive markets and almost involves a trade-off between costs and benefits. Everyone has a role in value creation, and it certainly is not the sole domain of financial analysts. In fact, the value created by financial engineers is smaller and less significant than the value created by good strategic, marketing, production, or personnel decisions.

QUESTIONS AND SHORT PROBLEMS

1. Everlast Batteries Inc. has hired you as a consultant. The firm had after-tax operating earnings in 1998 of $180 million and net income of $100 million, and it paid a dividend of $50 million. The book value of equity at the end of 1998 was $1.25 billion, and the book value of debt was $350 million. The firm raised $50 million of new debt during 1998. The market value of equity at the end of 1998 was twice the book value of equity, and the market value of debt was the same as the book value of debt. The firm has a cost of equity of 12% and an after-tax cost of debt of 5%.
   a. Estimate the return on capital earned by Everlast Batteries.
   b. Estimate the cost of capital earned by Everlast Batteries.
   c. Estimate the economic value added by Everlast Batteries.
2. Assume, in the preceding problem, that Everlast Batteries is in stable growth, and that it expects its economic value added to grow at 5% a year forever.
   a. Estimate the value of the firm.
   b. How much of this value comes from excess returns?
   c. What is the market value added (MVA) of this firm?
   d. How would your answers to a, b, and c change if you were told that there would be no economic value added after year 5?
3. Stereo City is a retailer of stereos and televisions. The firm has operating income of $150 million, after operating lease expenses of $50 million. The firm has operating lease commitments for the next five years and beyond:

Year	*Operating Lease Commitment*
1	55
2	60
3	60
4	55
5	50
Years 6–15	40 each year

   The book value of equity is $1 billion, and the firm has no debt outstanding. The firm has a cost of equity of 11% and a pretax cost of borrowing of 6%. The tax rate is 40%.
   a. Estimate the capital invested in the firm, before and after adjusting for operating leases.
   b. Estimate the return on capital, before and after adjusting for operating leases.
   c. Estimate the economic value added, before and after adjusting for operating leases. (The market value of equity is $2 billion.)
4. Sevilla Chemicals earned $1 billion in after-tax operating income on capital invested of $5 billion last year. The firm's cost of equity is 12%, its debt-to-capital ratio is 25%, and the after-tax cost of debt is 4.5%.
   a. Estimate the economic value added by Sevilla Chemicals last year.
   b. Assume now that the entire chemical industry earned $40 billion after taxes on capital invested of $180 billion, and that the cost of capital for the industry is 10%. Estimate the economic value added by the entire industry.
   c. Based on economic value added, how did Sevilla do relative to the industry?
5. Jeeves Software is a small software firm in high growth. The firm is all equity financed. In the current year, the firm earned $20 million in after-tax operating income on capital invested of $60 million. The firm's cost of equity is 15%.

a. Assume that the firm will be able to grow its economic value added 15% a year for the next five years, and that there will be no excess returns after year 5. Estimate the value of the firm. How much of this value comes from the EVA and how much from capital invested?
b. Now, assume the firm is able to reduce its capital invested this year by $20 million by selling its assets and leasing them back. Assuming operating income and cost of capital do not change as a result of the sale-lease-back, estimate the value of the firm now. How much of the value of the firm now comes from EVA and how much from capital invested?

6. Healthy Soups is a company that manufactures canned soups made without preservatives. The firm has assets that have a book value of $100 million. The assets are five years old and have been depreciated $50 million over that period. In addition, the inflation rate over those five years has averaged 2% a year. The assets are currently earning $15 million in after-tax operating income. They have a remaining life of 10 years, and the depreciation each year is expected to be $5 million. At the end of these 10 years, the assets will have an expected salvage value, in current dollars, of $50 million.
   a. Estimate the CFROI of Healthy Foods, using the conventional CFROI approach.
   b. Estimate the CFROI of Healthy Foods, using the economic depreciation approach.
   c. If Healthy Foods has a cost of capital in nominal terms of 10%, and the expected inflation rate is 2%, evaluate whether Healthy Foods' existing investments are value-creating or value-destroying.

CHAPTER 33

Valuing Bonds

The value of a bond is the present value of the promised cash flows on the bond, discounted at an interest rate that reflects the default risk in these cash flows. Since the cash flows on a straight bond are fixed at issue, the value of a bond is inversely related to the interest rate that investors demand for that bond. The interest rate charged on a bond is determined by both the general level of interest rates and the default premium specific to the entity issuing the bond. This chapter examines the determinants of both the general level of interest rates and the magnitude of the default premiums on specific bonds. The general level of interest rates incorporates expected inflation and a measure of real return, and reflects the term structure, with bonds of different maturities carrying different interest rates. The default premiums vary across time, depending in large part on the health of the economy and investors' risk preferences.

Bonds often have special features embedded in them that have to be factored into the value. Some of these features are options—for the bondholder to convert into stock (convertible bonds), for the bond issuer to call the bond back if interest rates go down (callable bonds), and for the bondholder to put the bond back to the issuer at a fixed price under specific circumstances (putable bonds). Other bond characteristics, such as interest rate caps and floors, have option features. Some of these options reside with the issuer of the bond, some with the buyer of the bond, but they all have to be priced. Option pricing models can be used to value these special features, and price complex fixed income securities. Some special features in bonds such as the existence of sinking funds, subordination of further debt, and the type of collateral used may affect the prices of bonds as well.

BOND PRICES AND INTEREST RATES

The value of a straight bond is determined by the level of and changes in interest rates. As interest rates rise, the price of a bond will decrease, and vice versa. This inverse relationship between bond prices and interest rates arises directly from the present value relationship that governs bond prices.

The Present Value Relationship

The value of a bond is the present value of the promised cash flows on that bond, discounted at an interest rate that reflects the default risk associated with the cash flows. There are two features that set bonds apart from equity investments. First, the promised cash flows on a bond (i.e., the coupon payments and the face value of the bond) are usually set at issue and do not change during the life of the bond. Even when they do change, as in floating rate bonds, the changes are generally linked to changes in interest rates. Second, bonds usually have fixed lifetimes, unlike stocks, since most bonds specify a maturity date.[1] As a consequence, the present value of a straight bond with fixed coupons and specified maturity is determined entirely by changes in the discount rate, which incorporates both the general level of interest rates and the specific default risk of the bond being valued.

The present value of a bond, expected to mature in N time periods, with coupons every period can be written as:

$$\text{PV of bond} = \sum_{t=1}^{t=N} \frac{\text{Coupon}_t}{(1+r)^t} + \frac{\text{Face value}}{(1+r)^N}$$

where Coupon_t = Coupon expected in period t
Face value = Face value of the bond
r = Discount rate for the cash flows

The discount rate used to calculate the present value of the bond will vary from bond to bond, depending on default risk, with higher rates used for riskier bonds and lower rates for safer ones.

If the bond is traded, and a market price is therefore available for it, the internal rate of return can be computed for the bond (i.e., the discount rate at which the present value of the coupons and the bond's face value is equal to the market price). This internal rate of return is called the yield to maturity on the bond.

There are several details relating to both the magnitude and the timing of cash flows that can affect the value of a bond and its yield to maturity. First, the coupon payment on a bond may be semiannual, in which case the discounting has to allow for the semiannual cash flows. (The first coupon will be discounted back half a year, the second one year, the third a year and a half, and so on.) Second, once a bond has been issued, it accrues coupon interest between coupon payments, and this accrued interest has to be added on to the price of the bond when valuing the bond.

ILLUSTRATION 33.1: Valuing a Straight Bond at Issue

The following is a valuation of a 30-year U.S. government bond at the time of issue. The coupon rate on the bond is 7.5%, and the market interest rate is 7.75%. The price of the bond can be calculated thus:

$$\text{PV of bond} = \sum_{t=1}^{t=30} \frac{75.00}{(1.0775)^t} + \frac{1{,}000}{(1.0775)^{30}} = \$971.18$$

This is based on annual coupons. If the calculation is based on semiannual coupons, the value of the bond is:

$$\text{PV of bond} = \sum_{t=0.5}^{t=30} \frac{37.50}{(1.0775)^t} + \frac{1{,}000}{(1.0775)^{30}} = \$987.62$$

[1]Console bonds are the exception to this rule, since they are perpetuities.

ILLUSTRATION 33.2: Valuing a Seasoned Straight Bond

The following is a valuation of a seasoned government bond with slightly less than 20 years left to expiration and a coupon rate of 11.75%. The next coupon is due in two months. The current 20-year bond rate is 7.5%. The value of the bond can be calculated as follows:

$$\text{PV of bond} = \sum_{t=0.5}^{t=19.5} \frac{58.75}{(1.075)^t} + \frac{58.75}{(1.075)^{2/12}} + \frac{1{,}000}{(1.075)^{19.67}} = \$1{,}505.31$$

This bond trades at well above face value because of its high coupon rate. Note that the second term of the equation is the present value of the next coupon.

A Measure of Interest Rate Risk in Bonds

When the fact that the promised cash flows on a bond are fixed at issue is combined with the present value relationship governing bond prices, there is a clear rationale for why interest changes affect bond prices so directly. Any increase in interest rates, either at the economy-wide level or because of an increase in the default risk of the company issuing the bond, will lower the present value of the stream of expected cash flows and hence the value of the bond. Any decrease in interest rates will have the opposite impact.

The effect of interest rate changes on bond prices will vary from bond to bond and will depend on a number of characteristics of the bond:

- *Maturity of the bond.* Holding coupon rates and default risk constant, increasing the maturity of a straight bond will increase its sensitivity to interest rate changes. The present value of cash flows changes much more for cash flows further in the future, as interest rates change, than for cash flows that are nearer in time. Figure 33.1 illustrates the present values of six bonds—a 5-year,

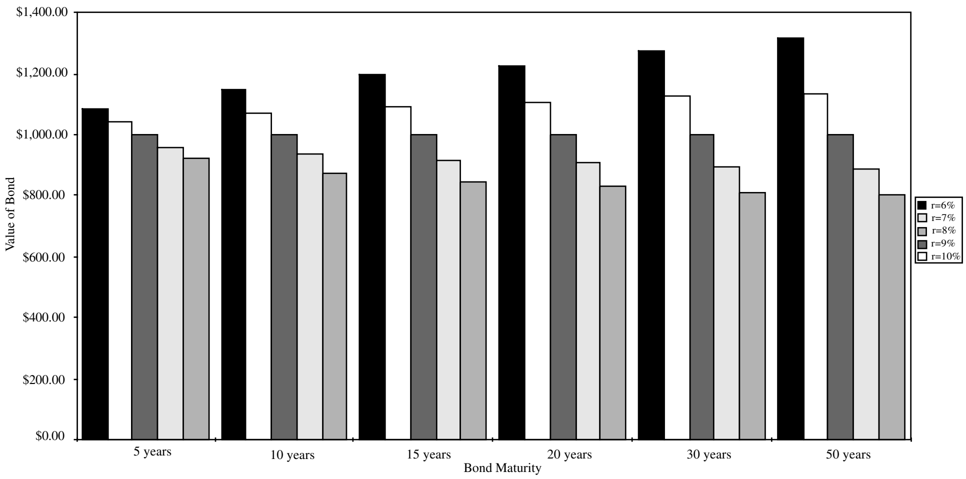


FIGURE 33.1 Bond Values and Interest Rates

a 10-year, a 15-year, a 20-year, a 30-year, and a 50-year bond—all with 8 percent coupons for a range of interest rates.

The longer-term bonds are much more sensitive to interest rate changes than the shorter-term bonds. For instance, an increase in interest rates from 8 percent to 10 percent results in a decline in value of 7.61 percent for the 5-year bond and of 19.83 percent for the 50-year bonds.

- *Coupon rate of the bond*. Holding maturity and default risk constant, increasing the coupon rate of a straight bond will decrease its sensitivity to interest rate changes. Since higher coupons result in more cash flows earlier in the bond's life, the present value will change less as interest rates change. At the extreme, if the bond is a zero coupon bond, the only cash flow is the face value at maturity, and the present value is likely to vary much more as a function of interest rates. Figure 33.2 illustrates the percentage changes in bond prices for six 30-year bonds with coupon rates ranging from 0 percent to 10 percent as the market interest rate of 8 percent changes.

  The bonds with the lower coupons are much more sensitive, in percentage terms, to interest rate changes than those with higher coupons.

