Happy 60th Anniversary CAPM! Why the Capital Asset Pricing Model Still Matters

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By Stephen R. Foerster, CFA

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When someone hears I'm currently writing the authorized biography of William (Bill) Sharpe, the most frequent question I get is, "Is he still alive?" Sharpe is the 1990 recipient of the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel, commonly known as the Nobel Prize in Economics. And, yes, in September 2024, he is still alive and well. He lives in Carmel-by-the-Sea in California. Every Thursday morning, he meets with his coffee klatch. He can often be seen walking his bichon-poodle near Carmel Bay. In June 2024, he celebrated his 90 birthday.

And September 2024 was another Sharpe milestone: the 60th anniversary of his seminal capital asset pricing model (CAPM) paper in *The Journal of Finance*. It is extremely rare for research to remain relevant after a decade let alone six. I'll explain what the paper is about, how it impacted the investment industry, most likely including your own portfolio, and why it still matters.

Photo by Stephen R. Foerster

The C-A-P-M

Let's talk about the model's name, common acronym, and what it's really about. First, Sharpe never called it the "capital asset pricing model." As the title of his seminal article indicates, it's about "capital asset prices." Later researchers referred to it as a model, adding the M. Second, once it became known as the capital asset pricing model, it was referred to by the acronym CAPM, pronounced "cap-em."

Virtually every finance professor and student refer to it as "cap-em" — everyone except Sharpe himself. He always uses the initialism C-A-P-M. (So, if you want to honor the creator of the model, you can refer to it as the C-A-P-M!) Third, the focus isn't really about prices of assets, but rather their expected returns. One of the key insights of the CAPM is that it answers an important investment question: "What is the expected return if I purchase security XYZ?"

Key Assumptions

Sharpe had written a paper published in 1963, “A Simplified Model for Portfolio Analysis,” that presented some of the same key concepts as in the seminal 1964 paper. There is an important difference between the two papers. As Sharpe later described it, in the 1963 paper, he carefully “put the rabbit in the hat” before pulling it out. The 1963 paper also answered that key question, “What is the expected return if I purchase security XYZ?”

But the rabbit he put in the hat was a preordained relationship between a security and the overall market — what I’ll describe later as beta. Andrew Lo and I interviewed Sharpe for our book, *In Pursuit of the Perfect Portfolio: The Stories, Voices, and Key Insights of the Pioneers Who Shaped the Way We Invest*. “So, I spent several months trying to figure out how to do it without putting the rabbit in the hat,” he said. “Was there a way to pull the rabbit out of the hat without putting it in to begin with? I figured out yes, there was.” In the 1964 article, Sharpe didn’t put a rabbit in the hat but rather he derived a market equilibrium based on theory.

With any theory, you need to make assumptions, to simplify what happens in the real world, so that you can get traction with the theoretical model. That’s what Sharpe did. He assumed that all that investors care about are expected returns and risk. He assumed investors were rational and well-diversified. And he assumed investors could borrow and lend and the same rate.

When Sharpe initially submitted the paper for publication in *The Journal of Finance,* it was rejected, mainly because of Sharpe’s assumptions. The anonymous referee concluded that the assumptions Sharpe had made were so “preposterous” that all subsequent conclusions were “uninteresting.” Undeterred, two years later Sharpe made some paper tweaks, found a new editor, and the paper was published. The rest, as they say, is history.

The CAPM in Pictures

Much of Sharpe’s classic paper focuses on nine figures or graphs. The first seven are in two-dimensional space, with risk — as measured by the standard deviation of expected returns — on the vertical axis and expected return on the horizontal axis. (Any finance student will quickly note that the now-common practice is to flip axes, which is represent risk on the horizontal axis and expected return on the vertical axis.)

On his horizontal axis, Sharpe began with the return on a special security that he called the “pure interest rate” or P. Today, we would refer to that special rate as the Treasury Bill return, or the risk-free rate, commonly represented as Rf.

