An Analysis of Long Term Investing in Index Funds with Leverage

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Brief Explanation of IXIC, SPY, and DIA

IXIC is the ticker symbol of the NASDAQ Composite, which according to wikipedia is "a stock market index of the common stocks and similar securities (e.g. ADRs, tracking stocks, limited partnership interests) listed on the NASDAQ stock market. Along with the Dow Jones Average and S&P 500 it is one of the three most-followed indices in US stock markets. The composition of the NASDAQ Composite is heavily weighted towards information technology companies. The NASDAQ-100, whose components are a subset of the NASDAQ Composite's, accounts for over 90% of the NASDAQ Composite's movement, and there are many exchange-traded funds (ETFs) tracking its performance." One can invest in IXIC by investing in its close approximation: QQQ, which tracks a modified-market-cap-weighted index of 100 NASDAQ-listed stocks.

SPY refers to the S&P 500, which is an American stock market index based on the market capitalizations of 500 large companies having common stock listed on the NYSE, NASDAQ, or the Cboe BZX Exchange. In real life, SPY is actually the ticker symbol of the SPDR S&P 500 trust, which is an exchange-traded fund which is designed to track the S&P 500 stock market index, and does so closely that one can basically consider it to be and equivalent of the S&P 500. This fund is the largest ETF in the world. Another ETF that tracks the S&P 500 is the Vanguard S&P 500 ETF (VOO).

DIA refers to the Dow Jones Industrial Average (DJIA), or simply the Dow, which according to wikipedia is "a stock market index that indicates the value of 30 large, publicly owned companies based in the United States, and how they have traded in the stock market during various periods of time. These 30 companies are also included in the S&P 500 Index. The value of the Dow is not a weighted arithmetic mean and does not represent its component companies' market capitalization, but rather the sum of the price of one share of stock for each component company. The sum is corrected by a factor which changes whenever one of the component stocks has a stock split or stock dividend, so as to generate a consistent value for the index." In real life, DIA is actually the ticker symbol of the SPDR Dow Jones Industrial Average ETF, which is designed to track the Dow Jones Industrial Average.

Point About Weightings

It's important to note that that the S&P 500 and the NASDAQ Composite are market-cap weighted, which means that companies with a larger market-cap account for a greater percentage of the holdings of the index and companies with a smaller market-cap account for a lesser percentage of the holdings of the index. There are other factors that go in to this so the proportionality is not exactly constant. For example, today May 14th 2019, the public company with the greatest market cap is Microsoft, which has a market cap of 960 billion USD. In other words, if today you purchased all of the shares of Microsoft to obtain 100% ownership of the company, it would cost you 960 billion USD. As a result of having the largest market cap, Microsoft accounts for a greater percentage of both the S&P 500 and NASDAQ Composite than any other company in both indices, accounting for about 4% of the S&P 500 and about 11% of the NASDAQ Composite. If today, Microsoft shares fell by 50% (and everything else remained constant), the S&P 500 would fall by 2% and the NASDAQ Composite by 5.5%. On the other hand, the DJIA is price weighted so that regardless of the market-cap of the company, the greater the selling price of the stock, the greater its percentage of the holdings in the DJIA. So today, Boeing has the greatest stock price of companies in the DJIA, with a price of 344 USD, so it accounts for the greatest percent of the DJIA - about 9%. This is despite the fact that Boeing does not have the largest market cap on the DJIA, with a market cap of only 194 billion USD. Microsoft has a much larger market cap but only accounts for about 3% of the DJIA because of its lower stock price of 125 USD.

The Goal

The goal is to understand how the IXIC, SPY, and DIA do over different periods of time with different amounts of 3x leverage so that we can compare them and get an idea of how they might do with similar amounts of leverage in the future.

Point about Time Periods and Data Used

The 3x leverage is actually done on a daily basis, but I used a weekly because it closely approximated the daily leverage and wouldn't require 7 times the number of data points.