While the maturity and the coupon rate are the key determinants of how sensitive the price of a bond is to interest rate changes, a number of other factors impinge on this sensitivity. Any special features that the bond has, including convertibility and callability, make the maturity of the bond less definite and can therefore affect the bond price's sensitivity to interest rate changes. If there is any

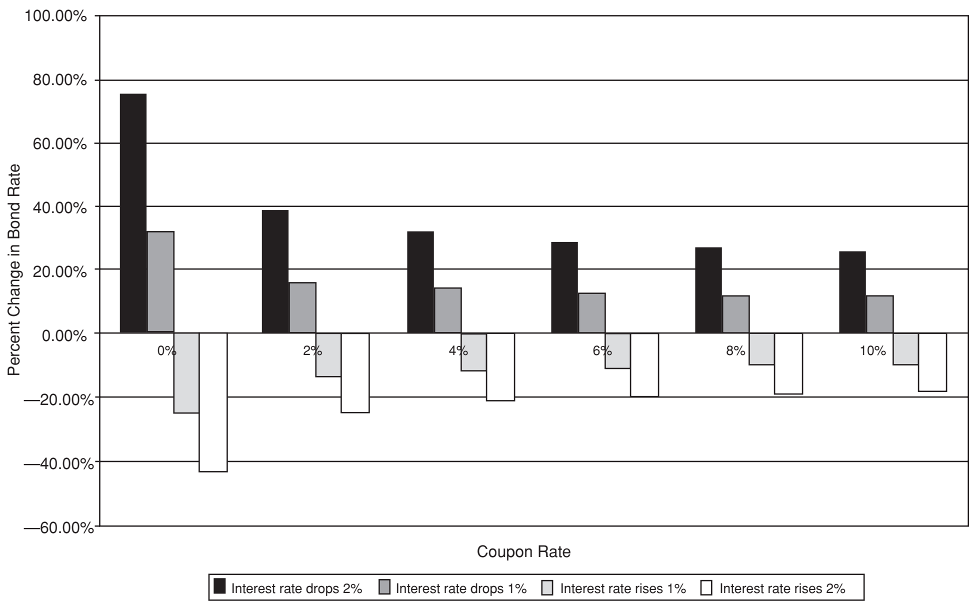


FIGURE 33.2 Percent Change in Bond Price—Interest Rate Changes from 8 Percent

relationship between the level of interest rates and the default premiums on bonds, the default risk of a bond can affect its price sensitivity.

A More Formal Measure of Interest Rate Risk—Duration

Since the interest rate risk of a bond is a significant component of its total risk, a more formal measure of interest risk is needed, which consolidates the effects of maturity, coupon rates, and the bond's special features. To arrive at this measure, consider the present value relationship developed earlier in this chapter:

$$\text{PV of bond} = \sum_{t=1}^{t=N} \frac{\text{Coupon}_t}{(1+r)^t} + \frac{\text{Face value}}{(1+r)^N}$$

Differentiating the bond price with respect to interest rate should provide a formal measure of bond price sensitivity to interest rate changes:

$$\text{Duration of bond} = \frac{dP/P}{dr/r} = \frac{\left[\sum_{t=1}^{t=N} \frac{t \times \text{Coupon}_t}{(1+r)^t} + \frac{N \times \text{Face value}}{(1+r)^N}\right]}{\left[\sum_{t=1}^{t=N} \frac{\text{Coupon}_t}{(1+r)^t} + \frac{\text{Face value}}{(1+r)^N}\right]}$$

The bond price differential, (dP/P)/(dr/r), is called the duration of the bond, and measures the interest rate sensitivity of the bond.

The duration of a bond is a weighted maturity of all the cash flows on the bond including the coupons, where the weights are based on both the timing and the magnitude of the cash flows. Larger and earlier cash flows are weighted more than smaller and later cash flows. By incorporating the magnitude and timing of all the cash flows on the bond, duration encompassed all the variables that affect bond price sensitivity in one measure. The higher the duration of a bond, the more sensitive it is to changes in interest rates.

The duration of a bond will always be less than the maturity for a coupon bond, and equal to the maturity for a zero coupon bond with no special features. In general, the duration of a bond will decrease as the coupon rate on the bond increases.

The measure of duration described here is called Macaulay duration and it is the simplest version, based on yields to maturity. It is based on the assumption of a flat term structure. There are modified versions of duration, which are more flexible in their assumptions about the term structure and its shifts over time.

ILLUSTRATION 33.3: Estimating Durations for Coupon Bonds

This example estimates the duration of a seasoned government bond with 20 years left to expiration and a coupon rate of 11.75%. The interest rate is 7.5%. The duration of the bond, assuming annual coupon payments, can be calculated as follows:

t	*Cash Flow*	*PV of Cash Flow*	*t × PV of Cash Flow*
1	$ 117.50	$ 109.30	$ 109.30
2	$ 117.50	$ 101.68	$ 203.35
3	$ 117.50	$ 94.58	$ 283.75
4	$ 117.50	$ 87.98	$ 351.94
5	$ 117.50	$ 81.85	$ 409.23
6	$ 117.50	$ 76.14	$ 456.81
7	$ 117.50	$ 70.82	$ 495.77
8	$ 117.50	$ 65.88	$ 527.06
9	$ 117.50	$ 61.29	$ 551.57
10	$ 117.50	$ 57.01	$ 570.10
11	$ 117.50	$ 53.03	$ 583.36
12	$ 117.50	$ 49.33	$ 591.99
13	$ 117.50	$ 45.89	$ 596.58
14	$ 117.50	$ 42.69	$ 597.65
15	$ 117.50	$ 39.71	$ 595.67
16	$ 117.50	$ 36.94	$ 591.05
17	$ 117.50	$ 34.36	$ 584.17
18	$ 117.50	$ 31.97	$ 575.38
19	$ 117.50	$ 29.74	$ 564.98
20	$1,117.50	$ 263.07	$ 5,261.48
		$1,433.27	$14,501.21

Duration of the bond = $14,501/1,433 = 10.12

DETERMINANTS OF INTEREST RATES

The interest rate used to discount cash flows on a bond is determined by a number of variables—the general level of interest rates in the economy, the term structure of interest rates, and the default risk of the bond. Figure 33.3 provides the building blocks for arriving at the interest rate on a straight corporate bond.

The first block is the level of short-term default-free interest rates, and it captures the overall level of rates in the economy. The second block is a maturity premium, which reflects the difference between longer-term default free rates and short-term rates, and is generally positive. The third block is a default premium, which is related to the default risk of the bond in question and is always positive. This section takes a closer look at these blocks.

Level of Interest Rates

The short-term default-free rate can be decomposed into two components—an expected inflation rate during the period and an expected real rate of return.

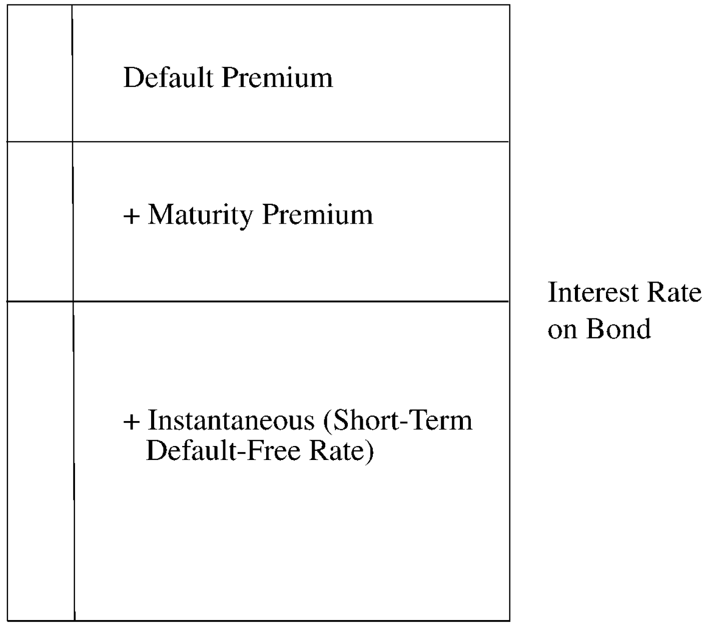


FIGURE 33.3 Building Blocks for Interest Rates

Short-term default-free rate = Expected inflation + Expected real rate of return

This identity is known as the Fisher equation and essentially implies that changes in short-term rates can be traced to changes in either expected inflation or the expected real rate of return. The more precise version of the Fisher equation allows for the compounding effect:

$$(1 + r) = (1 + I)(1 + R)$$

where r = Nominal interest rate
I = Expected inflation
R = Expected real rate of return

It should be emphasized that the Fisher equation is an identity, and there is no question of it being proved or disproved. The real questions that arise from the equation arise as a consequence of specific assumptions about the real rate and expected inflation.

Expected Inflation Expected inflation is clearly the dominant variable determining interest rates. Generally speaking, a forecaster who can predict changes in inflation well should also have a good track record in predicting interest rate changes. The first step in forecasting inflation is understanding its determinants.

Determinants of Inflation There is consensus on the determinants of inflation, though there is little agreement about the effects of specific actions on inflation.

To understand both the determinants of inflation and the sources of disagreement between the different schools of thought on inflation, consider another identity:

$$P = M\,V/Y$$

where P = Price level
M = Money supply in the economy
V = Velocity of money circulation in the economy
Y = Real output in the economy

The velocity of money measures how often the currency, used to define the money supply M, circulates in the economy, and how much is created in terms of transactions for every unit of currency created. Thus, if $1 in additional currency created $3 in transactions, the velocity of money is 3. While the money supply used in the equation can be defined in a number of different ways ranging from just currency to broader aggregates, the velocity has to be defined consistently.

This identity can be stated in terms of changes as follows:

$$dP = (dM)(dV)/dY$$

The left-hand side of this identity is the inflation rate, and the right-hand side provides the three determinants of the inflation rate:

1. *Change in the money supply.* If the money supply increases, with no concurrent change in real output and money velocity, the inflation rate will increase. This is the basis for the argument by many monetarists, who believe that there is no linkage between real output and money supply and that money velocity is stable over long periods, that loose monetary policy (increasing money supply) is the reason for high inflation. While some monetarists will concede that monetary policy can have short-term effects on real output, most argue that it cannot impact real output in the long term. They also argue that while money velocity may change over time, that these changes occur over the very long term, and are unlikely to have a major impact on inflation.
2. *Change in money velocity.* If the money velocity increases, with no concurrent change in money supply and real output, the inflation rate will decrease. Economists have long debated why money velocity changes over time. One determinant is technology, since changes in the way people save (from checking accounts to money market accounts) and in the way they spend (from cash transactions to credit card transactions) affect the money velocity. Another is the faith the public has in the currency. In hyperinflationary environments, individuals are much less willing to hold currency (because it depreciates in value so quickly) and therefore attempt to convert the currency into real goods. This unwillingness to hold currency translates into higher money velocity. Thus, if the central bank is viewed as having eased the reins on money supply, there is often a concurrent increase in money velocity, leading to a surge in inflation.
3. *Change in real output.* If the real output increases, with no concurrent increase in money supply and money velocity, the inflation rate will decrease. This is of-

ten the basis of the argument used by Keynesians for easing monetary policy during economic downturns. Increasing the money supply, they argue, results in a concomitant increase in real output, since there is excess capacity, and the effects on inflation are therefore muted or nonexistent.

Measuring Inflation A true measure of inflation would consider changes in the prices of all goods and services used in an economy, weighted by their usage values. The reported measures of inflation, at either the consumer or the producer level, attempt to do so, but often lag changes in true inflation because of a number of reasons. The first is that not all goods and services are traded in a marketplace, and prices are not easily available and goods are not always standardized. Thus it is easy to gauge the inflation in medical prescription prices, but much more difficult to gauge the inflation in the prices of medical services. The second is that all inflation indexes are based on samplings of prices of goods, rather than the universe of all goods traded. Even if the sample is not biased, there is the possibility of sampling error that enters into the numbers. The third is the issue of weighting on the basis of usage value. Due to practical considerations of time and resources, the weights are not adjusted every time the inflation index is computed to allow for changes in usage. Instead index weights are adjusted infrequently, leading to biases in the measured inflation. Thus the inflation indexes that kept the usage of gasoline by households constant in the late 1970s while oil prices were climbing (and people were cutting back on the use of gasoline) tended to overstate the inflation rate. The final consideration is about the level at which inflation is to be measured, since counting goods at every level of the process (from commodity to manufactured good to retailed good) would result in double or even triple counting the same good. Different inflation indexes examine inflation at different stages in the process, and can therefore lead to different conclusions about whether inflation is increasing, decreasing, or staying unchanged.

Forecasting Inflation Since changes in inflation signal changes in interest rates, economists and analysts have expended considerable time and resources forecasting inflation, with mixed results. The forecasting approaches used range from the naive to the sophisticated and are based on everything from gut feeling to elaborate models. The output from these models can be contrasted with predictions based purely on past inflation—either the inflation in the last time period or time-series models that examine trends and shifts in past inflation—and the results for the most part are mixed. Elaborate forecasting models do no better than time-series models in the short term, but may better capture changes in inflation in the long term because they consider information beyond what's available in past inflation rates.

