An Introduction to Empirical Asset Pricing and Hedge Fund Strategies

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August 2024

I. Introduction

My reasons for creating this series are threefold.[1,2] Firstly, I genuinely enjoy thinking about these topics. Secondly, I want to share my knowledge with others. And lastly—and somewhat shamelessly—I am hoping to extend my reach as I embark on my job search. But before we dive in, here's a little bit about myself.

I'm Aidan Vyas, a senior at Rice University studying Economics and Computer Science,[3] with a deep passion for empirical asset pricing. My research experience spans global macroeconomic investing, individual stock selection, and I'm currently exploring how prices and fundamentals affect stock returns in the long run.

This series aims to provide a suitable introduction to the economics of investing. We'll start by establishing some common ground on key concepts and then explore the relevant academic literature and industry best practices. Finally, I'll share some of my thoughts and research findings.

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[1]Pedagogically, it would be optimal to work through the life cycle of the canonical lemonade stand. However, given the current demands on my time, I have opted to assume that the reader has a basic understanding of economics. My hope is that this series will eventually develop into the training manual for interns at the hedge fund I plan to launch one day.

[2]In full transparency, this draft was revised and edited with the help of Claude Sonnet 3.5.

[3]At the time of writing.

A. The Assets and Instruments

Principally, investors allocate their money between the *risk-free* asset and one of many *risky* assets—e.g., stocks, bonds, commodities, and various derivatives—that might make them more money.

Equities: Owning a Slice of the Corporate Pie

Stocks are probably the most-well known group of *risky* assets. When you buy a stock, you're literally buying a small piece of a company. For instance, if you own 15 shares of Apple, you've got about a one-billionth stake in the whole company.[4] Pretty cool, right?

As a stockholder, you're not just along for the ride. You get some perks, like a share of the company's profits (we call these dividends) and the right to vote on big company decisions (such as electing the board of directors, approving mergers and acquisitions, and setting executive compensation). Think of it as being a tiny boss!

Now, figuring out how much a company is worth can get a bit technical. Essentially, it's all about summing up the cash flows that the company will make in the future and discounting them back to their present value, after accounting for outstanding debt obligations and current cash balances.[5] This is why stock prices can be so jumpy—they're based on what people think will happen in the future, which is inherently uncertain.

Because of this uncertainty, and because money tomorrow is worth less than money today, the two main risks borne by equity investors are *cash flow risk* (will the company make as much as everyone hopes?) and *interest rate risk* (if interest rates go up, those future cash flows might be worth less than they are today).

Instead of putting all of your eggs in one basket (or all of your money into one stock), some people prefer to invest in lots of companies at once, thereby diversifying away *idiosyncratic* (firm-specific) risk, leaving only the *systemic* (market-wide) risk. This is where **stock market indices** come in handy. An index, like the S&P 500 or the Dow Jones Industrial Average, represents a group of stocks. It's like a snapshot of the market. Here's the catch: you can't directly buy an index. It's just a tracking tool. But don't worry, there's a solution for that...

Enter **exchange-traded funds**, or ETFs.[6] These nifty investment vehicles pool money from lots of investors to track a specific index. The cool part? ETFs trade on exchanges

[4] There are approximately 15 billion shares of Apple stock outstanding.

[5] This is a simplification. In actuality, other assets and liabilities should be considered.

[6] As a quick aside, ETFs are often compared with mutual funds. The difference being that mutual funds can only be bought and sold at the end of each trading day, are often actively managed, and have minimum investment requirements. ETFs, on the other hand, have no minimum investment requirements, typically boast a lower expense ratio, and are more tax efficient and transparent when compared to mutual funds.

just like individual stocks, so they're super easy to buy and sell. If you want to invest in the whole S&P 500 with one purchase, an S&P 500 ETF is your go-to.[7]

Fixed Income: Lending Money to Make Money

Moving beyond stocks, we have **bonds**. Think of these as IOUs from governments or companies that need money to finance budget deficits or to invest in new projects. When you buy a bond, you're essentially lending money. In return, you often get periodic *interest* payments (known as the yield) and the *principal* (your original investment) returned at *maturity* (the bond's expiration date).