To be clear, for IXIC I used the NASDAQ Composite, for SPY I used the S&P 500, for DIA I used the Dow Jones Industrial Average (DJIA) from yahoo finance. The links are below:

NASDAQ Composite: https://finance.yahoo.com/quote/%5EIXIC?p=%5EIXIC
S&P 500: https://finance.yahoo.com/quote/%5EGSPC/
DJIA: https://finance.yahoo.com/quote/%5EDJI/

One might ask why I didn't use the actual QQQ, SPY, and DIA ETFs because that's what one would actually be buying in real life. The reason is that their data only goes back to 1999, 1993,

and 1999 respectively, when the ETFs were created. While data for the NASDAQ Composite, S&P 500, and the DJIA goes back to February 1971, January 1950, and January 1985, respectively.

One might then ask why I used the term SPY to refer to the S&P 500, which is not exactly the same as the real SPY ETF, and the term DIA to refer to the DJIA, which is not exactly the same as the real DIA ETF, as using such terminology is very confusing. The reason is that that was probably a mistake, but a mistake that is now too late to fix (in other words I'm too lazy to fix it). It's like how electrical current is the flow of positive charge, too late to fix.

From January 1985 to January 2018 (10 year periods)

I forgot to write on these graphs but they're over 10 year periods. Obviously 1st decile is the 10th percentile, 1st quartile is the 25th percentile, 2nd quartile is the 50th percentile (otherwise known as the median), 3rd quartile is the 75th percentile, and 9th decile is the 90th percentile. Multiple of principle is perhaps a clearer method of seeing how much your money actually changes over the whole period of time rather than the