The introduction of inflation-adjusted Treasury bonds a few years ago has provided an interesting alternative for those who would rather rely on markets than on economists for their inflation estimates. In particular, if we view the market interest rate on an inflation-indexed Treasury bond as a riskless real rate and the market interest rate on a nominal Treasury bond of equal maturity as a nominal rate, the expected inflation rate can be estimated as follows:

$$\text{Expected inflation rate} = \frac{(1 + \text{Nominal rate})}{(1 + \text{Real rate})} - 1$$

For instance, if the nominal rate is 5.1 percent and the real rate is 2.7%, you can estimate the expected inflation rate as follows:

$$\text{Expected inflation rate} = (1.051/1.027) - 1 = .0233 \text{ or } 2.33\%$$

Testing the Fisher Equation As mentioned earlier, the Fisher equation is an identity that cannot be proved or disproved. There have, however, been numerous attempts to impose additional constraints on the model, to test the usefulness of the model in explaining changes in interest rates over time. These studies go back to Fisher's own work on interest rates and inflation, where he found that the correlation between the rate of inflation and the commercial paper rate was low in both his sample periods—1890 to 1914 and 1915 to 1927.

Fama (1975) made the assumption that real rates do not change much over time and that changes in interest rates should therefore almost entirely be caused by changes in inflation. He tested this proposition by regressing interest rates against expected inflation:

$$I_t = a + b\, R_t$$

where R_t = Nominal interest rate during period t
I_t = Expected inflation during period t

Fama argued that if his initial assumption about constant real rates was true, this regression would yield the following:

- The intercept would be equal to the constant real rate over the period.
- The slope of the regression would be one, since all changes in interest rates would be a consequence of changes in inflation.

Lacking an adequate measure of expected inflation, Fama used the one-month Treasury bill rate at the start of each month as a measure of expected inflation during the month, and the one- and three-month Treasury bill rates as measures of nominal rates. His results, for the period 1953 to 1971, were as follows:

Consumer price index regressed against one-month T-bills:

$$\underset{}{I_t} = \underset{[0.0003]}{0.0007} + \underset{[0.10]}{0.98}\, R_t \qquad R^2 = 0.29$$

Consumer price index regressed against three-month T-bills:

$$\underset{}{I_t} = \underset{[0.0011]}{0.0023} + \underset{[0.11]}{0.92}\, R_t \qquad R^2 = 0.48$$

Based on this regression, Fama concluded that the hypothesis of constant real rates was supported and that the slope was statistically indistinguishable from one, suggesting that there was a one-to-one relationship between changes in interest rates and expected inflation.

The studies that followed have generally not been as encouraging. Wood, for instance, updated Fama's regression, after adding a lagged measure of inflation to it, and contrasted the results for two periods—1953 to 1971 and 1974 to 1981.

$$I_t = a + b\,R_t + c\,I_{t-1}$$

Period	*Regression*	*R-Squared*
1953–1971	$I_t = 0.0006 + 0.84\,R_t + 0.09\,I_{t-1}$	0.309
	[0.0003] [0.111] [0.064]	
1974–1981	$I_t = -\,0.0023 + 0.25\,R_t + 0.47\,I_{t-1}$	0.371
	[0.0008] [0.12] [0.11]	

The coefficient on nominal interest rates (R_t), which was close to 1 for the 1953–1971 time period used by Fama in his study, drops to 0.25 for the 1974–1981 time period.

The reason for the surprisingly good results from 1953 to 1971 may be traceable to the fact that inflation was very stable during this period, and that changes in inflation tended to be small. Thus, it seems likely that the hypothesis of stable real rates and a one-to-one relationship between interest rates and inflation will be rejected in any period or any economy where there is volatility in interest rates and inflation. Since the importance of forecasting increases with the volatility of interest rates and inflation, the cautionary notes on forecasting short-term interest rates based only upon expected inflation should be taken to heart.

Expected Real Rate of Return The other component of the Fisher equation is the expected real rate of return. On an intuitive level, the expected real rate of return is the rate at which individuals are willing to trade off current consumption for future consumption. Given the preference for present consumption, the expected real rate of return should be positive, but can vary widely across time and across economies. If individuals in a society have a strong desire for current consumption, the expected real rate of return will have to be high to induce them to defer consumption.

Realized Real Rates of Return Since the expected real rate of return is based on the preference functions of individuals, which are difficult to observe, we are reduced to observing realized real rates of return, which can be defined to be:

$$\text{Realized real rate of return} = \text{Nominal interest rate}_t - \text{Actual inflation}_t$$

where $\text{Nominal interest rate}_t$ = Nominal interest rate at the beginning of period t
$\text{Actual inflation}_t$ = Actual inflation during period t

While the expected real rate of return should be positive, the realized real rate of return can be positive or negative, depending on the period under observation. During the 1970s, for instance, bond investors in the United States earned negative real rates of return as actual inflation outstripped expected inflation.

Expected Real Return and Expected Real Growth Ultimately, real returns to investors in an economy comes from real growth in the economy. One way to approach the estimation of expected real return is to estimate the expected real

ROLE OF THE CENTRAL BANK

Central banks do not set interest rates, but they certainly can influence them in two ways. On a short-term basis, central banks can tighten or loosen their reins on the money supply and try to slow an overheated economy or regenerate a sluggish economy. In either case, though, we should not attribute more power to central banks than they actually have. The only interest rate that the Federal Reserve in the United States, for instance, directly controls is the federal funds rate. By raising or lowering this rate it can hope to affect other rates, but the market does not always cooperate. It is generally true that market interest rates tend to move with the federal funds rate, but there are two caveats: The first is that markets tend to lead the Federal Reserve, as bond investors build in expectations of changes in Fed policy; and the second is that the correlation tends to be strongest for short-term rates (Treasury bills and commercial paper) and weaker for longer-term rates.

On a long-term basis, central banks can have a much bigger impact on interest rates through their conduct of monetary policy and the resolution that they show about fighting inflation. It is no coincidence that high inflation occurs most often when central banks are undisciplined when it comes to monetary policy and show no resolve when it comes to taking tough measures to fight inflation.

growth rate in the economy. Thus the expected real return in an economy growing in the long term at 2.5 percent a year should be approximately 2.5 percent. If the expected real return increases above the long-term growth rate in the economy, the imbalance will lead to a depletion of savings and a shortfall in investments. Alternatively, if the real return decreases below the long-term growth rate, the imbalance will lead to an accumulation of savings and overinvestment.

Maturity Premium

The maturity premium refers to the difference in interest rates between a short-term (or instantaneous) default-free interest rate and an interest rate for a longer-maturity default-free bond. In the following section, the maturity premium is clarified further and a number of different theories designed to explain the magnitude of the maturity premium are examined.

The Yield Curve The relationship between maturity and interest rates is usually captured by a yield curve, which graphs yields on bonds against bond maturities. Figure 33.4 summarizes the Treasury yield curve in January and June 2001.

In January 2001 the yield curve was slightly downward-sloping, but by June 2001 the yield curve had reverted; short-term rates dropped while long-term rates increased slightly. While the yield curve has generally been upward-sloping over much of this century, there have been periods where the yield curve has been downward-sloping. Figure 33.5 shows the yield curves from 1980 to 2001. In the early 1980s, short-term rates were higher than long-term rates for a period. Over the past two decades, rates have dropped at both ends of the spectrum.

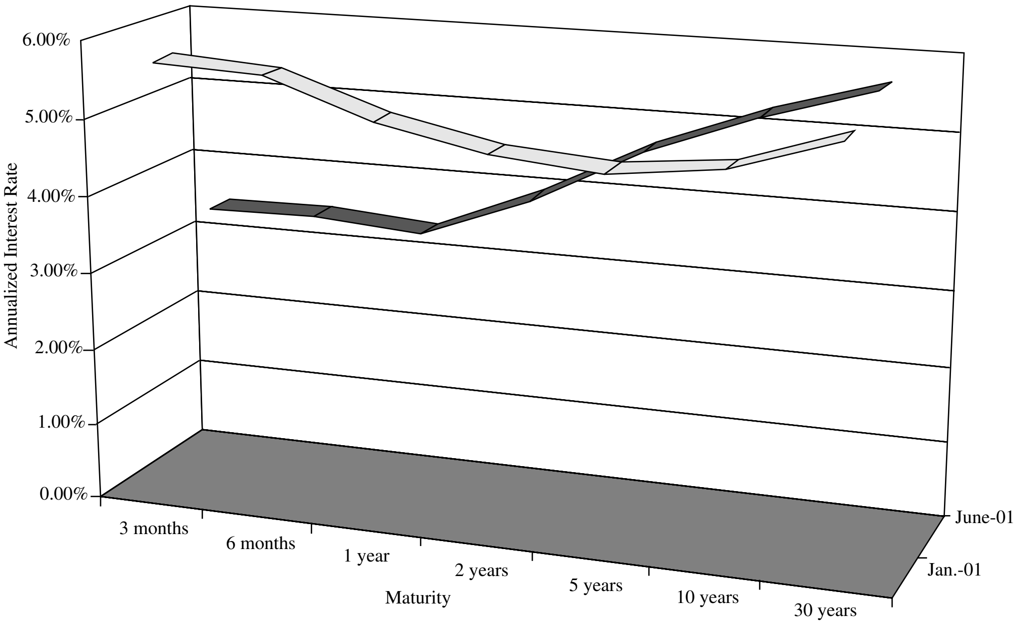


FIGURE 33.4 Yield Curves—January 2001 and June 2001
Source: Federal Reserve.

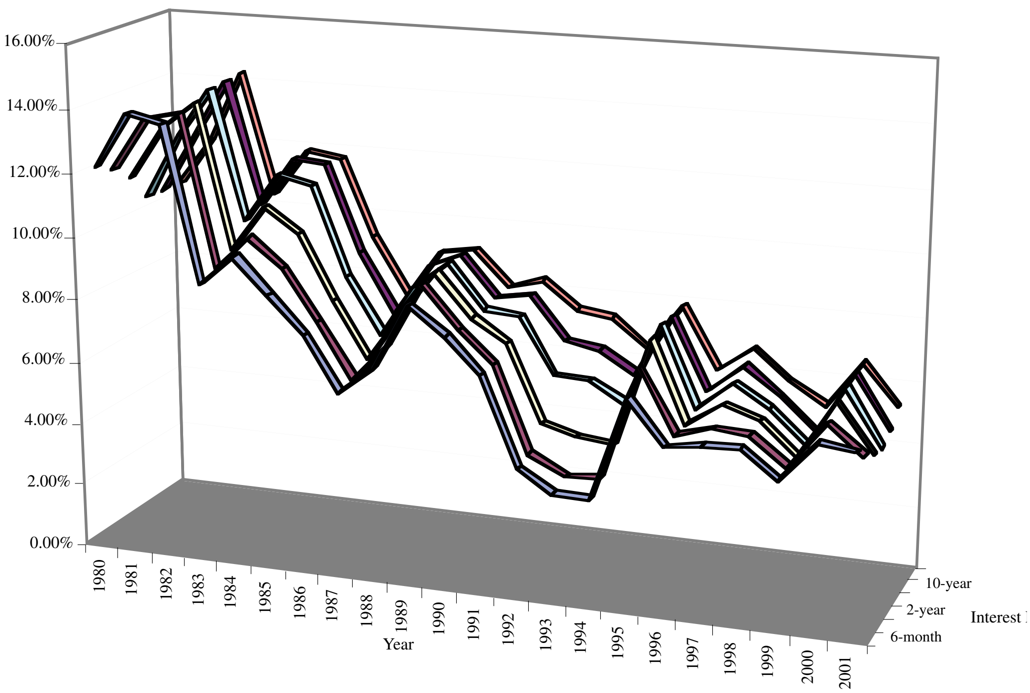


FIGURE 33.5 Yield Curves: 1980–2001
Source: Federal Reserve.

While the yield curves are generally constructed using the yields to maturity of government bonds, the presence of coupons on these bonds affects the calculated yield to maturity. This limitation can be overcome in one of two ways. The first is to construct a yield curve using only zero coupon government bonds of different maturities. The second is to extract spot interest rates from the yields to maturity of coupon bonds, and to plot the spot rates against maturities. The following example illustrates the process of extracting spot rates.