The curve igg’ is Harry Markowitz’s efficient frontier: the “optimal” combination of risky securities such that each portfolio on the curve has the highest expected return for a given level of risk, and also the lowest risk for a given level of expected return. Sharpe’s model essentially looked for combinations of the risk-free security, P, with each portfolio on the curve igg’ that would provide the optimal risk-expected return. It is clear from the graph that the optimal mix is formed by a line from P that is tangent to curve igg’ — in other words, the mix that combines the risk-free asset P and portfolio g.

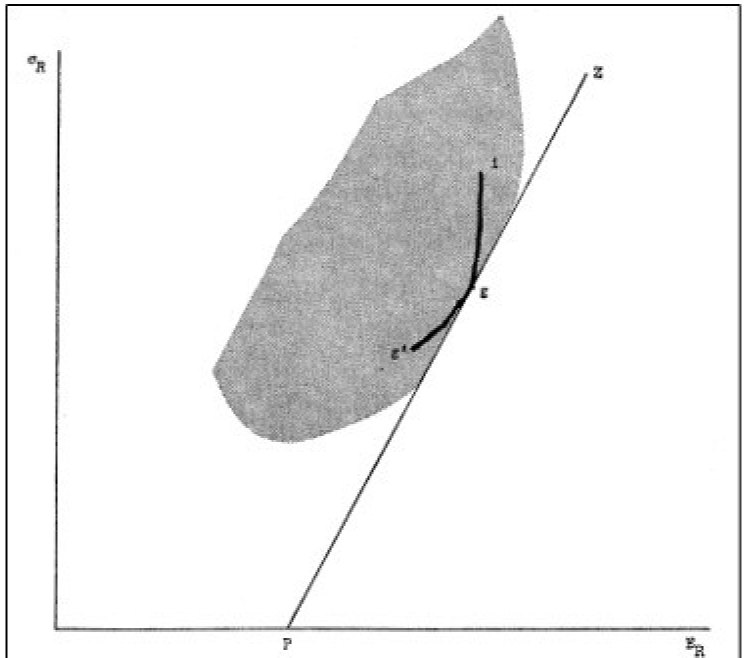

FIGURE 7

In Sharpe’s world, we can think of the investor as essentially having three choices. She can invest all of her money in risky portfolio g. If that’s too much risk for her, she can divide her portfolio between combinations of risk-free P and risky g. Or, if she wants even more risk she can borrow at the risk-free rate and invest more than 100% of her wealth in risky g, essentially moving along the line toward Z. The line PgZ is Sharpe’s famous Capital Market Line, showing the optimal combination of risk-free and risky investments, including either lending (buying a Treasury Bill) or borrowing (at the Treasury Bill rate).

The Footnote that Won a Nobel Prize

After presenting a series of graphs, Sharpe showed how this could lead to “a relatively simple formula which relates the expected rate of return to various elements of risk for all assets which are included in combination g. He then refers the reader to his footnote 22, an extensive 17 lines of equations and text that may be one of the most consequential footnotes in all of finance and economics literature.

22. The standard deviation of a combination of g and i will be:

$$\sigma = \sqrt{\alpha^2 \sigma_{Ri}{}^2 + (1-\alpha)^2 \sigma_{Rg}{}^2 + 2 r_{ig}\, \alpha(1-\alpha)\ \sigma_{Ri}\sigma_{Rg}}$$

at $\alpha = 0$:

$$\frac{d\sigma}{d\alpha} = -\frac{1}{\sigma}\left[\sigma_{Rg}{}^2 - r_{ig}\sigma_{Ri}\sigma_{Rg}\right]$$

but $\sigma = \sigma_{Rg}$ at $\alpha = 0$. Thus:

$$\frac{d\sigma}{d\alpha} = -\left[\sigma_{Rg} - r_{ig}\sigma_{Ri}\right]$$

The expected return of a combination will be:

$$E = \alpha E_{Ri} + (1-\alpha)\ E_{Rg}$$

Thus, at all values of α:

$$\frac{dE}{d\alpha} = -\left[E_{Rg} - E_{Ri}\right]$$

and, at $\alpha = 0$:

$$\frac{d\sigma}{dE} = \frac{\sigma_{Rg} - r_{ig}\sigma_{Ri}}{E_{Rg} - E_{Ri}}.$$

