Short sales and dollar-neutral strategies

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Basic outline of a short sale

The idea of a short sale is to profit from future price declines:

Suppose a stock is worth $100, and you predict it will fall to $70.

To sell the stock “short,” you do the following:

- *Borrow* a share from your broker, and sell it for $100.
- Now you have $100 proceeds from the sale, and a liability to deliver a share of the stock back to your broker in the future. This liability is called a “short position.”
- Reimburse the broker for any dividends that the stock pays.
- After the price falls, “close” your position by purchasing a share for $70 and delivering that share to the broker.

Conclusion: You have earned $30, exactly the amount of the price decline.

Basic observations about a short sale

Three fundamental observations about a short sale:

1. It offers the negative of the return on the investment.
2. The required investment (cash outflow) comes second.
3. The potential losses on the strategy are unlimited.

#2 and #3 create serious risk for the broker.

Now let's discuss these steps in more detail...

Margin requirements

The broker takes on risk by allowing you to sell short.

So the broker, and regulations, require you to post collateral.

Specifically, Regulation T requires that

1. when you open the trade, you deposit collateral with the broker worth 150% of the proceeds of the sale (initial margin);
2. after that, you must replenish the collateral whenever it falls below 130% of fair value (maintenance margin).

The law does not specify what form the collateral has to be.

But, the broker may require cash, or allow stock or other assets, depending on the investor, and on the asset being sold short.

Margin example for a retail investor

Redo the earlier example with typical retail margin requirements:

- You want to short-sell one share of stock worth $100.
- To meet the 150% initial margin, you need $150 of collateral.
  Suppose you have no other investments. Then you need $50.
- Deposit the $50 with the broker, borrow the stock from them, sell it for $100, and leave the combined $150 with your broker.
- Suppose you don't earn interest on that $150 in the meantime.
- One year later, you buy the stock for $70, deliver it to close out your short position, and withdraw the $150.

You started with $50 and now have $150 - $70 = $80, for a $30 profit.

Return on a short sale

The "return" on a short sale strategy can be a tricky concept to think about.

In the example we just did, you had to deposit \$50 of your own money, and ultimately walked away with \$80, so the return on the strategy is

$$\frac{\$80 - \$50}{\$50} = 60\%$$

This calculation highlights that the return on the strategy is closely tied to the amount of margin that is required for the position. As less is required, the return grows. As the amount of margin shrinks, the percentage return grows towards infinity.

This shows us that there are two factors affecting the return to short sales: First, a negative exposure to the movement of the underlying asset. Second, an amplification of that return due to the amount of margin that is required.

If the margin requirement were 200% instead of 150%, then the percentage return on your investment would exactly equal the negative return on the stock itself. These calculations will appear again when we talk about dollar-neutral funds below.

Margin calls during the year

Continuing the prior example:

- Suppose that during the year, the stock price rises to $200.
- Your collateral requirement is now 130% of $200, which is $260.
- Your broker will require you to deposit another $110.
- As the price rises higher, the required collateral does too.
- If you don't meet the requirement, the broker will close out your position by confiscating the collateral and purchasing the stock.

This is a major risk of short-selling as a strategy.

Even if you are right about the long-run stock price, it may be very difficult to hang on long enough to realize that profit.

Fees and costs

The broker can charge you an interest rate for lending you the stock, varying with the supply and demand of the specific stock.

The broker might *pay* interest on the cash that you keep on deposit. This is more common for institutional investors.

As with the other strategies in this class, we will just focus on measuring before-cost performance.

So from this point forward, we will imagine a fund that receives the risk-free rate on cash deposited with the broker, and we will ignore any lower rates or offsetting fees as trading costs to be dealt with separately.

Dollar-neutral investment funds

Let’s now imagine you set up a “dollar-neutral” investment fund:

This means it will hold equal dollar long and short positions.

You raise $100 from investors, buy $100 of stock, short-sell another $100, and keep the short sale proceeds with the broker.

- To cover the extra $50 margin, you place half of the $100 stocks purchased long in a specially-designated account.

Your initial balance sheet looks like this:

- Assets: $100 of investments, $100 of cash from short sale.
- Liabilities: $100 short position, $100 net assets.

One useful measure for a fund like this is “gross leverage,” the sum of long and short positions divided by net assets.

- A dollar-neutral strategy has gross leverage of 2.