ILLUSTRATION 33.4: Yields to Maturity and Spot Rates

The following table provides prices and yields to maturity on one- to five-year bonds, and extracts spot rates from the yields to maturity:

Maturity	*Yield to Maturity*	*Spot Rate*
1 year	4.00%	4.00%
2 year	4.25%	4.26%
3 year	4.40%	4.41%
4 year	4.50%	4.51%
5 year	4.58%	4.60%

The spot rate is estimated from the two-year rate as follows:

$$\text{Price of two-year bond} = \text{Coupon}_1/(1 + {}_0r_1) + (\text{Face value} + \text{Coupon}_2)/(1 + {}_0r_2)^2$$

Assuming the bond is priced at par,

$$1{,}000 = 42.50/1.04 + 1{,}042.50/(1 + {}_0r_2)^2$$

Solving for ${}_0r_2$,

$${}_0r_2 = \sqrt{1{,}042.50/(1{,}000 - 42.50/1.04)} - 1 = 4.26\%$$

The other rates are extracted using a similar process,

$$1{,}000 = 44/1.04 + 44/1.0426^2 + 1{,}044/(1 + {}_0r_3)^3 \qquad {}_0r_3 = 4.41\%$$
$$1{,}000 = 45/1.04 + 45/1.0426^2 + 45/1.0441^3 + 1{,}045/(1 + {}_0r_4)^4 \qquad {}_0r_4 = 4.51\%$$
$$1{,}000 = 45.80/1.04 + 45.80/1.0426^2 + 45.80/1.0441^3 + 45.80/1.0451^4 + 1{,}045.80/(1 + {}_0r_5)^5 \qquad {}_0r_5 = 4.60\%$$

The difference between yields to maturity and spot rates increases as the bond maturity increases.

Spot and Forward Rates The spot rate on a multiperiod bond is an average rate that applies over the periods. The forward rate is a one-period rate for a future period, and can be extracted from the spot rates. For instance, if ${}_0S_2$ is the two-period spot rate, and ${}_0S_1$ is the one-period spot rate, the forward rate for the second period, ${}_1F_2$, can be obtained as follows:

$${}_1F_2 = (1 + {}_0S_2)^2/(1 + {}_0S_1) - 1$$

The forward rate for period 3 can be extracted using the spot rates for periods 2 and 3, and in general, the forward rate for period n can be written as:

$$_{n-1}F_n = (1 + {_0S_n})^n/(1 + {_0S_{n-1}})^{n-1} - 1$$

If the yield curve for spot rates is upward-sloping, the yield curve using forward rates will be even more so. Alternatively, if the spot rate yield curve is downward-sloping, the forward rate yield curve will be even more so. The following illustration builds on the previous one, and extracts forward rates from spot rates.

ILLUSTRATION 33.5: Spot Rates and Forward Rates

The forward rates are extracted from the spot rates for one- to five-year bonds. This is illustrated in the following table:

	Yield to Maturity	*Spot Rate*	*Forward Rate*
1	4.00%	4.00%	4.00%
2	4.25%	4.26%	4.52%
3	4.40%	4.41%	4.71%
4	4.50%	4.51%	4.81%
5	4.58%	4.60%	4.96%

Forward rate for year 2 = $1.0426^2/1.04 - 1 = 4.52\%$
Forward rate for year 3 = $1.0441^3/1.0426^2 - 1 = 4.71\%$
Forward rate for year 4 = $1.0451^4/1.0441^3 - 1 = 4.81\%$
Forward rate for year 5 = $1.0458^5/1.0451^4 - 1 = 4.96\%$

Determinants of the Maturity Premium The magnitude of the maturity premium is determined by a number of factors including expectations about inflation, investor preferences for liquidity, and demands from specific market segments. Each of these factors is examined in more detail in the following section.

Expected Inflation Expectations about future inflation are a key determinant of longer-term rates. In general, if inflation is expected to go up in future periods, longer-term rates will be higher than shorter-term rates. Alternatively, if inflation is expected to go down in future period, longer-term rates will be lower than shorter-term rates.

An extreme version of this story is the pure expectations hypothesis, where the term structure is driven entirely be expectations about inflation. Under this hypothesis, the yield curve will be upward-sloping, if investors expect inflation to rise in future periods, flat if investors expect inflation to remain unchanged in future periods, and downward-sloping if investors expect inflation to decline in future periods. This is illustrated in Figure 33.6.

The pure expectations hypothesis can also be stated in terms of forward rates

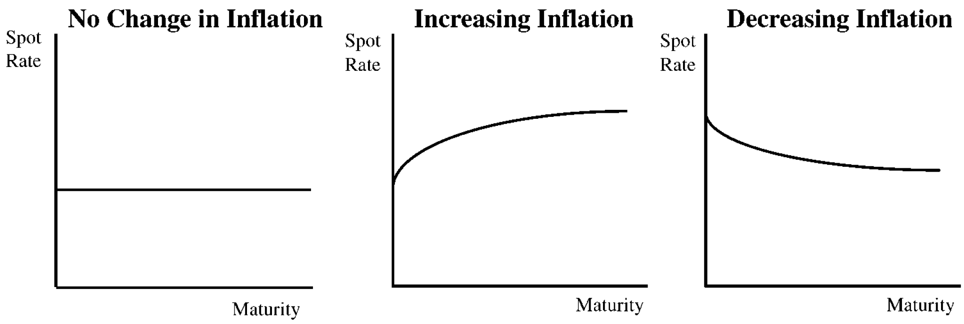


FIGURE 33.6 Pure Expectations Hypothesis

and expected spot rates. If the hypothesis is correct, the forward rate for period n should be the best predictor of the expected spot rate in that period; that is,

$$_{n-1}F_n = \text{Exp}(_{n-1}S_n)$$

where $_{n-1}F_n$ = Forward rate for period n
$\text{Exp}(_{n-1}S_n)$ = Expected one-period spot rate in period n

While the pure expectations hypothesis may be extreme in assuming that forward rates are determined entirely by expected spot rates, it does highlight the importance of expected inflation in determining the maturity premium.

Liquidity Preference The liquidity preference theory is not an alternative to the pure expectations theory but builds on it by taking into account uncertainty and risk aversion. In the form in which it was originally developed by Hicks (1946), the uncertainty was seen as accruing to the lender who concurrently charged a liquidity premium for lending for longer time periods. This uncertainty can also be stated in terms of bond prices, with long-term bonds being viewed as more volatile than short-term bonds, as interest rates change. Under this theory, holding expectations of inflation constant, longer-term rates will be higher than shorter-term rates. Stated in terms of forward rates and expected spot rates,

$$_{n-1}F_n = \text{Exp}(_{n-1}S_n) + L_t$$

where L_t = Liquidity premium corresponding to a bond maturity of t periods

Figure 33.7 illustrates how the liquidity premium builds on top of the pure expectations hypothesis.

While the traditional theory assumes a positive liquidity premium (L_t), the assumption that all lenders prefer to lend short-term over long-term may not be always appropriate. For instance, a lender with fixed liabilities 20 years from now may view a 20-year zero coupon bond as less risky than a Treasury bill, because it matches cash inflows to cash outflows. The question therefore becomes an empirical one: Does the average lender prefer to lend short-term or long-term?

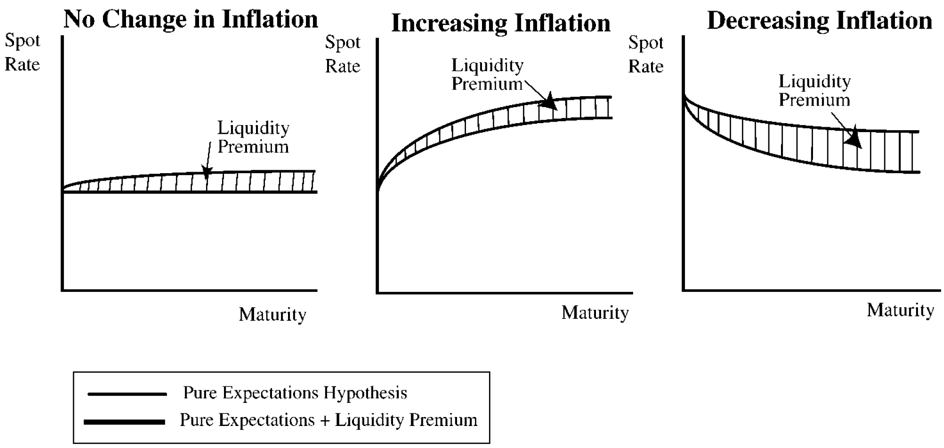


FIGURE 33.7 Term Structure with Liquidity Premium

McCulloch (1975) attempted to estimate term premiums for different time periods, and found positive term premiums, suggesting that lenders prefer short-term lending to long-term lending. Van Horne (1965) found term premiums increasing, albeit at a decreasing rate, with bond maturity.

Demands from Specific Market Segments The price of bonds, like any other security, is determined by demand and supply. If the market is segmented and there are sizable groups of investors whose demand is for a specific maturity, the term structure will be affected by these groups. Again, considering the extreme case, where investors will lend and borrow only for specific maturities, the interest rate at each maturity will be determined by demand and supply at that maturity. This is illustrated in Figure 33.8. Under this scenario, the term structure can take any shape, depending on the demand and supply at each maturity.

The assumption that investors will lend or borrow only for specific maturities, and not substitute other maturities even when it is extremely favorable for them to do so is an extreme one. In reality, market segments do exist and do affect the term structure, but only at the margin and for one or two maturities. For instance, the demand from Japanese investors in the late 1980s for just-issued 30-year bonds resulted in a slight kink in the term structure, where 30-year bond rates were slightly lower than 29-year bond rates, even though the rest of the yield curve was upward-sloping.

Empirical Evidence on Maturity Premiums Empirical studies of the term structure have examined several questions including the relative frequency of upward- and downward-sloping term structures, the magnitude of liquidity premiums, and the presence of market segments. The evidence can be summarized as follows:

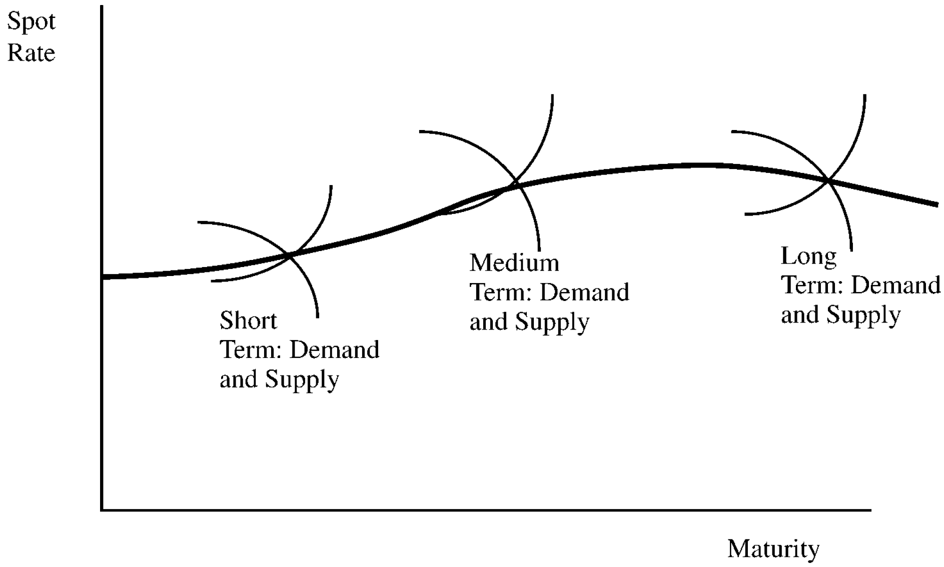


FIGURE 33.8 Market Segmentation and Term Structure

- The yield curve, at least in this century, has been more likely to be upward-sloping than downward-sloping. Examining yield curves at the beginning of each year from 1900 to 2000, the yield curve has been downward-sloping in only 29 of the 100 years. This is inconsistent with a pure expectations hypothesis, where downward-sloping yield curves should be just as likely as flat or upward-sloping yield curves.[2] It is, however, consistent with a combination of an expectations and liquidity preference hypotheses, where positive liquidity premiums are demanded over and above expected inflation.
- The term structure is much more likely to be downward-sloping when the level of interest rates is high relative to historical rates. The following table[3] summarizes the frequency of downward-sloping yield curves as a function of the level of interest rates.

		Slope of Yield Curve		
Period	*One-Year Corporate Bond Rate*	*Positive*	*Flat*	*Negative*
1900–1970	Above 4.40%	0	0	20
	3.25% to 4.40%	10	10	5
	Below 3.25%	26	0	0
1971–2000	Above 8.00%	4	2	3
	Below 8.00%	13	6	0

[2]Prior to the abandonment of the gold standard in the 1930s, negatively sloped yield curves were just as likely to occur as positively sloped yield curves.
[3]Some of the data table is extracted from Wood (1985).

This evidence is consistent with the expectations and liquidity preference hypotheses, but it is also consistent with a hypothesis that interest rates move within a normal range. When they approach the upper end or lower end of the normal range, the yield curve is more likely to be downward-sloping or upward-sloping, respectively.