Let's break it down with an example. Say you buy a $1,000 30-year Treasury bond with a 5% yield. Here's what happens:

1. You give Uncle Sam $1,000 today.
2. Every year for the next 30 years, you get $50 (that's your 5%).[8]
3. After 30 years, you get your original $1,000 back.

Sounds great, right? But remember, there are risks. The government or company might go bankrupt (*default risk*), or interest rates might change dramatically (*interest rate risk*).[9]

There are several flavors of bonds:

- **Government bonds** are generally the safest of the bunch, but returns can differ drastically in terms of *issuer* (which country sells them) and *duration* (how long until maturity).
- **Municipal bonds** are issued by state and local governments in the U.S. They're exempt from federal taxes (nice!), but they are more likely to default than federal government bonds.
- Similarly, **corporate bonds**—often issued by public companies to open a new factory, acquire a competitor, or invest in research and development—have higher yields than government bonds due to their higher default risk.

[7]Personally, I would recommend the Vanguard S&P 500 ETF, due to its ultra-low fees and long track record of transparency.

[8]Technically, it would be $25 semi-annually for the next 30 years, as interest payments on Treasury bonds are doled out every 6 months.

[9]Following the previous example, imagine that interest rates shoot up from 5 to 10 percent overnight. Investors would now much prefer newer bonds issued with the higher interest rates. To compensate for the relatively lower interest rates (and demand) for your bond, the price would have to fall. On the contrary, if interest rates were to plummet to 2%, your 5% yielding bond would now be seen as more attractive, increasing the price of the bond. This is why there is an inverse relationship between bond prices and interest rates.

- Finally, **convertible bonds** are like corporate bonds with a twist—you can convert them into a predetermined amount of stock. They typically offer lower interest rates than regular corporate bonds as a result of their lower *seniority*,[10] but they provide you the potential upside of stocks.

Commodities: Investing in Real Stuff

Beyond stocks and bonds, you can also invest in physical **commodities** like gold, oil, or wheat. But unless you want to store barrels of oil in your garage, you'll probably use a *futures contracts*.

Simply put, a *futures contracts* is an agreement to buy a specific commodity in the future at a price determined today. At the *settlement date* (when the contract expires), you either get the actual commodity delivered (hope you've got space for all that wheat!) or, more commonly, you settle up in cash, where the difference between the previously agreed-upon price and current market price is exchanged.

Futures contracts are mainly used by *hedgers* and *speculators*. *Hedgers* are typically businesses (think McDonald's) that need to guarantee a specific price in the future (let's say beef for a Big Mac). While *speculators* seek to profit on the movement in commodity prices.

Derivatives: Complex Financial Tools

Futures contracts are just one type of **derivative**—financial instruments that derive their value from an underlying asset. Broadly, they all share the same hedger and speculator dynamic, where the hedgers have a legitimate economic interest in reducing risk, while the speculators are looking to profit from price movements. Let's take a look at a few more:

- **Currency forwards** are agreements to exchange a specific amount of one currency for another at a future date and a predetermined price. These are great for multinational companies worried about currency fluctuations.

- **Interest rate swaps** allow companies to convert floating-rate debt into fixed-rate debt, or vice versa. Essentially, you may have a stream of interest payments associated with a floating-rate loan that are uncertain because they are dependent on the prevailing interest rates. By purchasing an interest rate swap, you can convert this stream of uncertain payments into a stream of fixed payments based on current interest rates. For example, if interest rates are low, a company might want to use an interest rate swap to lock in said low rates.

[10] Seniority refers to the priority in which bonds are paid in the event of bankruptcy. Bonds with higher seniority (corporate bonds) are paid off before more junior bonds (convertible bonds).