compound interest rate, which is just the annualized rate of change. I'll discuss the three graphs beneath them. One important point is that they do not include dividends, as the stock price does not include the effect of reinvesting dividends.
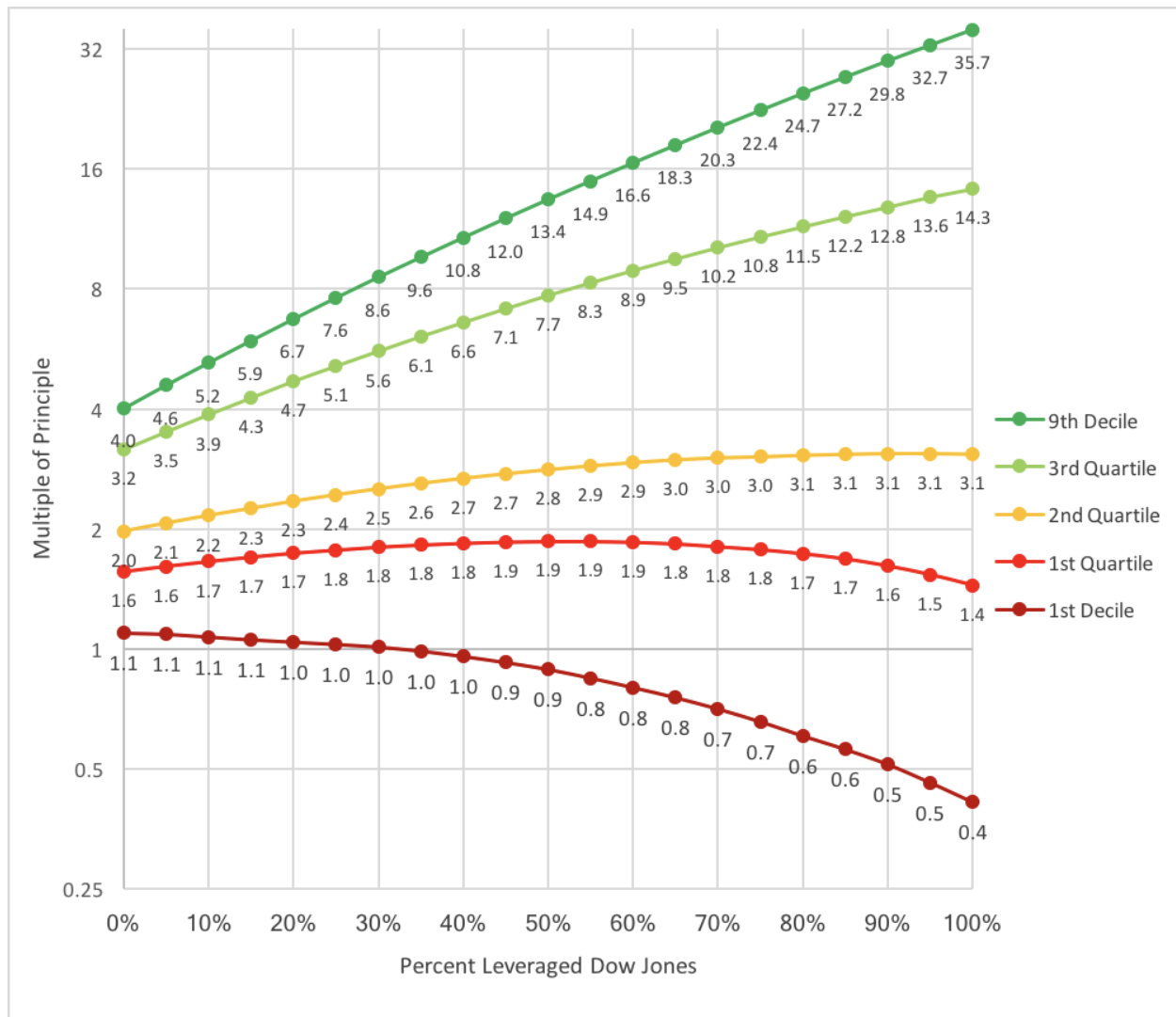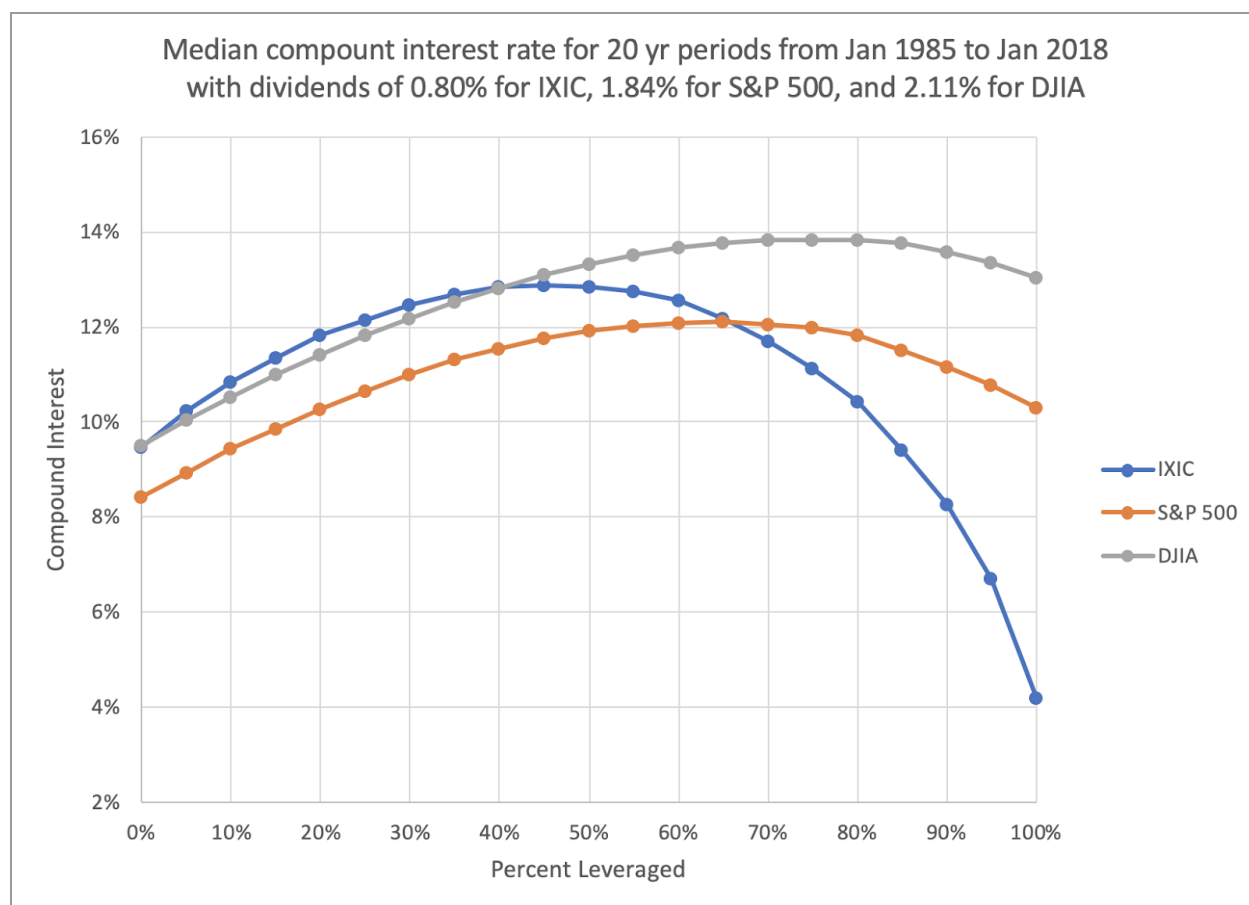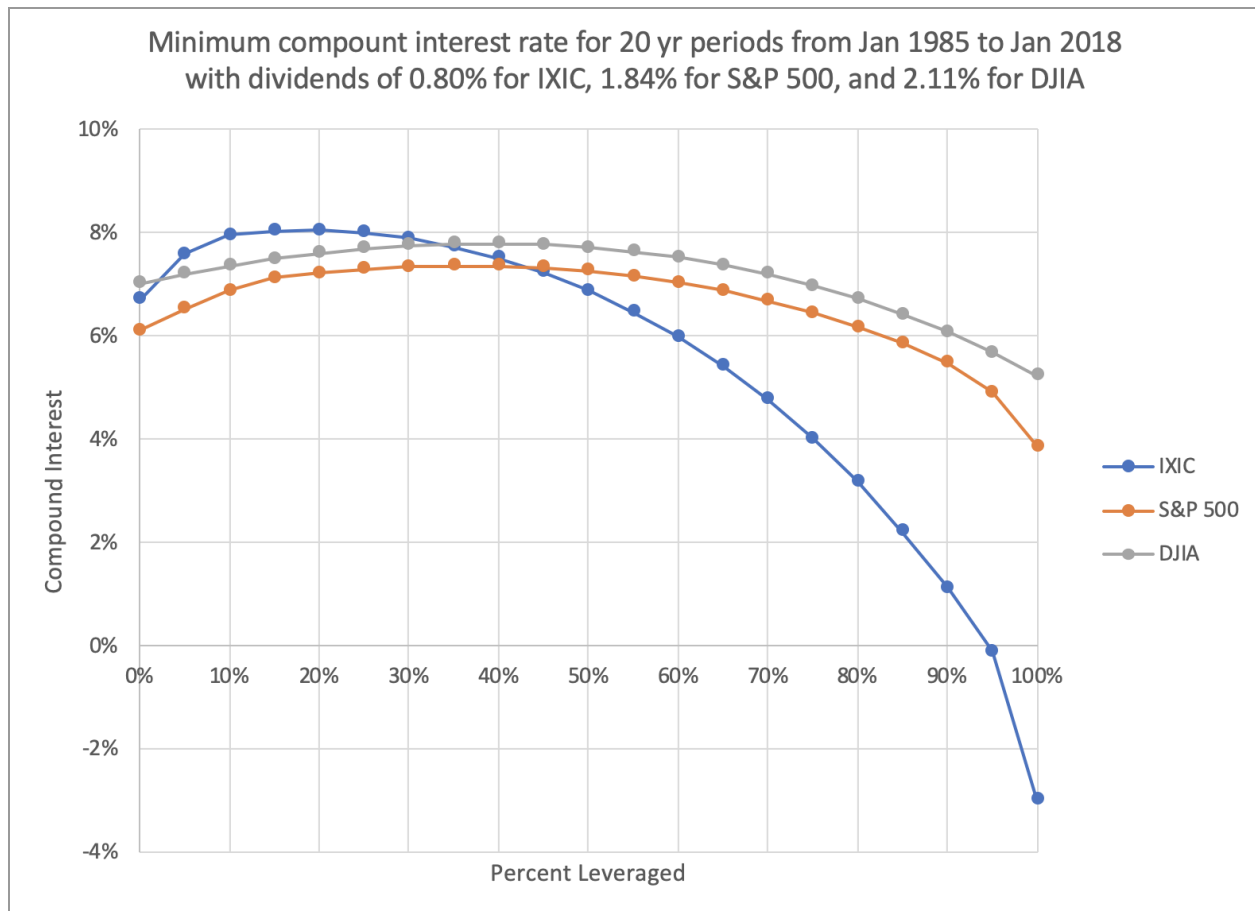
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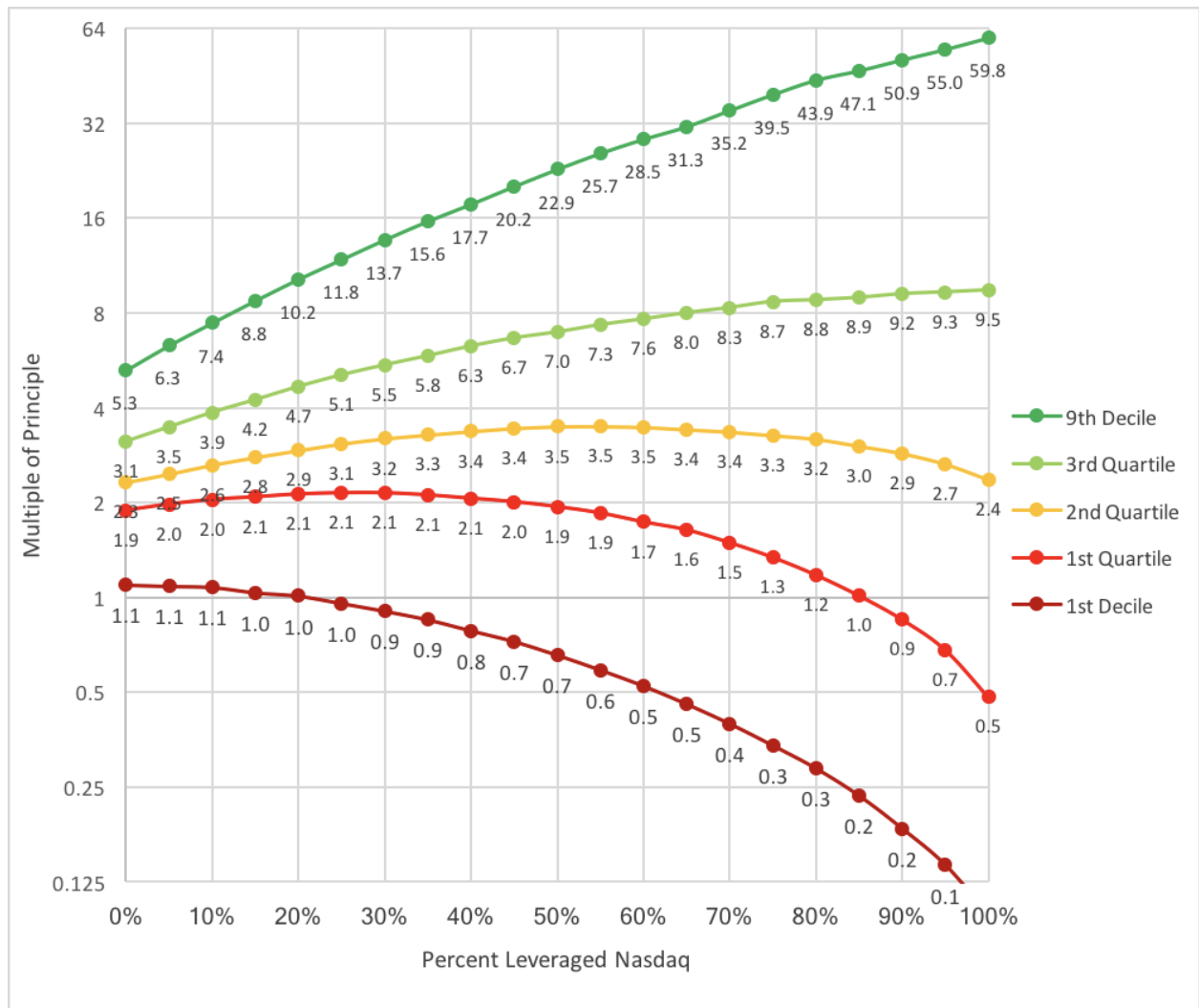
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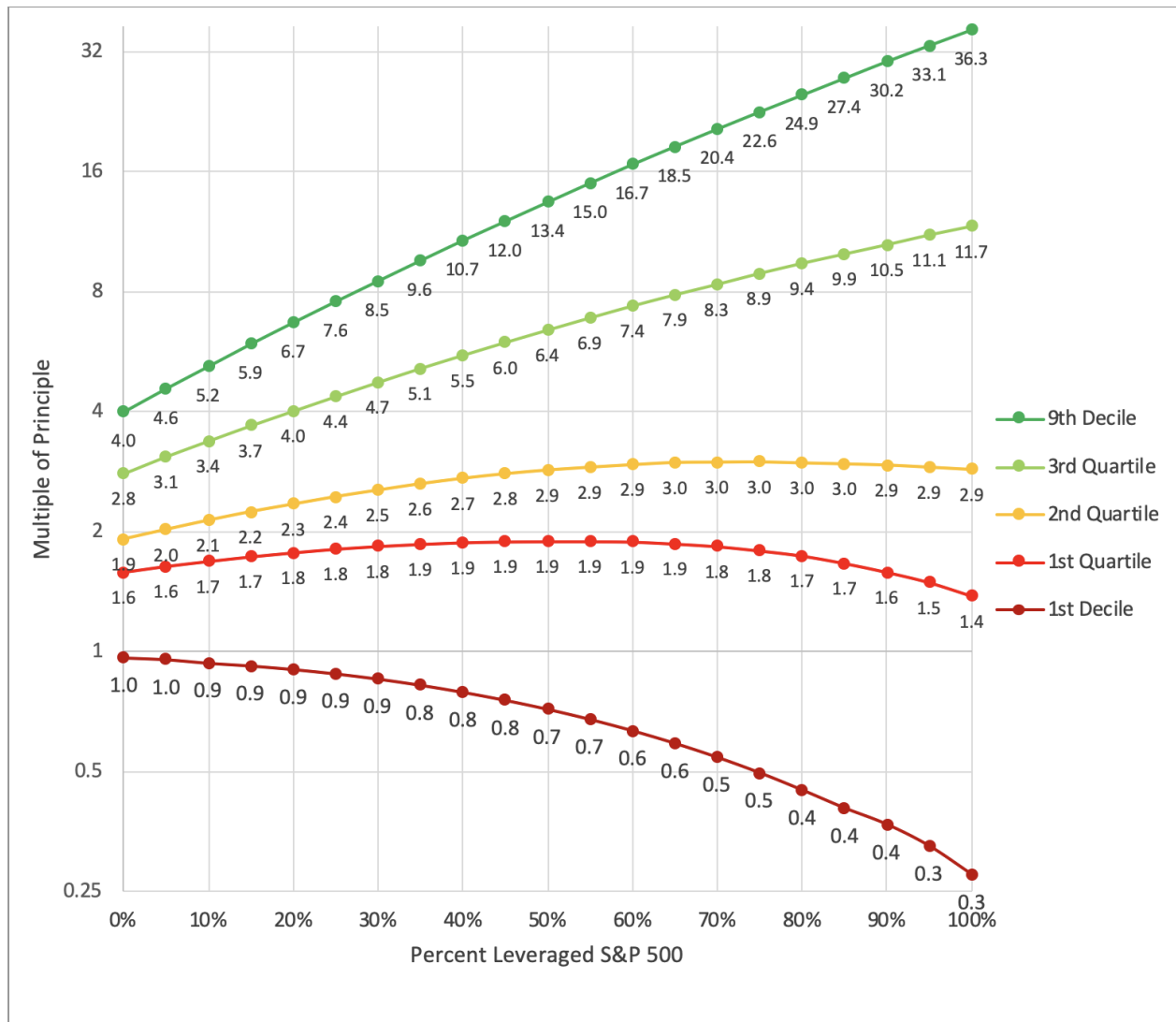
3.