Let the equation of the capital market line be:

$$\sigma_R = s(E_R - P)$$

where P is the pure interest rate. Since igg' is tangent to the line when $\alpha = 0$, and since (E_{Rg}, σ_{Rg}) lies on the line:

$$\frac{\sigma_{Rg} - r_{ig}\sigma_{Ri}}{E_{Rg} - E_{Ri}} = \frac{\sigma_{Rg}}{E_{Rg} - P}$$

or:

$$\frac{r_{ig}\sigma_{Ri}}{\sigma_{Rg}} = -\left[\frac{P}{E_{Rg} - P}\right] + \left[\frac{1}{E_{Rg} - P}\right] E_{Ri}.$$

That last line of the footnote may not look familiar, but with a bit of sleight-of-hand it will come into focus. Sharpe gave the left-hand-side a new name: Big, with "ig" as the subscript. In technical terms, Big is the covariance of the return on security i relative to security g, divided by the standard deviation of g. When creating the manuscript, Sharpe used a typewriter, with standard keys. What he really meant by B was the Greek letter b or beta. And as we'll see, that has become one of the most used measures of risk today.

What Drives Expected Returns?

One of the key insights from Sharpe's model is that when it comes to a security's expected return, all that matters is Big, or beta.

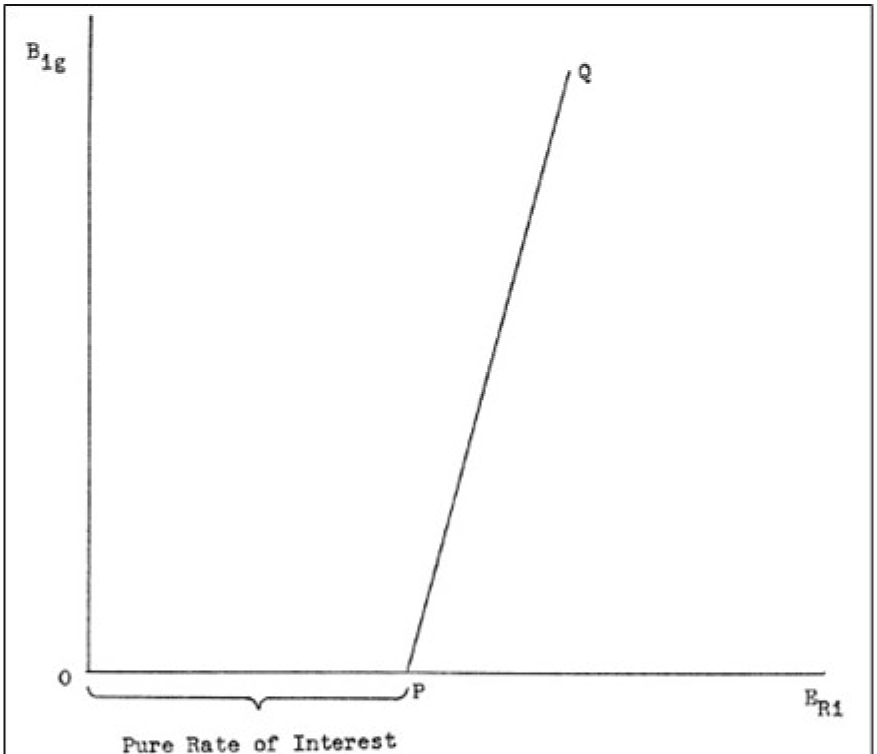

FIGURE 9

In Sharpe's final graph, expected return is still on the horizontal axis, but his new measure of risk, Big or beta, is on the vertical axis. Now the line PQ is actual the CAPM equation. What it powerfully shows is that, assuming an investor holds a well-diversified portfolio, the only measure of risk that matters is beta, or how risky the security is relative to the overall portfolio g. Since all investors want to hold g, then it must contain all assets. In other words, it must be the market portfolio. Today, we call that portfolio M.