- **Credit default swaps (CDS)** are insurance policies that payout in the case of a default on a bond or loan. You can think of them as fire insurance on your house. If your house burns down, or a company goes bankrupt, you get paid out. And the price of these contracts rise with the perceived default risk of the underlying asset.

- **Options** are another important type of derivative that gives the holder right, but not the obligation, to buy (**call option**) or sell (**put option**) an underlying asset at a predetermined price (*strike price*) within a specific time frame (expiration date). Here's a fun story. At the height of the dot-com bubble, Mark Cuban famously bought put options on Yahoo stock, providing him with a hedge against a potential decline in the stock price. When the bubble burst, Cuban made a fortune.

- Finally, **volatility futures** are contracts that allow investors to speculate on the future volatility of an underlying asset (typically the American or European stock market indices). These are almost exclusively used by speculators.

The Risk-Free Rate: The Baseline for All Investments

Alright, let's talk about the boring but super important **risk-free asset**. It's like the vanilla ice cream of the investment world—not exciting, but it's got a crucial role to play.

So, what's the risk-free asset? Well, it's commonly assumed to be short-term U.S. government bonds.[11] These assets are considered to be risk-free because they eliminate the two risks associated with government bonds: *default risk* (the U.S. government can always print more money to pay off its debts) and *interest rate risk* (short-term bonds are not very sensitive to changes in interest rates).

And the return on said asset is the *risk-free rate*. You can think of it as the hurdle that all other *risky* investments ought to surpass. If you're curious about how the risk-free rate has changed over time (maybe you're a finance history buff?), check out the Ken French Data Library (French, 2024).

The assets we've explored up to this point are publicly traded and relatively liquid. Their readily available prices make them ripe for empirical analysis and systematic investment strategies. However, there exists another realm of investments: **private assets**. These are characterized by their *illiquid* and *idiosyncratic* nature, setting them apart from their public counterparts. While real estate is the most familiar (and biggest) example, this group also includes venture capital, private equity, private credit, and even extends to more unconventional investments like fine art, rare wines, and professional sports teams.

[11] Specifically, U.S. Treasury bills (T-bills) with maturities ranging from 1 to 3 months.

B. The Jargon

Risk and Return: The Yin and Yang of Investing

The basic gist of the **Modern Portfolio Theory (MPT)** is that investors ought to maximize their returns per unit of risk—not just their total returns—so they get the most bang for their buck (Markowitz, 1952).

There are many different forms of risk, but for the purposes of the MPT, we focus on **volatility** (the standard deviation of an asset's excess returns—the formula for which is provided in Appendix A). Conceptually, volatility is a measure of how much an asset's returns fluctuate over time. The higher the volatility, the less predictable the asset's returns, and the more risk it carries.

As previously covered, the **risk-free rate** is the interest rate on short-term government bonds. It's how much an investor can receive if they don't take any risk by lending to the U.S. government, and in academia, it is commonly assumed to be the cost of borrowing.

The **total return** of an asset is simply much its price (in percentage terms) went up or down after adjusting for its yield (i.e., payments dispersed to the owner—e.g., dividends for stocks, interest payments for bonds, and rental income for real estate).

In asset pricing, we prefer to look at the **excess return** of an asset, which is defined as the total return minus the risk-free rate, as it allows us to compare "zero-dollar" portfolios. Essentially, an investor with zero dollars can borrow money at the risk-free rate to buy some asset. The value of their portfolio would simply equal the total return of said asset minus the risk-free rate.

