

stripped mortgage-backed security. A stripped mortgage-backed security is a trust formed from a pool of mortgage-backed securities, where the cash flows from the pool are divided into another set of securities called strips. These strips are distinguished by the percentages of the principal and interest components of the cash flows to which they are entitled. For example, a principal-only strip is a claim to 100 percent of the principal component and 0 percent of the interest component, whereas an interest-only strip is the reverse.

J.B.K., D.C., W.M. III

stripping. See ASSET STRIPPING; STRIPPED BONDS; ZERO-COUPON BONDS.

strong form of market efficiency. See WEAK, SEMI-STRONG AND STRONG FORMS OF MARKET EFFICIENCY.

subordinated debt. Different classes of debt typically have different priority in the event of the bankruptcy and subsequent liquidation or reorganization of the issuing corporation. Holders of subordinated debt have a claim which is junior to the claim of debt specified as senior in the subordination agreement. Subordination changes the value and characteristics of debt.

To see this, suppose a firm is initially financed with only pure (discount) debt and equity. At maturity, date t^* , the promised debt repayment, X , will be made if the value of the firm at t^* , V^* , is greater than the promised repayment. Otherwise the firm will default on its debt, turning the firm over to the debt holders. If the debt is repaid, then the value of the equity is the residual. Otherwise the firm defaults and equity is worthless. Thus, at maturity

$$D^* = \min[V^*, X]$$

$$E^* = \max[0, V^* - X],$$

where D^* is the value of debt and E^* is the value of equity at maturity.

Merton (1974) has shown that the value of the debt prior to maturity is the following solution to a partial differential equation,

$$D = VN(-d_1) + XN(d_2) \exp[-Rt\tau],$$

where $d_1 = \ln(V/X) + (r + \sigma^2/2)\tau$, $d_2 = d_1 - \sigma\tau$ and $N(Z)$ is the univariate cumulative normal distribution function. A classic result, obtained here, is that the value of debt declines with firm volatility, while equity value increases.

Now suppose that the capital structure of the firm is composed of equity and two types of debt differentiated by their priorities as claimants on the firm, but with the same maturity. If, at maturity, the value of the firm is greater than the promised repayment on the senior debt, X_1 , then the senior debt is paid in full. Otherwise the senior debt holders receive the value of the firm and the junior debt holder and equity holders get nothing. If the value of the firm at maturity is greater than the repayments to both the junior and senior debt, X_1 and X_2 , then all the debt is paid off and the equity holders get the residual. If the value of the firm at

maturity, V^* , is between X_1 and X_2 , then the junior debt receives the difference. Therefore, at maturity the boundary conditions for the three claimants are:

$$D_1^* = \min[V^*, X_1]$$

$$D_2^* = \max[\min(V^* - X_1, X_2), 0]$$

$$E^* = \max[V^* - (X_1 + X_2), 0],$$

where D_1^* and D_2^* are the values of senior and junior debt at maturity.

The current values of the claims on the firm can be obtained by solving the partial differential equations. The solution for the current value of the subordinated debt is

$$D_2 = V[N(d_1) - N(\hat{d}_1)] - X_1 \exp[-r\tau][N(d_2) - N(\hat{d}_2)] + (X_1 + X_2) \exp[-R\tau]N(\hat{d}^2),$$

where $\hat{d}_1 = \ln[V/(X_1 + X_2)] + (R + \sigma^2/2)\tau$, and $\hat{d}_2 = \hat{d}_1 - \sigma\tau$.

It is important to note that the value of the junior debt behaves differently with respect to time to maturity, the volatility of the firm's assets, and the riskless rate than does senior debt. Here the response of the value of junior debt to these variables is not unambiguous. If the value of the firm is close to the promised repayment on the senior debt, then the junior debt is effectively the residual claimant and will behave like equity. If, however, the value of the firm is significantly higher than the promised payment on the senior debt so that the likelihood of default is small, then the junior debt will behave like debt. This was first pointed out in Black and Cox (1976), which showed that junior debt is initially a convex function of the value of the firm and then becomes a concave function at a high enough value of the firm.

The use of subordinated debt has a long history. Johnson (1955) reports that the first public issue of subordinated debt was made in 1936. In that year, the General Finance Corporation issued ten-year debentures which were subordinated to the firm's short-term borrowing. This was not the first time that the principle of subordination had been used, however. Prior to that date it was common for commercial banks to require existing creditors to subordinate their claims as a precondition of lending. Up until 1952 when industrial companies first used them, publicly issued subordinated debentures were primarily used by finance companies. Since that date, debentures have become fairly widely used by other types of firms in both the financial and industrial sectors.

