The Sure Thing

Bond refunding: How operations research made its mark on Wall Street

By Andrew J. Kalotay

Nine years as director of special studies for Salomon Brothers can teach a person a lot about corporate finance. But I like to remember those first days when I hardly knew my way around. Back then I thought calls were made on the telephone, coupons were for the supermarket, and retirement meant moving to Florida. Bonds were the domain of stuffy old men with cigars.

My expertise was mathematics, a Ph.D. from the University of Toronto, 1968. My first job involved operations research at Bell Laboratories, tackling the problems on queueing with priorities, a problem fundamental to the telephone business. Funny the turns life takes. This article briefly traces some of the contributions operations research techniques have made to the world of debt refunding — a topic of great concern to large corporations, major Wall Street firms and investors. In 1992 corporations refunded close to $100 billion in bonds, and this year's activity is expected to be about the same. That spells big business.

My financial education started not on Wall Street, but at 195 Broadway in the Treasury Department of the old American Telephone and Telegraph Co. Back in 1974, Ma Bell ran the finances of 20 major telephone companies and Bell Laboratories, including its own substantial debt structure, so there seemed a need for knowledge in this area. Bonds appealed as a research topic because so little seemed to be written about them.

Bonds are contracts that obligate the issuer to make interest payments twice-yearly on the outstanding principal at a set coupon rate until maturity, when the principal is returned to the investors. A long-term corporate issue matures in 30 or 40 years, and a lot can happen during that time.

Bond contracts usually have an escape clause, the call provision. It allows the borrower to repay the bonds beginning five years after issuance at a declining penalty — initially slightly less than one year's interest.

Patton McGinley

Calls become important when interest rates drop below the coupon rate. If rates drop enough, corporations can replace the old bonds with new ones that cost less. The mechanics resemble that of refinancing an expensive fixed-rate mortgage with one that carries a lower rate. Deciding when it pays to go through the motions is where operations research has made significant gains in the world of corporate finance.

When I first approached the refunding question in 1974, interest rates were pushing skyward. Three Bell subsidiaries had just issued bonds with 10 percent coupons, a record at the time. Sooner or later, we knew, interest rates had to decline, presenting refunding opportunities for these and other issues. But what would be the best time to start taking them in?

The finance literature offered few clues about even how to approach such a question. One theme kept showing up in the journals: the present value of interest savings. Calculating the resulting cash flow savings was not a problem; the controversy had revolved around the choice of the discount rate. But by 1974 there was a consensus that because the cash flows from refunding are essentially riskless, the discount rate should be the corporation's cost of debt, rather than the cost of capital used for evaluating typical risky investments.

These results were insightful, but they were also incomplete. Discounting the cash flows shows the savings, but not what the issuer gives to get them. Any useful approach to debt refunding must incorporate this tradeoff.

Practical headway

Operations research made some practical headway on the refunding issue through taking a different approach. Instead of the calculation of savings, the literature concentrated on select-

ing the best time to "pull the trigger" on a refunding.

What the operations research recognized — and the finance periodicals essentially ignored — was the interest rate risk inherent in refunding. If rates continue to decline after a refunding, there is an opportunity cost. But if rates skip upward prior to refunding, the chance to lock in lower costing debt is lost. Researchers had taken tantalizing stabs at the problem but no one had come up with a comprehensive theory. For example, one of the articles showed how to determine the best time to call using dynamic programming if future rates are known with certainty, a rather severe assumption. Other articles extended this approach to uncertain rates, but used unrealistic stochastic processes, such as a simple Markov chain. The direction was correct, but the assumptions were naive and the institutional details were simply missing.

What the problem needed was a model that would account for all the relevant factors surrounding the refunding decision — the complete details of the issue, the volatility of interest rates, tax effects, transaction costs, whatever. The model also had to account for the call option that is embedded in the bond, because one needs to know not only the value of the savings but also the value of the option that gets forfeited.

In retrospect, solving the problem was easy compared with selling corporate America on the concept.

Options theory supplied the framework. The Black-Scholes option pricing formula — perhaps the single most significant contribution to finance theory — had already found its way to Wall Street and the investment community as a way to value exchange-traded options on stocks. Black-Scholes establishes the value of an option by synthetically creating a riskless hedge that combines the underlying stock and cash. But the trick came in adapting options theory to corporate bonds and to the problem of refunding.

Encouragement came at a securities seminar at the University of Chicago in May 1975 where Ed Thorpe, whose practical theories on options trading predated even Black-Scholes, privately gave his views on the refunding problem. Thorpe had authored two classic works which applied mathematical techniques to arbitrage: "Beat the Dealer" (blackjack) and "Beat the Market" (stock options).