Under this construction, returns become a lot less important because one could theoretically borrow more money (thereby taking on more risk) to achieve a higher return. This fact perfectly transitions us to our next piece of jargon—the **Sharpe Ratio**—which is defined in Appendix A as the excess return of an asset divided by its volatility (Sharpe, 1965). This equation essentially boils down to return over risk or the very thing that the MPT seeks to maximize.[12]

Once an investor has the determined the portfolio with the highest Sharpe ratio, the Modern Portfolio Theory dictates that they should simply hold that portfolio—leveraging it up (via borrowing money) or down (by holding more of the risk-free asset) to meet their individual risk preferences. The rest of this paper attempts to find said portfolio.

[12] As a quick aside, a close analogue to the Sharpe ratio is the **Information ratio**, which simply replaces the risk-free rate—in both the numerator and the denominator—with another benchmark (typically the return of the portfolio). The "market portfolio" is simply a portfolio that consists of all assets in a given market, held at their market values. The most common example would be the American stock market, where each individual stock would be weighted by its market capitalization, the number of shares multiplied by the price per share.

Number Crunching Nirvana: Where Math Meets Money

In practice, the MPT recommends that investors hold a group of uncorrelated assets with positive expected returns. **Correlation** refers to how much and in what direction two assets move in relation to each other. If two assets are positively (negatively) correlated, then they are likely to go up or down in the same (opposite) direction. Moreover, if they are uncorrelated, then the movement of one asset doesn't affect the movement of the other.

Two assets are said to be perfectly correlated if their returns can be completely explained by a positive linear function. For instance, if the returns of asset X are always equal to, double, or one-half of asset Y, then asset X and Y are perfectly correlated. Likewise, two asset are perfectly negatively correlated if their returns can be completely explained by a negative linear function, and two asset are perfectly uncorrelated if a linear function explains none of the relationship between the returns of the two assets.

Perfect positive (negative) correlations are represented by a correlation coefficient of 1 (-1), while perfectly uncorrelated assets are represented by a coefficient of 0. Between 0 and 1 (-1), increases (decreases) in the correlation coefficient represent an increasing positive (negative) linear relationship. A more formal definition of correlation can be found in Appendix A.

Correlation should not be confused with **beta**, which represents an asset's sensitivity to the market portfolio (or any portfolio for that matter), as measured by the coefficient in a linear regression of the excess return of an asset on the excess return of the portfolio. The specific formula for beta can be found in Appendix A. For example, if a stock has a market beta of 1, then it is expected to match the return of the market, but if it has a market beta of 0.5 or 2, then it is expected to return one-half or double the market return.

Alpha, the intercept of that very same linear regression, is the 'holy grail' of finance, and it refers to returns that cannot be explained by the market or other controls. It is important to note that while there is only one alpha, there can be multiple betas (e.g., a stock market beta, a bond market beta, and a gold beta), whereby each beta represents the coefficient on each control portfolio.

The final pieces of jargon are **skew** and **kurtosis** which are terms that describe the shape of a probability distribution. For a normal distribution, skewness informs us where the outliers are. If a distribution has negative skew, then it has a longer left tail (i.e., more extreme negative returns), while if a distribution has positive skew, then it has a longer right tail and more extreme positive returns.

Kurtosis refers to how observations cluster around the mean. A distribution is said to have positive excess kurtosis, or be *leptokurtic*, if there more outliers relative to a normal

distribution. In the opposing case, distributions with negative excess kurtosis are called *platykurtic* and have fewer outliers relative to a normal distribution. The specific calculations for both skew and kurtosis are involved and will generally be handled by common statistical packages, but if you are interested in reading more, please check out Appendix A.

Apart from the aforementioned terms, some other crucial asset pricing mathematics includes various regressions—**simple linear regressions**, **Fama-MacBeth regressions**, **panel regressions**, and **spanning tests**—in addition to the basic statistics of **t-statistics**, **p-values**, and **R-squared** (Fama & MacBeth, 1973). Moreover, the **Black-Scholes model** is a crucial tool for pricing options (Black & Scholes, 1973). However, these exact derivations are beyond the scope of the main text, so please refer to Appendix A for more information.