Vanguard Market Neutral fund balance sheet

($000s, except shares, footnotes, and per-share amounts)	Amount
Assets	
Investments in Securities, at Value[1]	
Unaffiliated Issuers (Cost $428,238)	472,762
Affiliated Issuers (Cost $14,349)	14,349
Total Investments in Securities	487,111
Investment in Vanguard	17
Cash	203
Cash Segregated for Short Positions	475,892
Receivables for Investment Securities Sold	3,523
Receivables for Accrued Income	1,276
Receivables for Capital Shares Issued	643
Total Assets	**968,665**
Liabilities	
Securities Sold Short, at Value (Proceeds $438,415)	469,712
Payables for Investment Securities Purchased	5,591
Collateral for Securities on Loan	1,686
Payables for Capital Shares Redeemed	320
Payables to Vanguard	42
Accrued Dividend Expense on Securities Sold Short	460
Total Liabilities	**477,811**
Net Assets	**490,854**

VMNFX discussion of short sales

2. Short Sales: Short sales are the sales of securities that the fund does not own. The fund sells a security it does not own in anticipation of a decline in the value of that security. In order to deliver the security to the purchaser, the fund borrows the security from a broker-dealer. The fund must segregate, as collateral for its obligation to return the borrowed security, an amount of cash and long security positions at least equal to the market value of the security sold short. In the absence of a default, the collateral segregated by the fund cannot be repledged, resold or rehypothecated. This results in the fund holding a significant portion of its assets in cash. The fund later closes out the position by returning the security to the lender, typically by purchasing the security in the open market. A gain, limited to the price at which the fund sold the security short, or a loss, theoretically unlimited in size, is recognized upon the termination of the short sale. The fund is charged a fee on borrowed securities, based on the market value of each borrowed security and a variable rate that is dependent upon the availability of such security, and the fund may receive a portion of the income from the investment of collateral which offsets the borrowing fee. The net amounts of fees or income are recorded as borrowing expense on securities sold short (for net fees charged) or interest income (for net income received) on the Statement of Operations. Dividends on securities sold short are reported as an expense in the Statement of Operations. Cash collateral segregated for securities sold short is recorded as an asset in the Statement of Assets and Liabilities. Long security positions segregated as collateral are shown in the Schedule of Investments.

VMNFX discussion of collateral

Long security positions with a value of $333,913,000 are held in a segregated account at the fund's custodian bank and pledged to a broker-dealer as collateral for the fund's obligation to return borrowed securities. For so long as such obligations continue, the fund's access to these assets is subject to authorization from the broker-dealer.

Using a dollar-neutral strategy to earn a return spread

Suppose you have identified two groups of stocks H and L. You think H will outperform L, and want to earn the spread $r_H - r_L$.

You raise \$100 from investors, and buy \$100 of the H stocks. You short-sell \$100 of the L stocks, and leave the proceeds as cash with your broker, earning r_f. Meet any further margin needs with stocks from the H portfolio.

As described earlier, your initial balance sheet would show net assets of \$100.

One year later, your balance sheet now looks like this:

Assets:
Investments: $100 \times (1 + r_H)$
Cash: $100 \times (1 + r_f)$ cash

Liabilities:
Investments sold short: $100 \times (1 + r_L)$
Net assets: $100 \times (1 + r_f + r_H - r_L)$.

Your investors' excess return per \$1 is exactly $r_H - r_L$.
Conclusion: Return spreads are investable strategies.

Dollar-neutral vs market-neutral strategies

Dollar-neutral means investing equal dollars long and short.

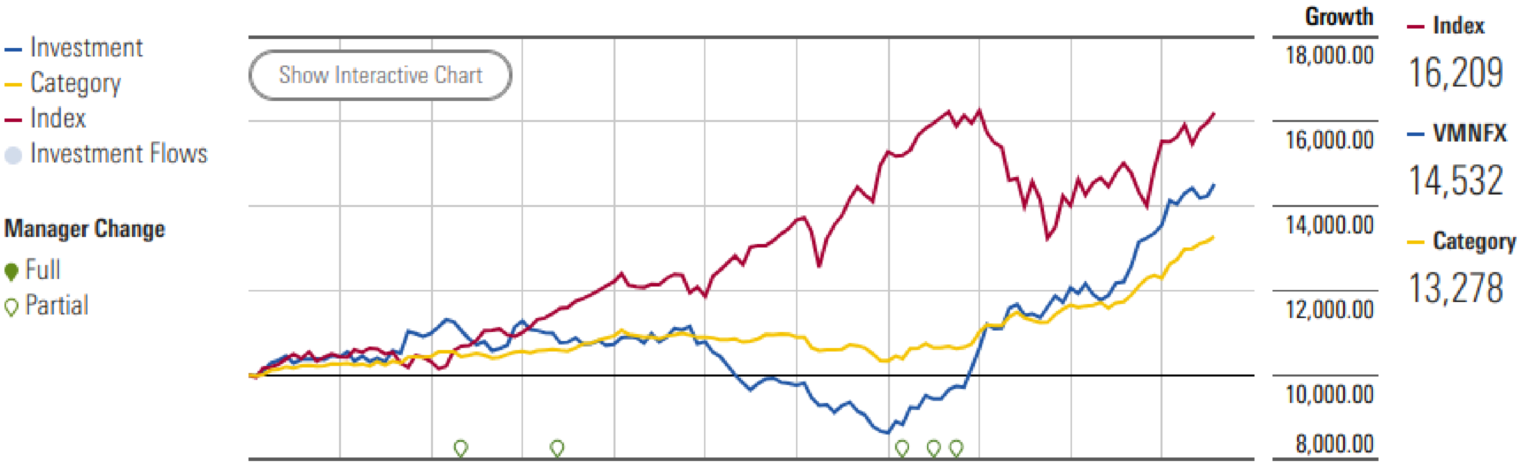
Market-neutral means aiming for beta to be low or zero.
A dollar-neutral strategy will not necessarily achieve this.