- Studies have generally found that expectations about future interest rates are important in shaping the term structure. Meiselman computed high positive correlations between forecasting errors and changes in various forward rates, and stable term premiums. In contrast, there are many researchers who argue that the volatility in interest rates is much too great to be explained by just expectations about future rates and constant term premiums. Shiller (1979) concluded that the greater the volatility in interest rates, the larger the term premiums.
- Attempts by the government to alter the shape of the yield curve by adjusting the maturity of issues have largely been unsuccessful in the long term. For instance, Operation Twist in 1962 was designed to make the yield curve flatter by lowering long-term rates and raising short-term rates by issuing short-term debt to finance deficits.[4] Though the yield curve did flatten, long-term yields did not decline. This can be viewed as evidence of the weakness of the market segmentation hypothesis.
- There is evidence that the shape of the term structure has strong predictive power for future changes in the real economy, with more upward sloping yield curves being associated with higher real growth. Harvey (1991) examined the G-7 countries (Canada, France, Germany, Italy, Japan, United Kingdom, United States) and concluded that 54 percent of world economic growth could be explained by the term structure.

Default Premium

While there is no possibility of default for bond issues made by the U.S. Treasury, corporate bonds or state/local bonds can default on interest or principal payments. The same can be said about bonds issued by sovereigns with default risk. If there is any possibility of default on a bond, there will be a default premium in addition to the maturity premium on the bond. The default premium will increase with the perceived default risk of the bond and is generally also a function of the maturity and terms of the specific bond. Chapter 7 examined this issue in detail as part of the discussion of how best to estimate the cost of debt for a firm. Reviewing that discussion, the conclusions were:

- The most direct measure of default risk is the default rate, which measures defaulted issues as a percentage of the par value of debt outstanding. Hickman

[4]A similar, though less formal, attempt was made in 1993 by the U.S. Treasury Department to raise short-term rates and lower long-term rates by issuing more short-term bonds and fewer long-term bonds. It was successful at raising short-term rates, but long-term rates increased concomitantly.

investigated the default experience of fixed-income corporate bonds between 1900 and 1943, as a function of the bond rating.

	Ratings					
Size of Issue	*I*	*II*	*III*	*IV*	*V–IX*	*No Rating*
> $5 million	5.9%	6.0%	13.4%	19.1%	42.4%	28.6%
≤ $5 million	10.2%	15.5%	9.9%	25.2%	32.6%	27.0%

Hickman's study has been extended by several researchers, and data availability has made this easier to do. Altman computes default rates for high-yield bonds from 1970 to the present on an annual basis and relates them to bond ratings.

- Default spreads on bonds tend to increase during economic downturns and decrease during economic booms.
- Default spreads are generally larger for longer-term bonds than they are for shorter-term bonds, for any given level of default risk. There may be specific circumstances, though, where the reverse is true. Johnson defines a "crisis-at-maturity" scenario, usually in the midst of a recession or a depression, where a firm is perceived to have insufficient funds to meet its immediate debt servicing needs, though it is expected to revert to health in the long term. In this scenario, the default premiums will be lower for longer-maturity bonds than for shorter-maturity bonds. Johnson found evidence of inverted default premium term structures during 1934, in the midst of the Depression.

SPECIAL FEATURES IN BONDS AND PRICING EFFECTS

The preceding section examined the question of how to price a government or a corporate bond based on the expected coupons and the appropriate interest rate for the bond. Most bonds, though, have other features added on, some of which make the bonds more valuable and some less valuable. This section considers how best to value these special features.

Convertibility

A convertible bond is a bond that can be converted into a predetermined number of shares, at the option of the bondholder. While it generally does not pay to convert at the time of the bond issue, conversion becomes a more attractive option as stock prices increase. Firms generally add conversion options to bonds to lower the interest rate paid on the bonds.

Conversion Option In a typical convertible bond, the bondholder is given the option to convert the bond into a specified number of shares of stock. The conversion ratio measures the number of shares of stock for which each bond may be ex-

CORPORATE BONDS IN EMERGING MARKETS

In the framework developed here, you build up to the rate on a corporate bond by adding a default spread to the government bond rate. This process works only when the government is viewed as having no default risk. When governments have default risk, as is often the case in emerging markets, the process becomes more complicated. To estimate the appropriate interest rate on a corporate bond in an emerging market, you have to begin by estimating a riskless rate. The best way to do it is to build it up from the Fisher equation—add an expected inflation rate to the real rate of return in that market. The latter can be set equal to the expected real growth rate in the economy, but the former can be a volatile number in high inflation markets. An alternative approach is to begin with the government bond rate and subtract the estimated default spread for the government; this default spread can be obtained using the rating for the government.

You could also estimate the corporate bond rate for a company in an emerging market in a different currency—U.S. dollars or euros. In this case, the riskless rate will be defined in that currency—the Treasury bond rate in the U.S. for dollars and the German government bond rate in euros. The default spread for the company can then be added on to this riskless rate to estimate the corporate bond rate.

There is one final point that needs to be confronted with corporate bonds in emerging markets, and it relates to whether you should incorporate the country default risk spread into the corporate bond rate. For instance, should the interest rate on a bond issued by Embraer, the Brazilian aerospace firm, incorporate the default spread on Brazilian government bonds? For smaller firms, the answer should generally be yes. For larger firms with substantial operations outside the country, we have a little more leeway. These firms may be able to borrow at rates lower than the sovereign rate.

changed. The market conversion value is the current value of the shares for which the bonds can be exchanged. The conversion premium is the excess of the bond value over the conversion value of the bond.

Thus a convertible bond with a par value of $1,000, which is convertible into 50 shares of stock, has a conversion ratio of 50. The conversion ratio can also be used to compute a conversion price—the par value divided by the conversion ratio, yielding a conversion price of $20. If the current stock price is $25, the market conversion value is $1,250 (50 × $25). If the convertible bond is trading at $1,300, the conversion premium is $50.

The effect of including a conversion option in a bond is illustrated in Figure 33.9.

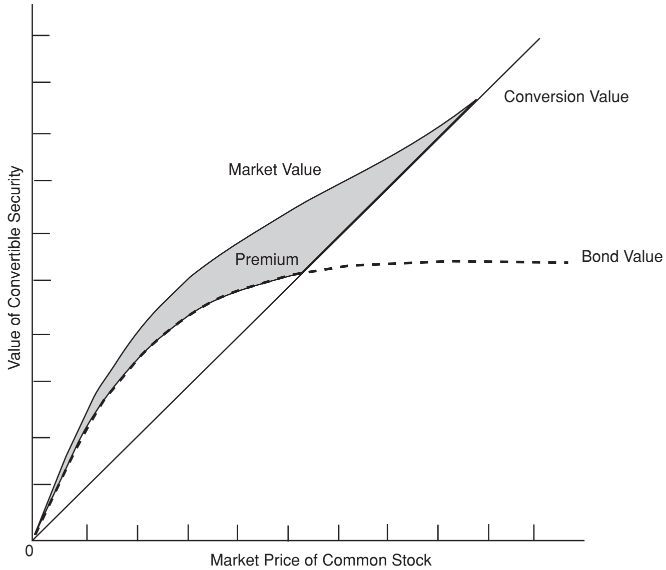


FIGURE 33.9 Bond Value and Conversion Option

Determinants of Value The conversion option is a call option on the underlying stock, and its value is therefore determined by the variables that affect call option values—the underlying stock price, the conversion ratio (which determines the strike price), the life of the convertible bond, the variance in the stock price, and the level of interest rates. The payoff diagrams on a call option and on the conversion option in a convertible bond are illustrated in Figure 33.10. Like a call option, the value of the conversion option will increase with the price of the underlying stock, the variance of the stock, and the life of the conversion option, and decrease with the exercise price (determined by the conversion option).

The effects of increased risk in the firm can cut both ways in a convertible bond—it will decrease the value of the straight bond portion while increasing the value of the conversion option. These offsetting effects will generally mean that

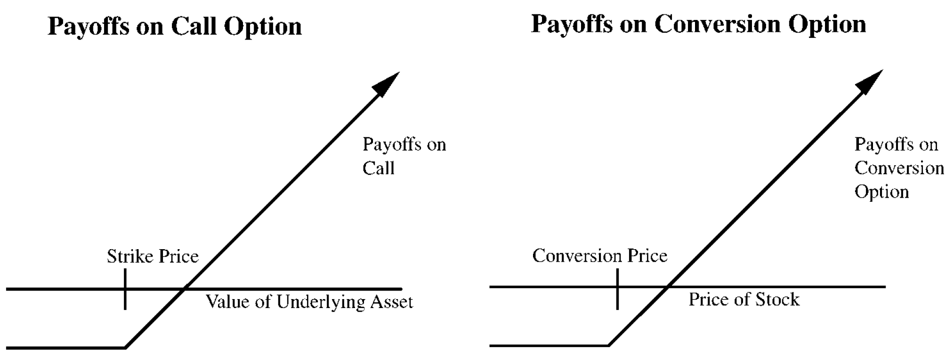


FIGURE 33.10 Call Option and Conversion Option: Comparing Payoffs

convertible bonds will be less exposed to changes in the firm's risk than are other types of securities.

Option pricing models can be used to value the conversion option with three caveats: Conversion options are long-term, making the assumptions about constant variance and constant dividend yields much shakier; conversion options result in stock dilution; and conversion options are often exercised before expiration, making it dangerous to use European option pricing models. These problems can be partially alleviated by using a binomial option pricing model, allowing for shifts in variance and early exercise and factoring in the dilution effect. These changes are described in more detail in Chapter 5. The following illustration provides an example of the use of option pricing models in valuing a conversion option in a convertible bond.

The value of a convertible bond is also affected by a feature shared by most convertible bonds that allow for the adjustment of the conversion ratio (and price) if the firm issues new stock below the conversion price or has a stock split or dividend. In some cases, the conversion price has to be lowered to the price at which new stock is issued. This is designed to protect the convertible bondholder from misappropriation by the firm.

Effect of Forced Conversion Companies that issue convertible bonds sometimes have the right to force conversion if the stock price rises to a specified level. This right to force conversion caps the profit that can be made on the conversion option, and hence affects its value. Figure 33.11 illustrates the effect of forced conversion on the expected payoffs.

The value of a capped call with an exercise price of K_1 and a cap of K_2 can be calculated as follows:

$$\text{Value of capped call } (K_1, K_2) = \text{Value of call}(K_1) - \text{Value of call}(K_2)$$

This is because the cash flows on a capped call can be replicated by buying the call with a strike price of K_1 and selling the call with a strike price of K_2.

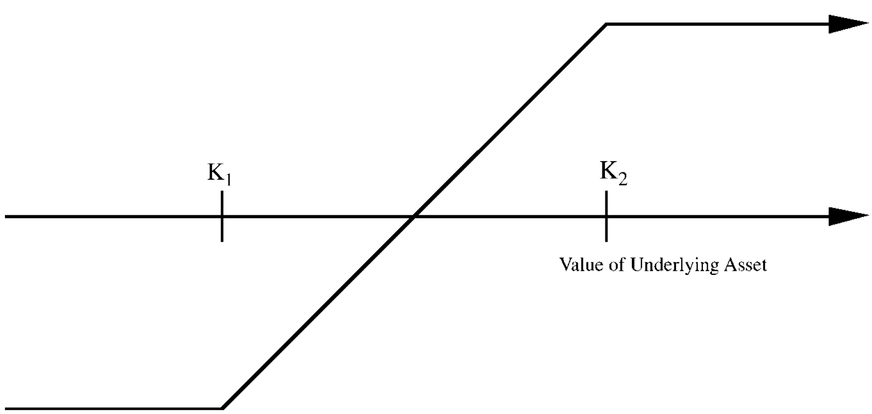


FIGURE 33.11 Value of a Capped Call

ILLUSTRATION 33.6: Valuing a Conversion Option/Convertible Bond

In December 1994, General Signal had convertible bonds outstanding with the following features:

- The bonds will mature in June 2002. There were 100,000 convertible bonds outstanding.
- They had a face value of $1,000 and were convertible into 25.32 shares per bond until June 2002.
- The coupon rate on the bonds was set at 5.75%.
- The company was rated A–. Straight bonds of similar rating and similar maturity were yielding 9.00%.
- The stock price in December 1994 was $32.50. The volatility (standard deviation in log stock prices) based on historical data was 50.00%.
- There were 47.35 million shares oustanding. Exercising the convertible bonds will create 2.532 million additional shares (100,000 × 25.32 shares).

The two components of the convertible bond can be valued as follows.

STRAIGHT BOND COMPONENT

If this bond had been a straight bond, with a coupon rate of 5.75% and a yield to maturity of 9.00% (based on the bond rating), the value of this straight bond would have been:

$$\text{PV of bond} = \sum_{t=.5}^{t=7.5} \frac{28.75}{(1.09)^t} + \frac{1{,}000}{(1.09)^{7.5}} = \$834.79$$

This is based on semiannual coupon payments (of $28.75 for semiannual periods).