C. The Jargon

Risk and Return: The Yin and Yang of Investing

Imagine you're at an ice cream shop. You've got two choices: plain vanilla (safe but maybe a bit boring) or a mystery flavor (exciting but risky). This, in a nutshell, is the dilemma investors face every day. Welcome to the world of Modern Portfolio Theory (MPT)!

MPT suggests that smart investors are like savvy ice cream connoisseurs. They don't just go for the flavor with the biggest scoop (highest return). Instead, they look for the best taste-to-risk ratio. In other words, they want the most delicious ice cream with the least chance of an upset stomach.

In the investing world, we measure this "upset stomach" risk using something called **volatility**. Think of volatility as the financial equivalent of a roller coaster ride. The more ups and downs, the higher the volatility. It's calculated using a fancy math formula (don't worry, we've tucked it away in Appendix A for the curious cats among you).

Now, remember that vanilla ice cream we talked about? In finance, we call that the **risk-free rate**. It's like the interest you'd get from lending money to good old Uncle Sam. Not thrilling, but hey, at least you know you'll get your money back!

When we talk about how much money an investment makes, we use terms like **total return** and **excess return**. Total return is simply how much your investment grew, including any "toppings" (like dividends for stocks or interest for bonds). Excess return is a bit trickier - it's how much extra you made compared to if you'd just stuck with the vanilla (risk-free) option.

Now, here's where it gets fun. Imagine you could rate your ice cream experience by dividing how tasty it was by how likely it was to give you brain freeze. That's basically what the **Sharpe Ratio** does for investments. It tells you how much excess return you're getting

for each unit of volatility you're willing to stomach.

The whole point of MPT is to find that perfect ice cream sundae - a mix of flavors (investments) that gives you the highest Sharpe Ratio. Once you've found it, you can decide how big a scoop you want based on how much of a thrill-seeker you are!

Number Crunching Nirvana: Where Math Meets Money

Now, let's talk about how different investments play together. This is where **correlation** comes in. Imagine you and your friend are on seesaws. If you're perfectly in sync (going up when they go down and vice versa), you're negatively correlated. If you're both going up and down together, you're positively correlated. And if your movements have nothing to do with each other, you're uncorrelated.

In the investment world, we measure this synchronization on a scale from -1 (perfect opposite movement) to +1 (perfect same movement), with 0 meaning no relationship at all.

But wait, there's more! Enter **beta**, the cool cousin of correlation. If correlation tells you how investments move together, beta tells you how much they move. It's like comparing your seesaw movements to the playground bully's. If your beta is 1, you're matching the bully move for move. If it's 0.5, you're only going half as high (or low). And if it's 2, you're doubling their movements (you showoff, you).

Now, what if you're so good at the seesaw that you can go higher than anyone else, regardless of what the bully is doing? That extra height is what we call **alpha**. It's the secret sauce, the unexplained awesomeness that investors are always hunting for.

Lastly, let's talk about the shape of things. In the world of finance, we use **skew** and **kurtosis** to describe how our investment returns are distributed. Skew is like the lean of a Jenga tower - is it tilting left (negative skew, more bad surprises) or right (positive skew, more good surprises)? Kurtosis, on the other hand, is about how stable that tower is. High kurtosis means more extreme events (both good and bad), while low kurtosis means things are pretty steady.

There's a whole world of other jargon out there - regressions, t-statistics, p-values, and more. They're like the advanced moves in a video game. Important? Absolutely. But you don't need to master them to start playing. If you're curious, though, we've got more details waiting for you in Appendix A.

And for all you option traders out there, we can't forget the **Black-Scholes model**. It's like the secret recipe for pricing options. We won't spill all the beans here, but if you're itching to know more, Appendix A has got your back.

Remember, in the world of finance, jargon is just a way of describing the game. Don't let it intimidate you. With a bit of practice, you'll be speaking the language like a pro in no time!

Appendix A. Formulas

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