Edward O. Thorp is the author of the best-seller *Beat the Dealer: A Winning Strategy for the Game of Twenty-One* (Random House 1962, 1966). It presented the first scientific system ever devised for a major casino gambling game and revolutionized the game of blackjack. His book *Beat the Market* (Random House 1967, coauthored with S.T. Kasouf) helped launch the derivatives revolution that transformed world securities markets. His hedge funds and his personal portfolio has been profitable in each of the subsequent 42 years. Based on his work, he and Jay Regan launched the first market neutral hedge fund in 1969. Dr. Thorp, with Claude Shannon, also invented the first wearable computer in 1961 to win at roulette. He has also written *Elementary Probability* (1966), *The Mathematics of Gambling* (1984) and numerous mathematical papers on probability, game theory, and functional analysis.

He completed undergraduate and graduate work at U.C.L.A., receiving the B.A. and M.A. in physics, and the Ph.D. in mathematics in 1958. He has taught at U.C.L.A., M.I.T., New Mexico State University and was Professor of Mathematics and Finance at the University of California at Irvine.

How to Maximize Your Trust Assets

Overview: Cryonicists have the problem of protecting and compounding future assets over a very long time, perhaps centuries. The problem and the solution are essentially the same as that of creating a perpetual endowment. I addressed this in my columns for the quantitative financial magazine *Wilmott*, from which this is drawn. You can read the original articles and others on my (under construction) website www.edwardothorp.com.

The figures in the Table for a 1.9% payout rate for a tax exempt entity with negligible administrative costs apply to a taxable entity that has a 1.9% cost per year for taxes plus administration – say 1% for administration and 0.9% for taxes. If these costs are less, results will be better and if these costs are more, results will be less. If future real returns on investment are better than the past results will be better and, if they are less good, results will also be less good.

A Million Dollars For Mathematics
-- And An Exercise in Finance

by Edward O. Thorp

"Compound interest," said one of the Barons Rothschild, "is the eighth wonder of the world."

My wife Vivian and I are offering the University of California, where I taught for many years, one million dollars to endow a chair in mathematics at the Irvine campus. Our objectives are (1) to support the research of an individual mathematician of exceptional talent, and (2) using a modified investment and distribution policy, to better achieve this by causing the principal, through the power of compound growth, to eventually increase so that the chair becomes one of the most richly endowed in the world, thereby attracting extraordinary mathematical talent to UCI and UC.

Investment Policy: Asset Allocation

We believe that there are just two basic investment decisions for the non-taxable (hence, in the U.S. unleveraged[1]) investor: (1) the allocation of assets to major categories such as stocks, bonds, real estate and commodities, and to their numerous subcategories, and (2) whether to choose active investing (attempting to pick outperforming securities within an asset class) or to choose passive investing ("buying the market," via indexing). We'll address each of these in turn.

Since this endowment is a perpetuity, we're interested in the long term rate of return on asset classes. In his famous book *Stocks for the Long Run*, Jeremy Siegel gives the compound rate of return of major U.S. financial asset classes for 1802-1997, a period of 196 years! The real, i.e. inflation adjusted, rates of return were[2]: stock market 7.0%, long term governments 3.5%, short term governments .9%, gold -0.1%, cash -1.3% (i.e. consumer price inflation was 1.3%). This is corroborated in the monumental study *Triumph of the Optimists*, where Dimson et al cite real annualized rates of return for the U.S. for 1900-2000 as:[3] equities 6.7%, bonds 1.6% and bills 0.9%. They also show a similar pattern held true worldwide, over the sixteen countries they studied.

The first major study of this type, a famous paper by Ibbotson and Sinquefield which appeared in 1976, is now annually updated as the *Stock, Bonds, Bills and Inflation Yearbook*. For the period from December 31, 1925 through December 31, 1998, the 1999 yearbook gives[4] for the U.S.: Large company stocks 7.9%, small company stocks 9.1%, long term corporate bonds 2.6%, long term government bonds 2.2%, intermediate term government bonds 2.2%, U.S. Treasury bills 0.7%, and cash -3.1%.

Over long periods of 30 years or so, stocks have regularly and substantially outperformed bonds, bills and gold. This "equity premium" represents a price long term investors have been paid to take on risk. Short horizon investors have paid it by virtue of their collective demand for safety. So we have both empirical and theoretical reasons to expect an equity premium to exist in the future. Estimating the magnitude of the future equity premium is currently the subject of extensive discussion among economic and financial theorists and practitioners. But, motivated by what we believe is the strong likelihood of some continuing long run advantage[5] to equities, we have resolved the asset allocation issue by specifying that the endowment funds be held in equities to the extent practical, i.e. nearly entirely except for necessary, convenient and generally small cash balances.

Though stocks won't necessarily outperform the other asset classes over the hopefully very long existence of the chair, in the race for the greatest compound rate of growth we agree with Damon Runyon's advice: "The race is not always to the swift, nor the battle to the strong, but that's the way to bet!"

Investment Policy: Active Management Versus Passive Management

The next issue is how to choose the equities in which to invest. The basic decision is whether to be a "passive" investor, which is defined as "buying the market," or to be an "active" investor, which means picking stocks, either directly or through intermediaries ("money managers"), in an effort to "beat the market."

To explain the tradeoffs between passive and active investing, we begin with a simplified and idealized illustration. Suppose "the market," or universe of potential stock investments, consists of all U.S. listed stocks. Then an investor in stocks is "passive," and holds the market portfolio, if he has the same fixed

percentage of each of the roughly 10,000 listed stocks[6] on U.S. exchanges. For instance, with Berkshire Hathaway's (BRK.A, BRK.B) recent market capitalization of $114 bn, and a (hypothetical) total market capitalization of $11.4 trillion, 1% of the value of stock portfolio of each passive investor would be in Berkshire Hathaway stock. The passive investor holds securities in the same proportions as do all investors collectively. A passive investor who invested $11.4 million in a market worth $11.4 trillion would own one one-millionth of the stock of each listed company. Putting aside the practical issues of actually doing this for now, we move on to the "active" investor.

An active investor is defined as any investor other than a passive investor. So his allocations vary from the collective allocation. This can be inadvertent (inheritance, significant ownership of a business, grants of shares of stock by employers, etc.) or an attempt to choose a portfolio that will have a performance superior to that of the market. Examples of ways to do this include hiring financial advisors, either directly or indirectly through mutual funds or hedge funds, and trading one's own account using "information."

We now come to a key insight. Note that since each passive investor owns a fraction f_i of the market portfolio, then all the $(i = 1, 2, \ldots, n)$ passive investors as a group must own a fraction $f = f_1 + \ldots + f_n$ of the entire market portfolio. The leftover portion, which must be the fraction $1 - f$ of the entire market portfolio, is what is owned by all the active investors collectively.

Thus the active investors as a group own the market portfolio even though no one of them does individually. If we continue our idealized example by assuming (for the moment) that there are no transactions costs, then it follows that:

1) Each individual passive investor, and passive investors as a group, get the market return.
2) Active investors collectively, but not necessarily individually, get the return on the market portfolio.
3) The returns to active investors, to the extent they deviate from the market return, are (before costs) dispersed both above and below the market return with an average (capitalization weighted) dispersion of zero.

(Continued in the next issue.)

---

[1] We're aware of the current exemption which allows tax exempt U.S. entities to invest in possibly leveraged offshore hedge funds.

[2] Segel, Tables 1-1 and 1-2.

[3] Dimson, et al, Figure 4.2.