VALUING THE CONVERSION OPTION

The value of the conversion option is estimated using the Black-Scholes model, with the following parameters for the conversion option:

Type of option = Call
Stock price = $32.50
Time to expiration = 7.5 years
Riskless rate = 7.75% (rate on 7.5-year Treasury bond)
Dividend yield on stock = 3.00%

Number of calls per bond = 25.32
Strike price = $1,000/25.32 = $39.49
Standard deviation in ln(stock prices) = 0.50

Allowing for the dilution inherent in the exercise and using the warrant valuation model from Chapter 5 we get:

Value of one call = $13.57

Value of the conversion option = $13.57 × 25.32 = $343.51

VALUE OF CONVERTIBLE BOND

The value of the convertible bond is the sum of the straight bond and conversion option components:

Value of convertible bond = Value of straight bond + Value of conversion option
= $834.79 + $343.51 = $1,178.30

This valuation is based on the assumption that the conversion option is unconstrained and that the bonds are not callable. The effects of introducing these changes into the analysis will be examined in the following sections.

Callability

The issuer of a callable bond reserves the right to call back the bond and pay a fixed price (generally at a premium over the par value) for it. Thus, if interest rates decline (bond prices rise) after the initial issue, the firm can refund the bonds at the fixed price instead of the market value. Adding the call option to a bond should make it less attractive to buyers, since it reduces the potential upside on the bond. As interest rates go down, and the bond price increases, the bonds are more likely to be called back.

The distinction between a straight bond and a callable bond are illustrated in the Figure 33.12. The difference on the upside between straight and callable bonds is quite clearly illustrated in the figure. As interest rates decline, the values of the two bonds diverge, whereas they converge as interest rates increase.

There are several common features shared by most callable bonds. Most callable bonds come with an initial period of call protection, during which the bonds cannot be called back. Such bonds are called deferred callable bonds. The call price on most callable bonds is set at an initial level above par value plus one annual coupon payment, but declines as time passes and approaches the par value.

Valuing the Callability Option The issuer's right to call back a bond if interest rates drop (or bond prices rise) to an attractive level is a call option on the bond and can be valued as such. The payoffs on a callable bond are shown in Figure 33.13.

The value of the callable feature on a callable bond will increase as interest rates decline, and as the volatility of interest rates increases. Since the callable feature is held by the issuer of the bond, the value of a callable bond can be written as:

Value of callable bond = Value of straight bond – Value of call feature in bond

A callable bond should therefore sell for less than an otherwise similar straight bond.

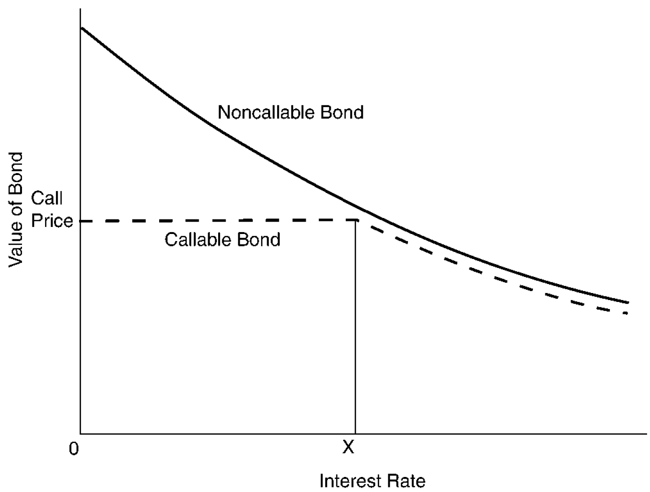


FIGURE 33.12 Callable versus Straight Bonds

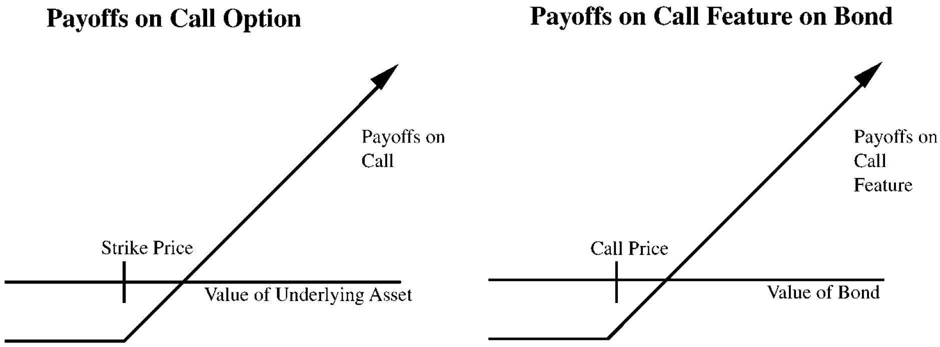


FIGURE 33.13 Payoffs on Call Feature on Bond to Seller of Bond

Traditional Analysis The traditional approach to analyzing callable bonds is to estimate yields to call as well as yields to maturity. The former is based on the assumption that the bond will be called at the first call date, while the latter assumes holding the bond until maturity. The two yields are compared, and the investor chooses the lower of the two as a measure of the expected return on the bond. This approach can also be extended to calculate the yield to all possible call dates, and picking the lowest of these yields as the expected yield on the callable bond. This yield is called the yield to worst.

While this approach may give the investor some sense of the potential downside from the callability of the bond, it suffers from all the standard problems of the yield to maturity calculation. First, it assumes that the investor can reinvest all coupons until the bond is called at the yield to call, which is not a realistic assumption since calls are much more likely if interest rates go down. Second, it assumes that the bond will be called on the call date, which takes away the option characteristics of the call feature.

ILLUSTRATION 33.7 Estimating Yields to Maturity and Call on a Callable Bond

Consider a corporate bond with 20 years to maturity and a 12% coupon rate that is callable in two years at 105% of the face value. The bond is trading at 98 currently. The yields to maturity and the yields to call on the corporate bond are as follows:

$$\text{Yield to maturity}: \sum_{t=0.5}^{t=20} \frac{60.00}{(1+r)^t} + \frac{1{,}000}{(1+r)^{20}} = \$980: \text{ Solve for r}$$

The yield to maturity is approximately 12.65%.

The yield to call can be similarly calculated:

$$\text{Yield to call}: \sum_{t=0.5}^{t=2} \frac{60.00}{(1+r)^t} + \frac{1{,}050}{(1+r)^{2}} = \$980: \text{ Solve for r}$$

The yield to call is approximately 13.61%. You would use the lower of these two values (12.65%) as your expected yield on this bond.

Price/Yield Relationship for a Callable Bond The price/yield relationship on a callable bond is different because the potential that the bond will be called back puts an upper limit on the price, making the relationship between price and yield convex for some range of the yields. The difference is illustrated in Figure 33.14.

The section of the price/yield relationship on the callable bond when the yield falls below y* has negative convexity—that is, the price appreciation on this bond will be less than the price depreciation for a given change (down or up) in interest rates.

Determinants of Value—Option Pricing Approach The call feature in a callable bond can be valued using option pricing models. It is a series of call options on the underlying bond, and its value is determined by the level and volatility of interest rates. There are some modifications that need to be made to the standard option pricing models before they can be applied in this context.

Once the call feature is valued as a series of option, the yield on a callable bond can be adjusted for the option features, and the difference between this adjusted yield and a noncallable bond of equivalent maturity is called the option adjusted spread. This approach is a more realistic way of considering the effects of the call feature on expected yields than the traditional yield to call approach.

The following illustration values the call feature on a callable bond.

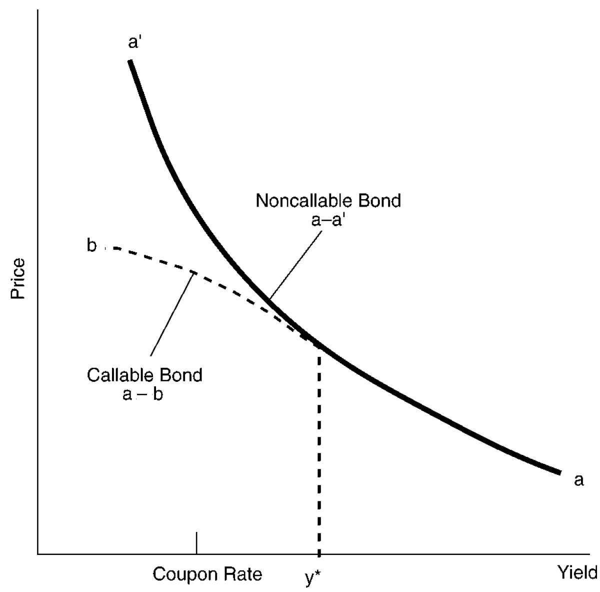


FIGURE 33.14 Callable Bond Prices and Interest Rates

ILLUSTRATION 33.8: Valuing a Callable Bond

The following analysis values a 17-year callable bond with a coupon rate of 12% by valuing the straight bond, the call feature on the straight bond, and the value of the callable bond as a function of the yield on the bond. The actual option valuation was done using a binomial option pricing model, an interest rate volatility of 12%, and a short-term interest rate of 6%.

Yield	*Value of Straight Bond*	*Value of Call Feature*	*Value of Callable Bond*
20.51%	$ 60.00	$ 0.00	$ 60.00
19.55%	$ 63.00	$ 0.00	$ 63.00
18.66%	$ 66.00	$ 0.00	$ 66.00
17.59%	$ 70.00	$ 0.00	$ 70.00
16.63%	$ 74.00	$ 0.00	$ 74.00
15.54%	$ 79.00	$ 0.02	$ 78.98
14.56%	$ 84.00	$ 0.06	$ 83.94
13.51%	$ 90.00	$ 0.22	$ 89.78
12.57%	$ 96.00	$ 0.67	$ 95.33
11.46%	$104.00	$ 2.11	$101.89
10.59%	$111.00	$ 4.60	$106.40
9.59%	$120.00	$ 9.80	$110.20
8.60%	$130.00	$17.81	$112.19
7.73%	$140.00	$27.21	$112.79

While the value of the straight bond increases as the yield drops, the callable bond's value stops increasing because the call feature becomes more and more valuable as the yield becomes lower. In fact, the value of the callable bond is maximized at $112.94.

Valuing a Callable-Convertible Bond Many convertible bonds have embedded call features. The presence of two options in the bond, one possessed by the buyer of the bond and the other possessed by the seller of the bond, and the interaction between the two options imply that the two options have to be valued together. Brennan and Schwartz (1977, 1980) provide an analysis of convertible bonds with call features, default risk, and stock price dilution. The simplest approach for illustrating the interaction between the various options is a binomial option pricing model.

Empirical Evidence on Call Feature When a convertible bond is callable, holders of the convertible bond lose the opportunity to make further returns on the bond as stock prices increase. Companies can establish a variety of call policies such as calling the instant the market value of the convertible rises above the call price or waiting until the market value is well in excess of the call price. Ingersoll (1977) argues that a bond should be called when its conversion value equals its call price. Given that a 30-day notice has to be given to bondholders of a call, firms may prefer to build a cushion to protect against risk during this period.

The empirical evidence however suggests that firms do not usually follow the optimal policy. Ingersoll, for instance, found that between 1968 and 1975 the average conversion value was 43.9 percent above the call price for bonds and 38.5 percent for preferred stocks. The call policy chosen by a firm and communicated to financial markets implicitly through its actions has an effect on the value of the convertible bond.

Mortgage-Backed Securities

Mortgage-backed securities, which came of age in the 1980s, securitized residential mortgages by packaging them and issuing marketable securities of various types on them—either as flow-through investments, where holders receive a share of the total cash flows on the pool of mortgages, or as derivative products, where holders receive customized packages of cash flows depending on their preferences. The latter, called collateralized mortgage obligations (CMOs), in their simplest form divide cash flows on the mortgage pool into four tranches, with cash flows on each tranche starting as the cash flows on the prior tranche are completed. Figure 33.15 illustrates this type of security.

In recent years, CMOs have been refined further, and even more specialized products have been created including stripped mortgage-backed securities (where cash flows are divided on the basis of principal and interest), floating rate classes, and inverse floaters (where the interest rate on the security increases as the index rate decreases).

Mortgages can be prepaid by borrowers if interest rates decline. This prepayment option that resides with borrowers affects the cash flows, and therefore the value, of all mortgage-backed securities.

Prepayment Option The homeowner may prepay a loan for any number of reasons, but the level of interest rates is a critical variable. If interest rates decline sufficiently, the potential gain from prepayment may exceed the cost of prepayment.