Following the Chicago seminar, Bill Boyce, a mathematician at Bell Laborato-

ries, and I teamed up. We quickly decided that the approach had to be computer-based; the problem was simply too complex to allow for a neat formula. Boiling down the man-made bond conventions into an eternal law would be fruitless.

We described the interest rate process using a log-normal random walk of the long term rate. Back then we could not incorporate the entire shape of the yield curve into our analysis, and had to pick one point on the yield curve. The Black-Scholes formula was not extended to cover bonds until 1986.

Solving and selling

In retrospect, solving the problem was easy compared with selling corporate America on the concept. As far as interest rate predictions went, treasurers — constantly suspicious of quantitative solutions — favored their own guesswork to science. How can stochastic long-normal random walk analysis compete with the keen insights of a treasurer who gets to judge the merits of the competing approach against his own?

Our research emphasized that even when refunding saves money, we must make sure that the bonds are not called prematurely. We established a threshold to simplify the refunding decision for corporate treasurers. Our recommendation was that refunding should not proceed unless the savings exceeded 85 percent of the value of the embedded call option. We named this ratio *refunding efficiency*, and emphasized that 85 percent was the bare acceptable minimum.

We also adapted the approach to allow corporations the flexibility of refunding outstanding debt in other ways than straight calling, such as tendering or simply buying in the market bonds that are not yet callable.

AT&T's management eventually embraced our approach, passing it along to Bell System treasurers in early 1976. By that time rates were on the decline, and during the next year Bell System companies refunded $3 billion in debt using the efficiency yardstick. While most of these refundings entailed calling bonds that were issued in 1970, they also included tenders for the three 10-percent issues sold barely two years earlier.

Our project won a prize in the 1979 College for the Practice of Management Science competition, and soon after an article entitled "Optimum Bond Calling and Refunding" appeared in *Interfaces* magazine. Perhaps because only OR specialists, not finance practitioners, read *Interfaces*, the article never became widely circulated. A companion piece published in the *Journal of Finance* received more attention. At any rate, we were still having our troubles convincing the corporate world.

The effort paid off handsomely for Salomon Brothers in 1986, when many corporations tendered for their own bonds. For a while Salomon dominated this activity with more than an 80 percent market share.

Interest rates helped hammer the message of refunding efficiency home for us. Long rates shot up to unprecedented heights in the early 1980s, then dropped precipitously around the middle of the decade. By 1981 I had joined Salomon Brothers and was ready — once again — to introduce the concept of efficiency, this time with the backing of a major Wall Street firm.

The big guns

Salomon pulled out the big guns for this project. For the financial community Doug Howard and I published a 20-page article reintroducing the concept of efficiency with the catch title, "Efficiency and Optimal Bond Refunding." Then we went on the hustings bringing the message to countless meetings with corporate treasurers and chief financial officers. The effort paid off handsomely for Salomon Brothers in 1986, when many corporations tendered for their own bonds. For a while Salomon dominated this activity with more than an 80 percent market share.

Wall Street moves quickest when it spots a sure thing. Goldman Sachs was next to jump on to the efficiency bandwagon and published its own booklet on the subject, without, I might add, acknowledging Salomon's research. Other major firms began including efficiency analysis when corporate treasurers started demanding it. Most of the studies still use the 85 percent threshold Boyce and I hashed out back in 1976.

Times change. And so should this benchmark, in my opinion. Financial markets today provide so many ways of hedging the value of embedded options that the benchmark should now be 90 percent.

The mathematics of valuation has advanced, too. The proliferation of derivative products in the 1980s has driven bond analysts to devise more realistic approaches. In particular, Ho and Lee have come up with a stochastic model of the entire yield curve, rather than of a particular term. This provides a more accurate valuation of the options embedded in a bond. Based upon such models of interest rates, we can talk today about a formal "arbitrage-free" method of assigning values to interest-rate-sensitive cash flows, including callable bonds. Now, if we can just sell corporate treasurers on it. □

Prior to founding Andrew Kalotay Associates, a New York-based consulting firm specializing in the debt management issues confronting corporate and sovereign borrowers, Dr. Kalotay was director of research in the Bond Portfolio Analysis Group at Salomon Brothers. He was with the Treasury Department at AT&T and Bell Laboratory in various managerial and technical positions before that.

Dr. Kalotay has a Ph.D. in mathematics from the University of Toronto, has taught at Wharton and the Columbia Business School, and is presently the Director of the Center for Finance and Technology at Polytechnic University.