As can be seen in these three graphs, the leveraged Nasdaq is more likely to have insanely high returns and insanely low returns, but doing slightly better on average. With 70% leverage the Nasdaq provides an unbelievable multiple of 35 for the 90th percentile, but a multiple of 0.4 for the 10th percentile. On the other hand, with 70% leverage the S&P 500 provides only a multiple of 20 for the 90th percentile, but a multiple of 0.5 for the 10th percentile. It does 43% worse at the high end but 25% better at the low end. In the middle, the Nasdaq does 13% better. On the other hand the DJIA does as well as the S&P 500 on the high end for 70% leverage but much better on the low end with a multiple of only 0.7 for the 10th percentile. The

DJIA does about as well as the S&P 500 for the low end. Since 1985, the Nasdaq has had the highest risk, the S&P 500 the second highest risk, and the DJIA the lowest risk. It's important to also note that although all three do about as well as each other on average, including dividends should help the DJIA the most and the Nasdaq the least. That's because dividends for the Nasdaq are low, being 0.80% today for QQQ, while SPY dividends are more than twice that at 1.84%, and DIA dividends are at 2.11%. In all, the results seem to suggest that the DJIA is the way to go. When you include dividends it should do a tiny bit better than the S&P 500, and seems to have much lower risk. One problem with this assumption is that it rests on past results. And because the DJIA is only 30 companies as opposed to the S&P 500's 500 companies, it is possible that the difference between the two is more a result of chance rather than of a true underlying difference. Because the S&P 500 includes more companies, that seems to suggest that there should theoretically be less risk going into the future.