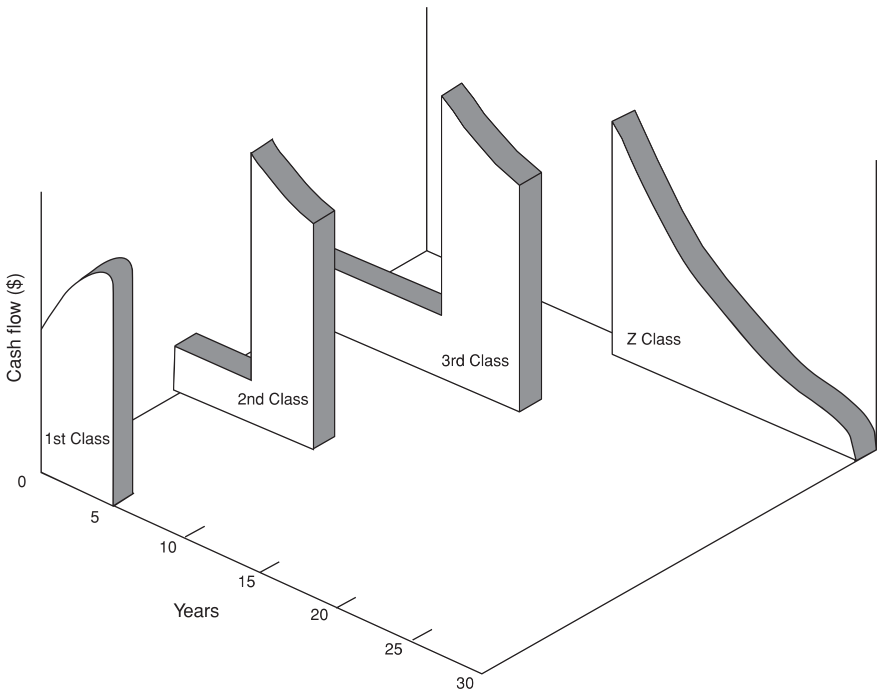


FIGURE 33.15 Cash Flows on a Mortgage Pool

Figure 33.16 illustrates the percentage of homeowners who prepay as a function of the difference between interest rate and the coupon rate, based on historical data.

If the level of interest rates were the only determinant of prepayment and homeowners were rational about prepayment decisions, the prepayment option could be valued very similarly to the call option in a callable bond (as a function of the level and volatility of interest rates).

There are, however, other variables besides the level of interest rates that determine whether homeowners prepay. For instance, there is a correlation between prepayment and the age of a mortgage, irrespective of interest rates. Furthermore, some homeowners may never prepay their mortgages no matter how much interest rates drop. There are also seasonal factors that affect prepayment. Consequently, option pricing models alone fall short in pricing prepayment options in mortgage-backed securities.

A number of researchers have attempted to develop models that explain prepayment as a basis for pricing the prepayment option, with characteristics such as age and coupon rate as inputs, in addition to specific characteristics of the borrowers in the pool. In cases where a specific rather than a generic pool of mortgages is being priced, the historical payment record of the specific pool is useful and is often the basis for estimating prepayments.[5]

Valuing the Prepayment Option The effect of the prepayment option on value will vary with the type of mortgage-backed security. Consider, for instance, the price behavior of interest-only and principal-only securities as interest rates change. As interest rates

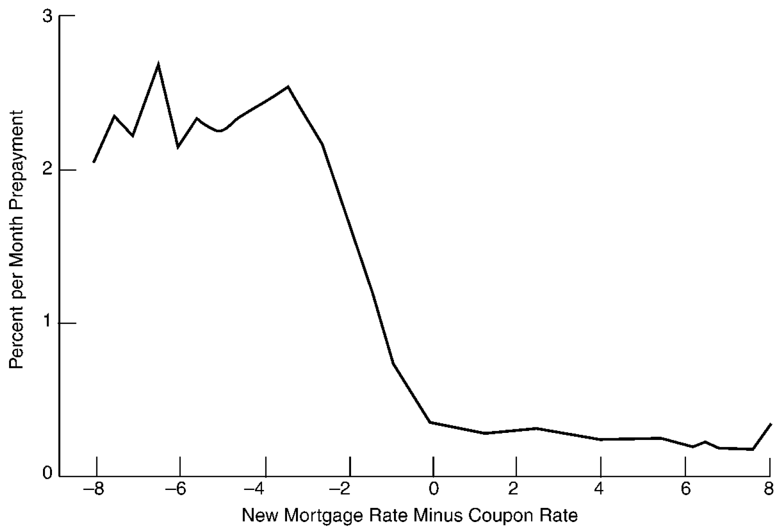


FIGURE 33.16 Prepayment History
Source: Sean Becketti, "The Prepayment Risk of Mortgage-Backed Securities," *Economic Review of the Federal Reserve Bank of Kansas City* (February 1989), 53.

[5]A number of variables have been found to be useful in explaining prepayments—the market price of a house relative to the original purchase price and geographical differences, for instance.

increase, the interest payments on the interest-only securities go up, leading to a higher value for the security, at least initially, though the present value effects (which are negative) start to dominate beyond a certain point. As interest rates decrease, the prepayments lead to lower interest payments and a lower value for the security. The principal-only securities behave more like conventional bonds, increasing in value as interest rates decline and decreasing in value as they increase. Figure 33.17 illustrates this relationship.

Interest Rate Caps and Floors

A floating rate bond is a bond that has an interest rate linked up to an index—either a government bond rate (Treasury bond or bill) or the LIBOR. The rationale for issuing such bonds is to reduce the interest rate risk for both the issuer and the buyer of the bond. Most floating rate bond issuers, however, cap their floating rate obligations to ensure that interest rates do not rise above a prespecified rate (the cap). Some floating rate bonds offer buyers some compensation by providing a floor, below which interest rates will not decline. If a floating rate bond has a cap and a floor, a collar is created.

Caps, Floors, and Collars The presence of a cap on a floating rate bond can be illustrated best by contrasting a bond with a cap with a floating rate bond without one, as shown in Figure 33.18. The cap on a floating rate bond has the same effect as a call option on interest rates with a strike price of K_c, with the issuer of the bond holding the option. A call option on interest rates translates into a put option on the underlying bond.[6] The price of a floating rate bond with a cap can then be written as:

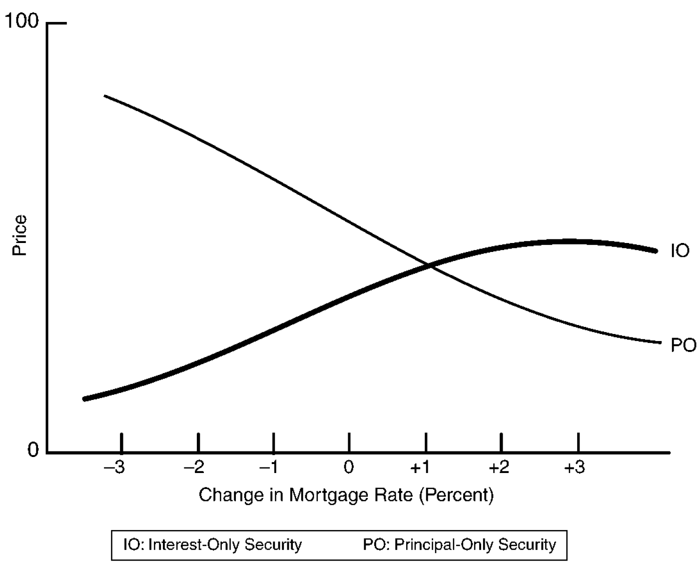


FIGURE 33.17 Mortgage Rates and Security Values

[6]The translation is not one to one. A call option on interest rates is the equivalent of a options on the underlying bill or bond, where α = 1/Exercise price of equivalent bill.

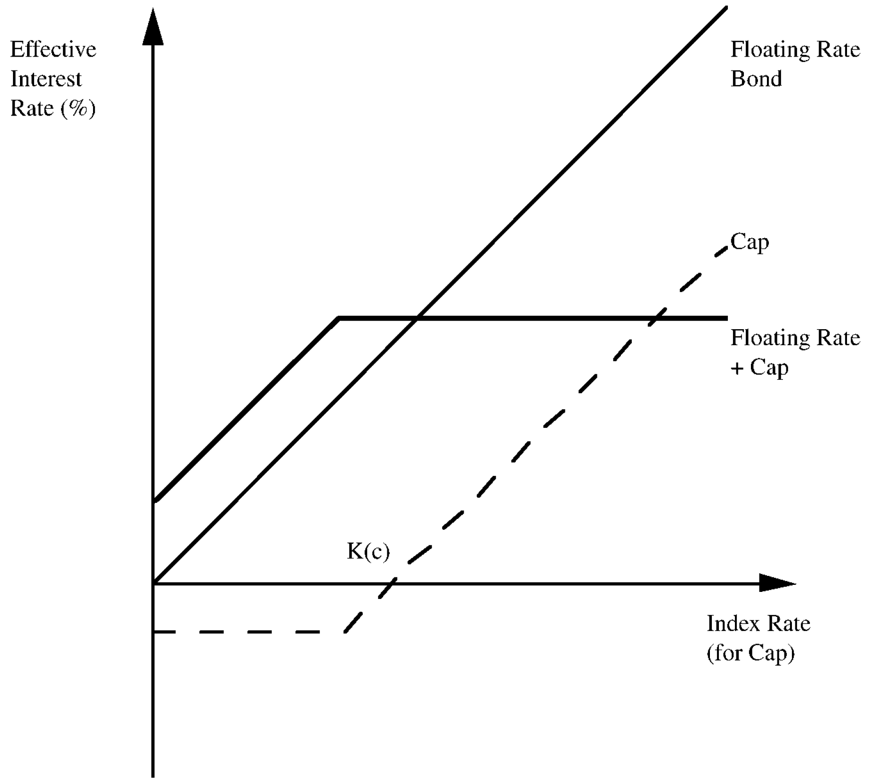


FIGURE 33.18 Effects of Caps on Floating Rate Loans

Price of floating rate bond with cap = Price of floating rate bond without cap
– Value of put on bond

The presence of a floor on interest rates can also be illustrated using a similar comparison of a bond with a floor with a bond without one in Figure 33.19. The floor on a floating rate bond has the same effect as adding a put option on interest rates with a strike price of K_f, with the buyer of the bond holding the put. A put option on interest rates can be translated into a call option on the underlying bond. The price of a floating rate bond with a floor can then be written as:

Price of floating rate bond with floor = Price of floating rate bond without floor
+ Value of call on bond

Finally, the presence of both a cap and a floor can be illustrated in Figure 33.20. The presence of a collar on a floating rate bond creates two options—a call option with a strike price of K_c for the issuer of the bond and a put option with a strike price of K_f for the buyer of the bond. These options on interest rates can be stated again in terms of options on the underlying bond.

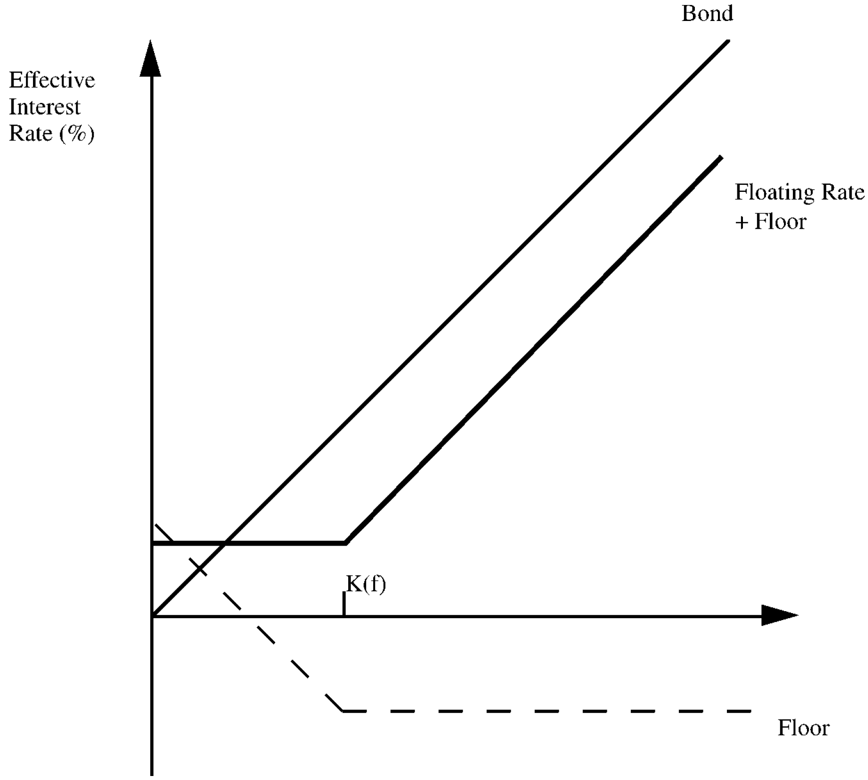


FIGURE 33.19 Effects of Floors on Floating Rate Loans

Price of floating rate bond with collar = Price of floating rate bond without collar
+ Value of call on bond
– Value of put on bond

Valuing Caps and Floors Option pricing models can be used to value caps, floors, and collars with some caveats. The key assumption in the Black-Scholes model of constant volatility over the life of the option is likely to be violated for floating rate options, both because of the long-term nature of these options and because the variance in the bond price is likely to change as the bond maturity declines. There have been attempts to use yield instead of price, and assume that it conforms to a lognormal distribution.