In practice, market-neutral funds are more common.

Morningstar tells us that VMNFX has a beta of 0.01.

> **Principal Investment Strategies**
> The Fund follows a market neutral strategy, which the Fund defines as a strategy designed to produce a portfolio that is neutral with respect to general stock market risk (sometimes referred to as beta neutrality). Beta is a measure of a portfolio's volatility relative to the volatility of the general stock market. The Fund, as a whole, does not seek to adhere to any other definition of market neutrality.

Growth of 10,000



Beta and alpha of a dollar-neutral strategy

The beta and alpha of a dollar-neutral fund are **exactly equal** to the difference of these numbers between the long and short portfolios. (We will convince ourselves of this with a numerical example later.)

If both the long and short are large, diversified portfolios from the same asset class (for example the stock market), then we would expect each portfolio on its own to have a beta close to 1 with that asset class, and the fund to have a beta close to zero.

In this sense a dollar-neutral fund will generally come *close* to being market-neutral, but will not exactly achieve this because the betas of the two portfolios will not be exactly equal to each other.

For a market-neutral fund, its alpha is equal to its average return, because its beta is zero. For a dollar-neutral fund, this will be approximately true, though not exactly true since beta is not exactly zero.

In both cases, this leads funds to suggest the risk-free return as the benchmark that investors should use, even though the funds' returns are very volatile on their own.

Distinguishing two effects of short sales

Short-selling can accomplish two distinct goals for you as a fund manager:

- Allows you to construct "pure" bets on price declines, or on relative spreads between returns of different securities.
- Provides **leverage**, amplifying returns (both positive and negative), if you use the short sale proceeds to purchase more securities.

The second point is exactly like our earlier example where the margin requirements can amplify or shrink the percentage return on the short sale.

In practice, funds typically do use short-sale proceeds to buy more securities.
So, in practice both of these effects are typically present when funds engage in short sales.

However, in our course, we mainly care about the first effect and want to set aside the second. For this reason, we will focus on strategies that retain the short-sale proceeds as cash. This is the only approach that does not create leverage.

Application: Building a dollar-neutral value strategy

This example will illustrate the ideas we have just covered, and will get you ready for Homework 4.

Let's recap what we know about value investing so far.

In Module 1 we considered a theoretical perspective:

- We described why it makes intuitive sense, for many people, to buy stocks that appear "cheap" relative to fundamentals.
- For example, you could use the market-to-book ratio as a measure of how cheap or expensive a stock is, and you could have a preference for "value" stocks (low ratio) over "growth" stocks (high ratio).
- But we also pointed out that if markets are efficient, these ratios should not predict future performance. Cheap stocks should stay cheap, and and expensive stocks should stay expensive, on average.

At the start of Module 2 we began to look at what the data says:

- At the start of Module 2 we looked at the data. Using carefully-built data on stock portfolios with higher and lower MB ratios, we found that you would have gotten higher average returns by holding the value stocks.
- But, that still wasn't enough for us. It was possible that cheap stocks were riskier in a way that offsets their higher return.
- So finally, we used the CAPM to investigate that question too. And it turned out that -- at least since 1950! -- value stocks deliver higher returns without having much higher beta.

Conclusion: With hindsight, investors should indeed have been holding more value stocks than what the value-weighted portfolio would suggest.

Now what? Here are two big questions that we still have not answered:

- First, from a practical perspective, what kind of product could someone offer to benefit from this pattern, if you expect it to continue?
- Second, regardless of how you implement the idea, how good is it really?
    - Is the extra return from value stocks big enough to matter?
    - Is it steady and reliable, or does it exhibit volatility and occasional large drawdowns?
    - Is it still present in recent years, or is it mainly driven by the early years in our data?