The most common explanation for the use of subordinated debt is that it is a response to concerns of senior debt holders. Additional senior debt reduces the range of outcomes over which all debt payments can be made to the advantage of equity holders. On the other hand, subordinated debt reduces the possibilities for shareholders to expropriate bondholders (see Fama and Miller 1972 and Smith and Warner 1979). This can be easily demonstrated. Suppose a firm already has debt outstanding. If it subsequently makes another issue of debt with the same seniority as the existing debt and uses the proceeds to retire equity (or pays out the proceeds to shareholders in some other way), the position of the initial bondholders will be adversely affected. The risk of the old debt is increased because the

new debt raises the probability that the firm will go bankrupt. This increase in risk is reflected by a fall in price on the old debt so that the initial bondholders are made worse off. In contrast, the equity holders are better off since the interest rate they are paying on the old debt is lower than if they had issued all the debt simultaneously. This transfer of value from bondholders to shareholders can be eliminated if the initial debt specifies that all subsequent issues be subordinated. Fama and Miller (1972) referred to this type of subordination as a 'me-first' rule.

There have been a number of empirical studies investigating the effects of violations of me-first rules. Kim, McConnell and Greenwood (1977) consider a sample of firms that formed wholly owned finance subsidiaries. These subsidiaries issue debt and purchase the accounts receivable of the parent firm. Owners of the debt issued by the subsidiary essentially have a more senior claim on the accounts receivable than the bondholders of the parent corporation. Thus, forming a wholly owned subsidiary is effectively equivalent to issuing debt which has a higher claim than the existing bonds. The authors consider a sample of 24 firms that established captive finance subsidiaries between 1940 and 1971. They found strong evidence of a wealth transfer from the original company's bondholders to its shareholders.

Brauer (1983) has also investigated the effect of violations of me-first rules. His study considered the pricing of two bonds issued by Sunshine Mining Company in 1980. These bonds were identical except for the different timing of their payments and a difference in their me-first protective covenants. Adjusting for the difference in timing of payments, Brauer found that the bond with the more effective protection from subsequent issue was indeed more valuable than the bond without it.

An alternative explanation for subordination has recently been suggested by Winton (1990). His approach centres on a variant of the delegated monitoring story that has developed in the literature. Gale and Hellwig (1985) (building on Townsend 1979) showed that if a lender finds it costly to verify the level of income of a borrower, then in the optimal debt contract there is no verification provided the payment on the debt is actually paid, since this minimizes the total verification costs. Winton considers a similar framework but with multiple lenders. It is shown that if all lenders have the same claim, there is an inefficiency because verification costs are duplicated when the borrower fails to make the required debt payments. If the investors each hold debt with different levels of seniority, this duplication is eliminated. Accordingly, subordinated debt reduces the cost of monitoring and increases the value of the firm.

FRANKLIN ALLEN AND ANTHONY M. SANTOMERO

See also BANKRUPTCY AND CAPITAL STRUCTURE; BOND COVENANTS; CORPORATE FINANCE; DEBT AND DEFAULT; CORPORATE VS. SOVEREIGN; INSOLVENCY AND BANKRUPTCY.

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sunspot equilibrium. The volatility of market outcomes (for instance, employment, the price level and exchange rates) and what - if anything - to do about it are important subjects in macroeconomics. Some observed randomness in market outcomes originates in shocks to economic fundamentals (preferences, endowments and technologies) that are transmitted through the economy. Uncertainty about economic fundamentals is called *intrinsic uncertainty*. The general-equilibrium model extended to incorporate uncertainty (see Arrow 1953, 1964) provides an explanation of how intrinsic uncertainty causes randomness in economic outcomes. However, this is not the only possible source of economic volatility. The remaining randomness, or *excess volatility*, can be thought of as *market uncertainty*, the randomness generated by the economic mechanism itself; see Shell (1987).

The sunspot-equilibrium concept was introduced by Cass and Shell; see Shell (1977, 1987) and Cass and Shell (1980, 1982, 1983, 1989). Sunspot models are full-blown rational-expectations, general-equilibrium models that allow for excess volatility. Hence they can be used to analyse macroeconomic and monetary economic fluctuations. Because sunspots models entail rational expectations, they are also useful for judging the robustness, stability and internal consistency of the rational-expectations hypothesis. Uncertainty that is not intrinsic to the economy is by definition *extrinsic uncertainty*. In this literature, the term 'sunspots' is synonymous with 'extrinsic randomizing device'. If an allocation of resources depends on the outcome of such a device, then it is a sunspot allocation and we say that *sunspots matter*. If the sunspot allocation is an equilibrium for the economy, then it is a *sunspot-equilibrium* (SSE) allocation. Allocations that do not depend on extrinsic uncertainty are