From January 1985 to January 2018 (20 year periods)

We can also look at 20 year periods. For this we'll include the dividends that exist today and only look at the median and minimum 20 year periods for the three indices.

Minimum compount interest rate for 20 yr periods from Jan 1985 to Jan 2018 with dividends of 0.80% for IXIC, 1.84% for S&P 500, and 2.11% for DJIA

As can be seen in these graphs, clearly the DJIA does best on average with 70% leverage, and this is true even before include dividends. A compound interest rate of anywhere between 12% and 14% is amazing, such a rate would turn $10,000 into $2.9 million and $7.0 million over 50 years, respectively. On the other hand, one could have got unlucky and got the worst of the 20 year periods between 1985 and 2018, this was the one roughly between 1989 and 2009 in which one would have experienced the dot-com crash of 2000 and the US recession of 2008. The compound interest rate with 70% leverage was about 7% for the S&P 500 and the DJIA, ever so slightly greater than what one would have achieved with 0% leverage for that same 20 year period.

Three important points:
1. Median returns are at a maximum for leverage at 75% for the DJIA, 65% for the S&P 500, and 45% for the IXIC.

2. Minimum returns are at a maximum for leverage at 40% for the DJIA, 35% for the S&P 500, and 20% for the IXIC.
3. Marginal median increases are equal to marginal minimum decreases between 60 - 65% leverage for the DJIA, 55% leverage for the S&P 500, and between 35 - 40% leverage for the IXIC. (Explained below.)

In order to explain the 3rd point, one must recall the fancy way to set price in economics, which is to find the price at which marginal benefits are equal to marginal costs. In this case, that would mean finding the leverage at which dR/dL (where R is returns and L is leverage) is equal and opposite between the median and the minimum. In other words, the leverage at which a small increase in leverage, say by 5 percentage points, increases median returns just as much as it decreases minimum returns. This should be the same point at which a small *decrease* in leverage *decreases* median returns just as much as it *increases* minimum returns. This happens at between 60% and 65% leverage for the DJIA, at 55% leverage for the S&P 500, and between 35% and and 40% leverage for the IXIC.

So what is the optimal leverage over a 20 year period? Clearly it's impossible to say exactly with this data as it depends on how much you're willing to risk get better returns. Reason suggests that for the DJIA and the S&P 500, it's somewhere around 60 - 70%. Beyond 60 - 65% for the DJIA the marginal decreases in returns at the minimum start to become greater than the marginal increases in returns at the medium, even though the greatest median returns occurs at 75% for the DJIA. In other words, even though you're getting slightly better results on average by increasing leverage above 60 - 65%, you're assuming much more risk; i.e., the increase in risk is greater than the increase in average benefit. The same occurs beyond 55% for the S&P 500 even though the greatest median returns occurs at 65% for the S&P 500. If you take an average between the costs and benefits equilibrium point and the maximum returns point, that would yield:

68.75% for the DJIA, 60% for the S&P 500, and 41.25% for the IXIC.