In today's example we will explain why the dollar-neutral strategy answers both questions.

- It provides a convenient product for investors to decide how aggressively they want to pursue the patterns we have found.
- On an abstract level, regardless of whether investors use the dollar-neutral strategy or a different approach, the returns on this strategy give us a useful indicator of the performance of the idea we are studying.

Our example focuses on trading stocks based on their B/M ratios, but everything I am saying could apply to any investment thesis that you might follow in any asset class. In the rest of Module 3 we will extend these ideas to investing based on market cap, momentum, and profitability, and from there you can continue to any potential idea.

I have already downloaded the following data:

- "rf" : monthly riskfree returns
- "mktrf" : monthly excess return the market (that is, a VW portfolio of all stocks)
- "hi30bm" : monthly return on a VW portfolio of the 30% of stocks that have the highest B/M ratios. This is roughly equal to the average return of the portfolios labeled 8, 9, 10 in our earlier figures that sorted stocks on B/M ratio.
- "lo30bm" : montly return on the 30% of stocks that have the lowest B/M ratios. This is roughly the average return of the portfolios labeled 1,2,3 in the earlier figure.

Notice that the last two are raw returns, not excess returns. We will just have to remember this in the analysis.

We will call the stocks in hi30bm the "value" stocks, and the stocks in lo30bm the "growth" stocks. Go back and remind yourself why if you need to!

Our benchmark investment strategy is always the market. Let's look at its average return, volatility, and Sharpe ratio:

In [3]:

```
print(f"Average monthly excess market return: {100*mktrf.mean() :.2f}%")
print(f"Volatility of monthly excess market return: {100*mktrf.std() :.2
SR_mkt = mktrf.mean() / mktrf.std()
print(f"Sharpe ratio of the market: {SR_mkt :.4f}")
```

```
Average monthly excess market return: 0.59%
Volatility of monthly excess market return: 4.59%
Sharpe ratio of the market: 0.1283
```

Now imagine someone sets up a dollar-neutral fund that takes a long position in the value stocks in "hi30bm", and a short position in the growth stocks in "lo30bm". We immediately know that the excess return on this fund (before fees) will be the difference of the two series. Let's just calculate that.

In [4]:
```
hilo = hi30bm - lo30bm
```

If we look at the same statistics for this fund, it doesn't look all that great:

In [5]:
```
print(f"Fund's average monthly excess return: {100*hilo.mean() :.2f}%")
print(f"Fund's volatility of monthly excess return: {100*hilo.std() :.2
print(f"Fund's Sharpe ratio: {hilo.mean() / hilo.std() :.4f}")
```

```
Fund's average monthly excess return: 0.36%
Fund's volatility of monthly excess return: 3.07%
Fund's Sharpe ratio: 0.1166
```

But this is the wrong way to assess investments! Instead we care about whether this fund can add value as *part* of a risky portfolio that also includes the market. For that we should look at its α and IR:

In [6]:
```
hilo_reg = ols_with_constant( hilo, mktrf ).fit()
hilo_reg.summary().tables[1]
```

Out[6]:

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0047	0.002	3.026	0.003	0.002	0.008
mktrf	-0.1950	0.034	-5.770	0.000	-0.261	-0.129

In [7]:
```
IR_hilo = hilo_reg.params[0] / hilo_reg.resid.std()
print(f"Fund's information ratio: {IR_hilo :.4f}")
print("Maximum possible Sharpe ratio,")
print("using this fund and the market portfolio: "
      f"{np.sqrt( SR_mkt**2 + IR_hilo**2 ) :.4f}" )
```

```
Fund's information ratio: 0.1610
Maximum possible Sharpe ratio,
using this fund and the market portfolio: 0.2058
```

To make it less abstract, let's quantify just how much this strategy could have actually benefited a risk-averse investor.

We will assume that they did not know in advance exactly the returns each strategy would generate, but that they did know the averages, volatilities, and correlations.

How to determine those things is a separate question. You may be willing to just substitute past averages, or maybe not. We largely set aside this question in our course because there is no way to prove a right or wrong answer about any of it.

Let's consider someone who only wanted 1% vol of excess return per month. If they have only a market index fund available, they would allocate about 21% of wealth to it:

In [8]:
```
print(f"Volatility of market portfolio: {100*mktrf.std() :.2f}%" )
allocation = .01 / mktrf.std()
print("Allocation to market portfolio,")
print(f"for an investor who only wants 1% monthly volatility: {100*alloc
```

```
Volatility of market portfolio: 4.59%
Allocation to market portfolio,
for an investor who only wants 1% monthly volatility: 21.76%
```

Over the course of the 30 years a $1 invested initially by this investor would have grown to $10.81.