Stapleton and Subrahmanyam (1990) noted that the value of a cap on interest rates can be written as a series of put options on the price of an equivalent bill or bond. Briys, Crouhy, and Schobel (1991) provided a framework for pricing caps, floors, and collars. They argued that caps and floors can be modeled as a series of independent options on zero coupon bonds. They allowed for the fact that bond prices do not follow the geometric Brownian motion used by Black and Scholes (1972), but adopted a different stochastic process to price caps, floors, and collars.

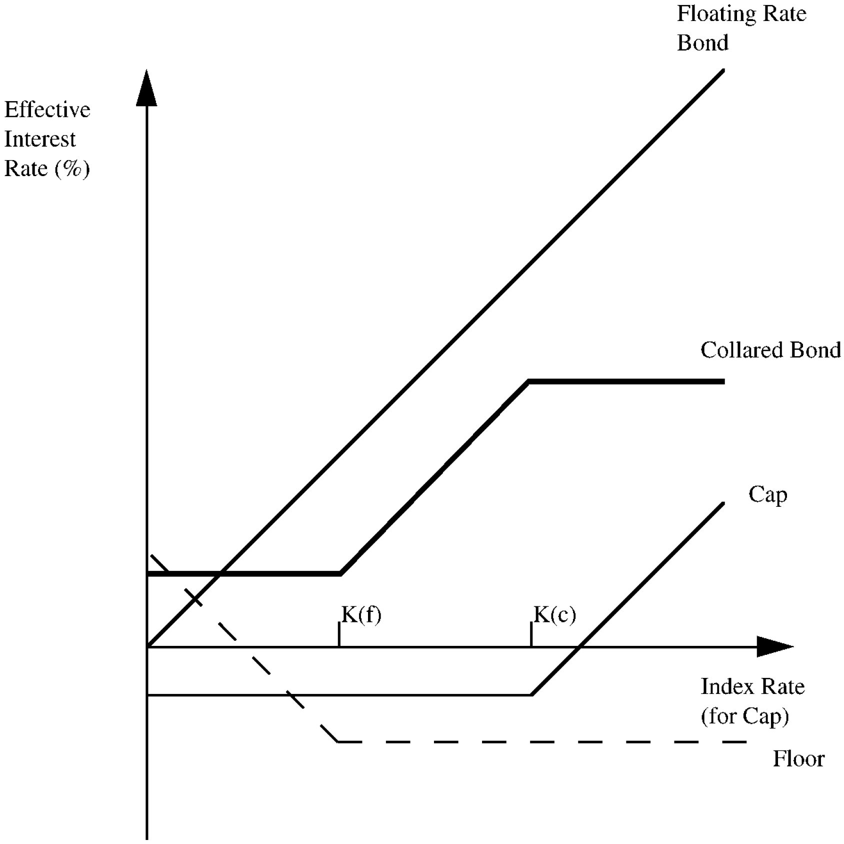


FIGURE 33.20 Effects of Collars on Floating Rate Loans

Other Features

There are a number of other bond features that affect the value of the bond: a sinking fund provision where the firm plans to retire a specified face value of the bonds outstanding each year, provisions relating to the subordination of future debt issues, and bond covenants on investment and dividend policy.

Sinking Funds Most industrial bond issues come with sinking fund provisions, requiring the issuer to retire a specified portion of the bond issue each year, starting a period of time (5 or 10 years) after the initial issue. The sinking fund provision can take one of two forms:

VALUING OPTIONS EMBEDDED IN BONDS

A corporate bond can often have three or four options embedded in it, and to value the bonds you have to value the options. While conventional option pricing models can be used to value fixed income options, you should note the following:

- The assumption of constant volatility that we often use to value options on stocks cannot be used to value options on bonds. Bonds are finite-life instruments and their volatility will decrease as they approach maturity. You will have to model the change in volatility over time to price the option.
- When multiple options exist in a bond, you will have to examine the relationship between the options to price them. For instance, consider a callable-convertible bond. While both callability and convertibility are options—one is held by the bond issuer and the other by the bond buyer—the exercise of one of these options voids the other. This will become a factor in when the options will be exercised and how much they are worth.
- The key underlying variable for some bond options—such as interest rate caps and floors—is the interest rate process, and how it is modeled can have a significant impact on the value of the options.

1. A trustee collects a cash payment from the bond issuer, and calls bonds for redemption at the sinking-fund call price, usually based on a lottery.
2. The bond issuer can buy back bonds in the open market and deliver the specified number of bonds to the trustee in the periods specified.

If the bond issuer has the option to do the latter, bonds will be bought back and delivered if the market price is less than the call price, and cash will be delivered to the trustee to make the call if the market price is greater than the call price.

Sinking funds usually relate to a single issue, but they can sometimes cover multiple issues ("funnel sinking fund"). Most sinking funds also allow the bond issuer to accelerate call backs if it is in the issuer's favor to do so (i.e., interest rates have gone down since the issue).

A sinking fund has two effects, one of which benefits the issuer of the bond and the other of which benefits the buyer of the bond. The issuer of the bond gets a delivery option, because he or she has an option to either deliver the cash for the call price or to buy the bonds at the market price. The value of this call option (similar to the option in a callable bond) will increase with the volatility of interest rates and decrease with the level of interest rates. The buyer of the bond has less default risk because of the requirement that some of the debt be retired each period. The net effect will determine whether a sinking fund provision adds or detracts from the value of a bond.

The empirical evidence on the sinking fund provision is mixed. While some of the earlier studies concluded that a sinking fund provision added to bond value, Ho and Lee (1989) found that its net value is insignificant overall, but that it adds more value as default risk increases.

Subordination of Further Debt and Collateral Existing debt holders are negatively affected by the issue of new debt, especially if the new debt has superior claims on the assets of the issuer. Therefore, some bond issues have subordination clauses, which put restrictions on the issue of additional debt. Additional debt might have to be subordinated to existing debt; that is, in the event of bankruptcy, subordinated debt will be paid off after existing debt is fully paid. The presence of subordination clauses in a bond agreement should make it less risky, and therefore more valuable.

Some bonds are issued with specific collateral issued behind them, with a specific asset of the firm backing up the promised payments on the bond. If the collateral is property, the bond is called a mortgage bond, whereas if it is securities, it is a collateral trust bond. Other bonds are issued without specific collateral and are called unsecured bonds. Other things remaining equal, secured bonds should be viewed as less risky and more valuable than equivalent unsecured bonds.

Effect of Bond Covenants Most bond issues are accompanied by a set of covenants that restrict the investment and dividend policies of the firm. These covenants are designed to protect bondholders from stockholders, who might try to expropriate wealth from them by investing in much riskier projects, especially if the firm is highly levered, or paying significantly higher dividends than expected.

Bond covenants should reduce the risk of expropriation on a bond and increase the value of the bond.

CONCLUSION

The price of a bond is the present value of the cash flows on the bond—coupons and face value—discounted back at an appropriate interest rate. To estimate that interest rate, the chapter began with the instantaneous riskless interest rate and added a maturity premium and a default premium to it.

Bonds become increasingly complex as special features are added to them, since these special features affect the cash flows, risk, and value of these bonds. Many of these special features have option characteristics—the chance to convert the bond into other securities or assets, the option to call the bond back if interest rates go down, and the option to put the bond back to the issuer if contractual obligations are not met. Traditional option pricing models can be used to value these options, some of which reside with the buyer (thus increasing the value of the bond) and some of which are held by the seller (which would reduce value). The presence of more than one of these options in the same bond (for example, a callable-convertible bond) does add to the complexity of the pricing process, but it can be overcome.

QUESTIONS AND SHORT PROBLEMS

1. Estimate the value of a just-issued 20-year government bond with an 8% coupon rate if interest rates are at 9%. How much will this value change if interest rates go up by 2%? If they go down by 2%? (Coupons are paid semiannually.)
2. Estimate the value of seasoned government bond with a 7.5% coupon rate and 12 years to maturity, if interest rates are at 8.0%. (Coupons are paid semiannually, and the next coupon is due in three months.)
3. Estimate the duration of a government bond with a coupon rate of 10% and a five-year maturity, if the yield to maturity on the bond is 8%. (You can assume, for purposes of simplicity, that the coupons are paid annually.)
4. Why are longer-term bonds more sensitive to a given change in interest rates than shorter-term bonds? Why are zero coupon bonds more sensitive than coupon bonds of equal maturity?
5. If the nominal interest rate is 8%, and expected inflation is 5%, estimate the expected real rate of return. Why might the actual real rate of return deviate from this expectation?
6. You are provided with the following information on government bonds of different maturities:

Maturity	*Yield to Maturity*
1 year	5.0%
2 years	5.5%
3 years	6.0%
4 years	6.5%
5 years	7.0%

   You can assume that the bonds are trading at par, and that therefore the coupon rates are equal to the yields to maturity.
   a. Plot the yield curve using the yields to maturity.
   b. Estimate the spot rates for the different maturities.
   c. Estimate the forward rates for each of the five years.
7. If lenders demand a liquidity premium for lending long term, yield curves will always be upward-sloping. Is this statement true? Why or why not?
8. Some studies that looked at low-rated bonds in the 1980s found that the default premiums received on these bonds were much larger than the default rates on them. (In other words, investors in these bonds made more over the period, even after adjusting for actual defaults, than investors in higher-rated or default-free bonds.) They then concluded that the default premiums were too high. Would you agree? Why or why not?
9. You are analyzing a convertible bond with a face value of $1,000 and an annual coupon of 4%, which is convertible into 30 shares of stock anytime over

the next 20 years. The current stock price is $27, and the convertible is trading at $1,177. Estimate the following:

a. The conversion ratio and conversion price.
b. The conversion premium.
c. The value of the conversion option if the interest rate on straight bonds issued by the same company is 8%.

10. ITC Corporation has convertible bonds outstanding with the following features:
    - The bonds mature in 15 years; there are 100,000 bonds outstanding.
    - Each bond can be converted into 50 shares of stock at any time until expiration.
    - The coupon rate on the bond is 5%; straight bonds issued by the company are yielding 10%.
    - The current stock price is $15 per share, and the standard deviation in ln (stock prices) is 40%.
    - There are 20 million shares outstanding.

    a. Value the conversion option.
    b. Estimate the value of the straight bond portion.
    c. If these bonds were issued at par, who would be gaining? Who would be losing?
    d. What impact would forced conversion have on the value of this convertible bond?
11. A company has two issues of bonds outstanding; they both have the same maturities and coupon rates, but differ in one respect: The first issue (issue A) is callable, while the second is not. Respond true or false to the following statements:
    a. The callable bonds will trade for a higher price than the noncallable bonds.
    True ____ False ____
    b. The callable bonds have a shorter duration than the noncallable bonds.
    True ____ False ____
    c. The callable bonds will have a higher yield than the noncallable bonds.
    True ____ False ____
    d. The callable bonds will be more sensitive to interest rate changes than the noncallable bonds.
    True ____ False ____
12. You are evaluating the yield on a callable bond with a 10-year maturity and a 9% coupon rate. The bonds can be called back at 110% of par in three years. The bond is trading at $950.
    a. Estimate the yield to maturity.
    b. Estimate the yield to call.
    c. Which of the two would you use in analyzing the bond?
13. Collateralized mortgage obligations (CMOs) provide investors with the opportunity to invest in cash flows from mortgage obligations. These cash flows are affected by mortgage prepayments. Assume that you have valued (and bought) CMOs on the assumption that homeowners will prepay as soon as it is rational for them to do so. What would be the effect on your returns if:
    a. Homeowners consistently waited too long before prepaying mortgages?
    b. Homeowners consistently prepaid mortgages at the right time?
14. Answer true or false to the following statements, and explain:
    a. A floating rate loan with no cap or floor has very low or no duration.
    True ____ False ____

b. A floating rate loan with a cap will have a higher interest rate than a similar floating rate loan with no cap.
True ____ False ____

c. A floating rate loan with a floor will have a higher interest rate than a similar floating rate loan with no floor.
True ____ False ____

d. A loan with a sinking fund provision will have a lower interest rate than a similar loan with no sinking fund provision.
True ____ False ____