We can now re-write Sharpe's original derivation of the CAPM to the more-familiar version: E(Ri) = Rf + b x [E(Rm) – Rf] or E(Ri) = Rf + bi x MRP, where i represents security i and MRP is the market risk premium. Here's the intuition. Let's suppose you're considering investing in a stock for the next 10 years — or maybe not. Alternatively, you could invest in long-term Treasuries and secure a return of Rf. Or you could invest in the market as a whole and get an expected return of E(Rm). That works out to be the same as Rf + MRP. Or finally, you could invest in security i. Your expected return, E(Ri) would be driven by how much market risk you are exposed to, bi.

Beta has a simple interpretation: how risky a particular security is relative to the overall market. In terms of benchmarks, by definition "the market" has a beta of 1.0. For a particular security, beta suggests what the particular return change is for every 1.0% change in the market. For example, for a low-risk stock with a beta of 0.5, if the market (often proxied as the S&P 500 Index) goes up by 1.0 percent, we would expect stock i to go up by 0.5 percent; if the market is down by 1.0%, we expect stock i to go down by 0.5 percent. The same logic holds for a risky stock, say with a beta of 1.5. If the market goes up by 1.0%, we would expect stock i to go up by 1.5%. If the market is down by 1.0 percent, we expect stock i to go down by 1.5%.

Why the CAPM Still Matters

Sharpe's seminal 1964 paper matters for three reasons.

1. Beta is the appropriate measure of risk for a stock that is part of a diversified portfolio. It is also a widely available measure, on sites such as Yahoo!Finance. All that matters is risk relative to the market. If you have a diversified portfolio, it doesn't matter how volatile a stock is on its own.
2. Sharpe's model, and in some sense Figure 7, shows us a way to measure performance across well-diversified portfolios such as mutual funds. We can measure a fund's performance or return, say over the past five years, in excess of what a risk-free investment would have returned. That's the return measure. If we compare that to the fund's risk, as measured by the standard deviation of the fund's return over that period, we have a return-to-risk measure. That's what Sharpe described in subsequent research papers and became known as the Sharpe ratio. It's probably the most common measure of performance today.
3. In Sharpe's CAPM paper, he defined his special portfolio, g, the one that everyone would want to hold, as one that represented "all assets." That's why we call it the market portfolio. In a narrower interpretation, it should at least contain all stocks. Specific to the United States, that implies buying an index fund like one that replicates the S&P 500 Index. We have Sharpe's model to thank for the multi-trillion-dollar index fund that has emerged over the past 50 years. Chances are that you're invested in an index fund, either directly or indirectly, say through a pension fund.

Of course, the CAPM has its critics. There are some competing models of expected return that capture additional factors beyond the market. There are some questionable empirical test results. And yet, the model is still front and center in finance courses and still used by practitioners. And it's a very intuitive model. It has stood the test of time.

So please join me in wishing the CAPM a happy birthday, with many more to come!

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About the Author(s)

Stephen R. Foerster, CFA

Stephen R. Foerster, CFA, is a co-author, with Andrew Lo of MIT's Sloan School of Management, of In Pursuit of the Perfect Portfolio: The Stories, Voices, and Key Insights of the Pioneers Who Shaped the Way We Invest, Princeton University Press, 2021, which won the Axiom Personal Finance category silver medal. His latest book is Trailblazers, Heroes, and Crooks: Stories to Make You a Smarter Investor, Wiley, September 2024. He is currently writing the authorized biography of William Sharpe, 1990 recipient of the Nobel Prize in Economics.