In [9]:

```
investor_returns = (1-allocation)*rf + allocation*(rf+mktrf)
final_value = (1 + investor_returns).cumprod()[-1]
print(f"Final value of $1 invested initially: ${final_value :.2f}")
```

```
Final value of $1 invested initially: $10.81
```

You may think the investor is being irrational for wanting such a low amount of risk, but their preferences are what they are. Perhaps you could convince them to take on more risk, but in this example you will see how we could have increased their performance wihout needing to do that.

Now imagine they have the dollar-neutral strategy as well. Figure out their optimal risky portfolio as in Homework 2:

In [10]:

```
Sigma = np.cov([ mktrf , hilo ])
mu = [ mktrf.mean() , hilo.mean() ]
weights_unscaled = np.dot( np.linalg.inv(Sigma), mu )
optimal_weights = weights_unscaled / weights_unscaled.sum()
print("The investor's optimal risky portfolio is: ")
print(f"  {100*optimal_weights[0] :.2f}% on the market portfolio,")
print(f"  {100*optimal_weights[1] :.2f}% on the fund.")
```

```
The investor's optimal risky portfolio is:
  41.32% on the market portfolio,
  58.68% on the fund.
```

Calculate the excess returns on the optimal risky portfolio:

In [11]:
```
optimal_returns = optimal_weights @ [ mktrf , hilo ]
```

And check that these returns achieve the maximum Sharpe ratio we calculated earlier:

In [12]:
```
optimal_avg = optimal_weights @ mu
optimal_vol = np.sqrt( optimal_weights @ Sigma @ optimal_weights )
optimal_SR = optimal_avg / optimal_vol
print(f"Sharpe ratio of optimal portfolio: {optimal_SR :.4f}")
```

```
Sharpe ratio of optimal portfolio: 0.2058
```

Now recalculate the investor's desired allocation to the portfolio.

The volatility of their new risky portfolio is actually lower than the market portfolio by itself, so the investor is willing to hold more of it. They allocate about 45% of their wealth to it:

In [13]:
```
print(f"Volatility of the optimal risky portfolio: {100*optimal_vol :.2

new_allocation = .01 / optimal_vol
print("Percentage of wealth allocated to the optimal risky portfolio:")
print(f"{100*new_allocation :.2f}%")
```

```
Volatility of the optimal risky portfolio: 2.20%
Percentage of wealth allocated to the optimal risky portfolio:
45.38%
```

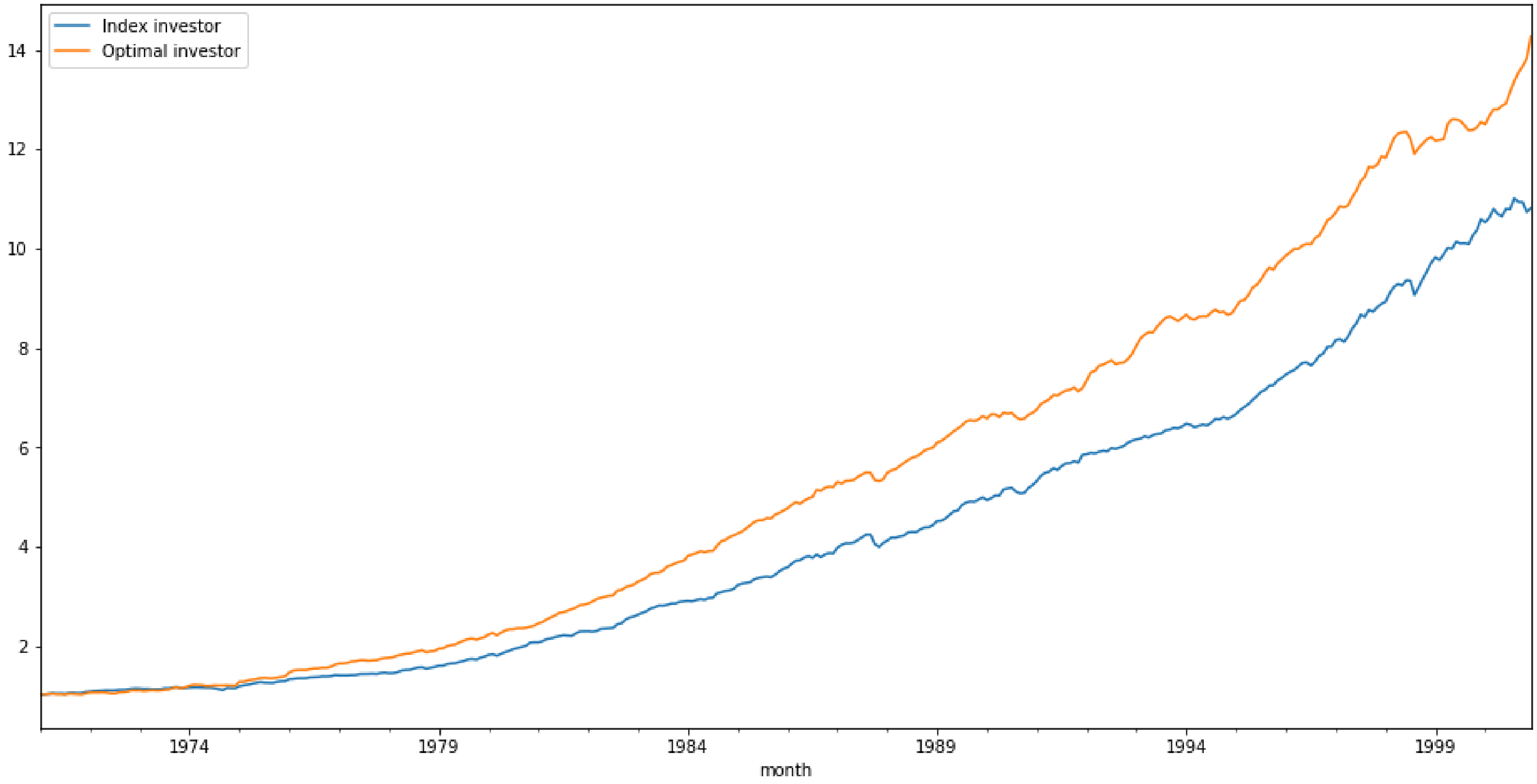
And with this allocation an initial $1 would have grown to $14.26 over 30 years:

In [14]:
```
new_investor_returns = (1-new_allocation)*rf + new_allocation*(rf+optima
final_value = (1 + new_investor_returns).cumprod()[-1]
print(f"Final value of $1 invested initially: ${final_value :.2f}")
```

```
Final value of $1 invested initially: $14.26
```

Let's plot the performance of the two strategies:

In [15]:
```
(1+investor_returns).cumprod().plot(legend=True,label="Index investor")
(1+new_investor_returns).cumprod().plot(legend=True,label="Optimal inves
```



It makes a big difference!

In Homework 4 you will refine and improve this strategy even further.

For now the main takeaway is that we can build such strategies and evaluate them on the statistics we know from Module 2.

Finally, let's check the facts about dollar-neutral strategies that we mentioned earlier.

Look at average returns, and CAPM regression results, for the value stocks on their own:

In [16]:
```
print(f"Average monthly excess return on value portfolio: {100*(hi30bm-r
ols_with_constant((hi30bm-rf),mktrf).fit().summary().tables[1]
```

```
Average monthly excess return on value portfolio: 0.91%
```

Out[16]:

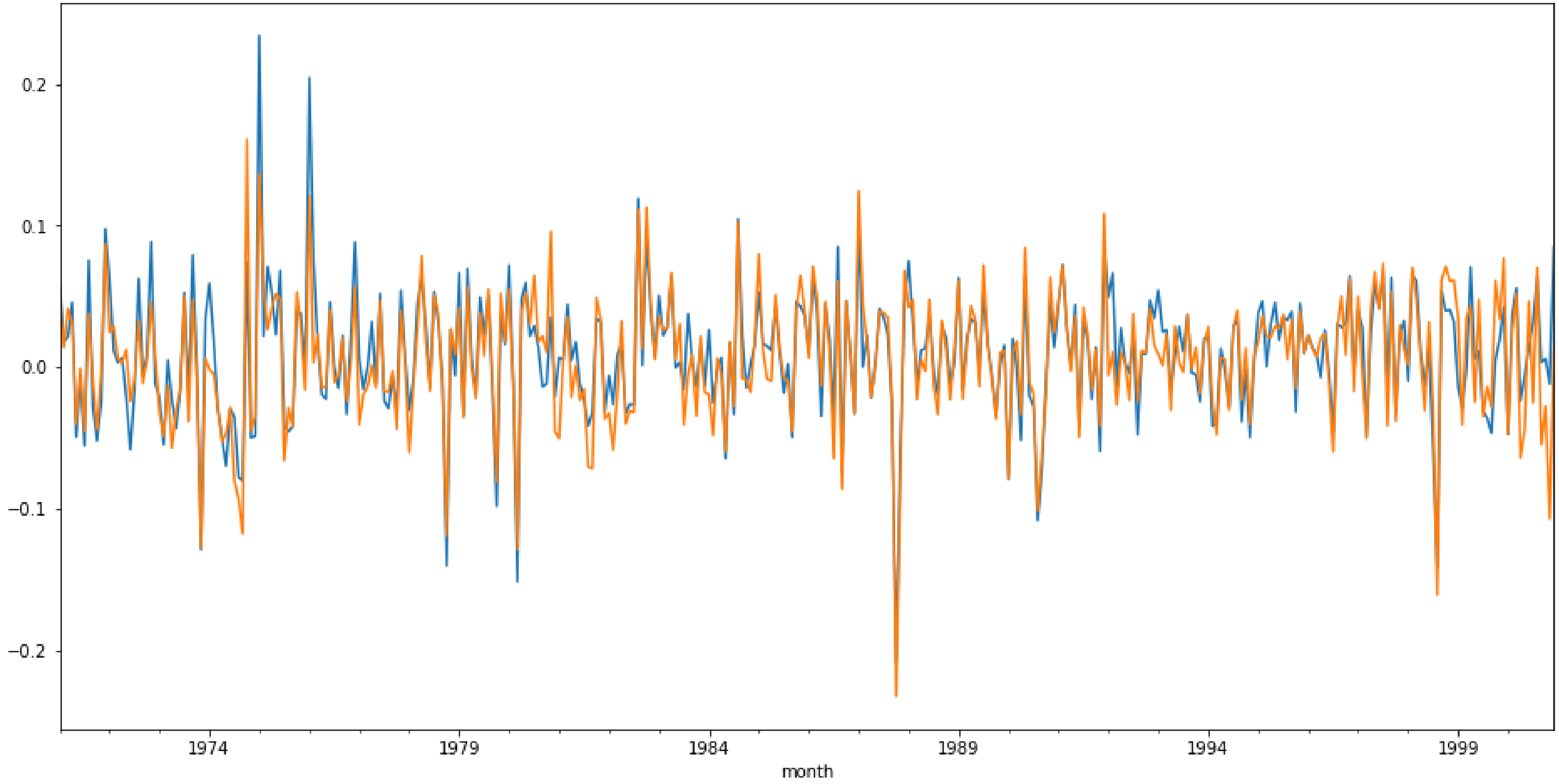
	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0039	0.001	3.500	0.001	0.002	0.006
mktrf	0.8754	0.024	36.048	0.000	0.828	0.923

Their alpha is much lower than their average excess return. This is to be expected with a long-only portfolio of stocks, because its beta is almost guaranteed to be very high!

This complicates the analysis of the strategy: Its average return alone is not very informative about its usefulness to the typical investor.

A value stock portfolio has high market beta

In [17]:
```
(hi30bm-rf).plot();
mktrf.plot();
```



Repeat the same analysis for the growth stock portfolio:

In [18]:
```
print(f"Average monthly excess return on value portfolio: {100*(lo30bm-r
ols_with_constant((lo30bm-rf),mktrf).fit().summary().tables[1]
```

```
Average monthly excess return on value portfolio: 0.55%
```

Out[18]:

	coef	std err	t	P>|t|	[0.025	0.975]
const	-0.0008	0.001	-1.385	0.167	-0.002	0.000
mktrf	1.0704	0.012	85.936	0.000	1.046	1.095

Just like the value stocks, it has high average returns, but much lower alpha (in this case essentially zero).

Finally, run the same regression for the dollar-neutral strategy:

In [19]:
```
print(f"Average monthly excess return on value portfolio: {100*hilo.mean
ols_with_constant(hilo,mktrf).fit().summary().tables[1]
```

```
Average monthly excess return on value portfolio: 0.36%
```

Out[19]:

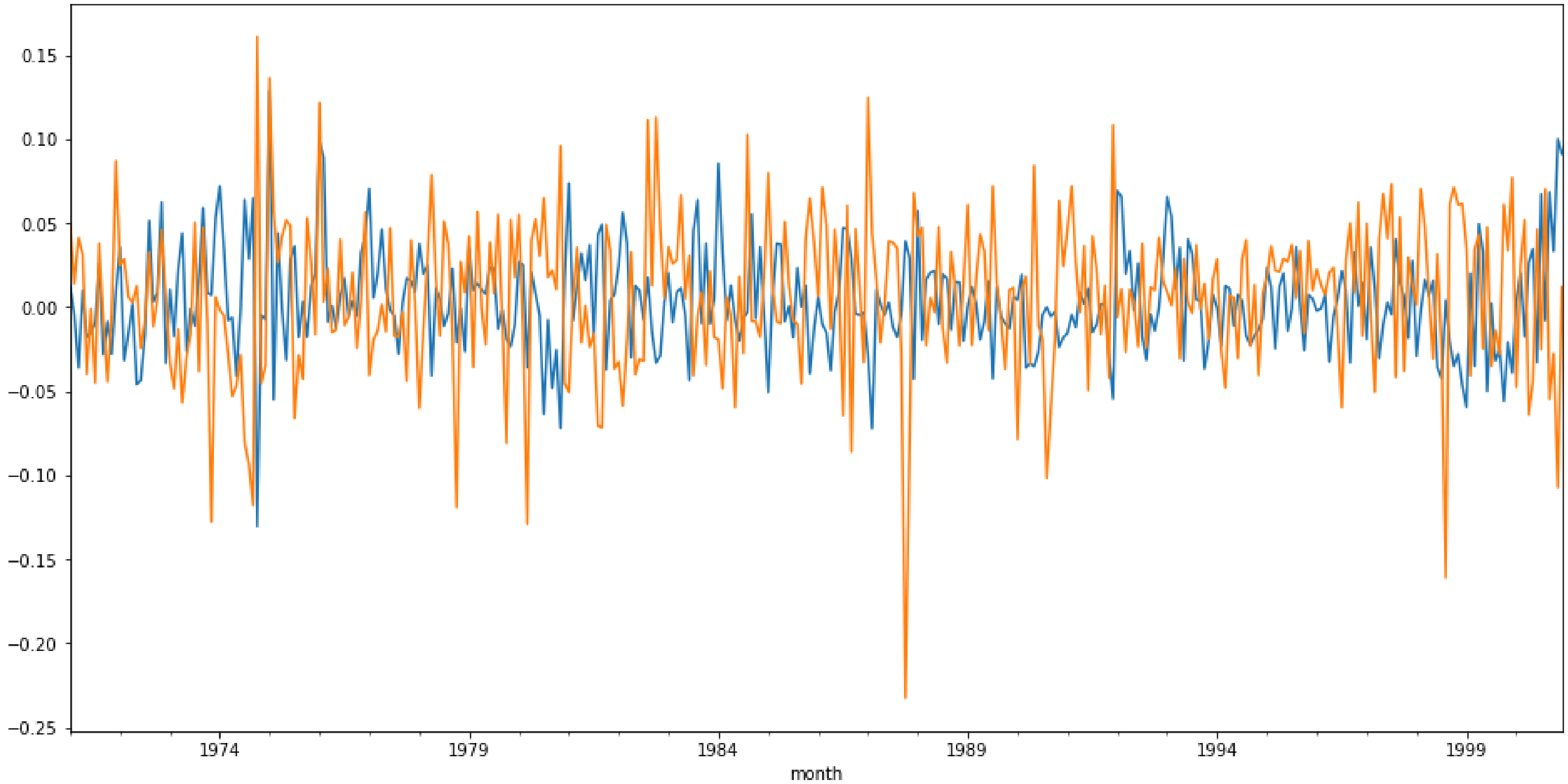
	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0047	0.002	3.026	0.003	0.002	0.008
mktrf	-0.1950	0.034	-5.770	0.000	-0.261	-0.129

As promised earlier, these beta and alpha values are exactly the difference of the same numbers for the value and growth stocks on their own.

Also as mentioned earlier, the alpha of the dollar-neutral strategy is close to its average return, which was not true for either value or growth stocks on their own. In fact, alpha is slightly above average return for this strategy, because its beta is negative.

The dollar-neutral return has very low beta

```
In [20]: hilo.plot();
         mktrf.plot();
```



Conclusion: If a market-neutral strategy can deliver any positive average return *at all*, then it will have positive alpha and be valuable to investors. It may be very risky on its own, but as a small allocation, it can add a lot of value alongside an index fund.

This is why market-neutral funds benchmark themselves against the risk-free rate.

For a dollar-neutral strategy, the same thing is approximately true: Its beta will not be exactly zero, but will generally be close to zero. So its average return is a good indicator of its alpha, even if they are not exactly equal.

For research purposes, it is thus very natural to study investment strategies by using them to sort stocks into "better" and "worse", and simply examine the spread of the returns of these two groups. This spread is investable, and represents something "new" in that it is not very correlated with the index that the investor already holds.

If you end up convincing yourself that an investment idea is valuable, you might very well *implement* it with a different approach. But the return spread is a good way to *study* the idea. It takes only seconds to calculate, and maintains a practical connection with a real strategy you could actually implement.

Our topic for next week is "factor models", which will continue these ideas further.