Crossectional Asset Pricing

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Introduction

Object of interest: Cross section of (US) stock returns (Collection of all stocks traded in a market, such as NYSE.).
Evolution of understanding (Where do factors come from?)

- CAPM
- Anomalies
- The Fama and French 3 factor model
- Momentum
- ..
- The Fama and French 5 factor model

The Capital Asset Pricing Model (CAPM) – Theory

Theoretical starting point: The Capital Asset Pricing Model (CAPM), due to Sharpe [1964], Lintner [1965] and Mossin [1966].
Want to value all available equities (the corporate sector of the economy).
CAPM is a one period model.
Payouts from all stocks: All that is available to consume in the economy in the last period.
Consumption = aggregate stock market return.
Risk that matter to equity owners: their future consumption opportunities.
Hence, the only relevant risk in the CAPM: covariability with aggregate stock market return,
or

$$\beta_i(\text{beta}) = \frac{\text{cov}(r_i, r_m)}{\text{var}(r_m)}$$

Initial Tests

Early testing of the CAPM.
Late sixties, early seventies.
CRSP, academic database with US stock returns, starting 1926, collected at the University of Chicago.
Well known studies: Black et al. [1972] Fama and MacBeth [1973]
Initial results supportive of the CAPM.
Expected Returns linked to estimates of beta.
However, even in the early tests examples of additional explanatory variables.
E.g. idiosyncratic risk seemed to matter.

Anomalies?

After the success of the initial empirical tests of CAPM:
Academics convert finance industry to calculate NPV, using CAPM to adjust for risk.
Key influence, publication of Brealey and Myers [1980].
Seventies: Normative prescription: "all you need is beta".
Early eighties: Beginning to see empirical work where "beta is not enough", predicting returns with other variables.
Embarassing, since it seems to contradict the normative prescription.
First line of defence:

- Well, beta is not observed, it is only estimated.
- The "true beta" is the covariance of the firms' future business with the stock market.
- Using historical return data to estimate beta assumes "nothing changes"

But...

The Size Anomaly

But small stocks have *really* higher returns... Particularly in January...

This is a pattern that is not isolated to the US, look to Norway (1980–2015).

Month	1(small)	2	3	4	5(large)
Jan	8.6	5.5	5.7	4.1	2.8
Feb	4.7	2.9	3.6	2.3	1.2
Mar	3.1	2.5	2.1	2.1	1.7
Apr	3.5	3.2	3.4	2.9	3.0
May	1.9	1.5	1.5	1.9	1.0
Jun	0.3	-0.3	-0.6	-1.0	-1.4
Jul	3.4	2.2	2.3	2.5	3.3
Aug	1.1	0.1	0.0	-0.3	-0.8
Sep	0.7	-0.6	-1.1	-2.0	-1.7
Oct	0.4	1.2	1.2	0.9	0.7
Nov	1.7	-0.1	0.2	0.6	-0.1
Dec	1.0	0.8	2.9	3.5	2.7

Averages of monthly (percentage) returns for 5 size portfolios for Norway. Averages shown for each month.

Anomalies do not go away

Even allowing for time-varying beta not enough to explain away the crossectional patterns.
This effect could not be reconciled with the CAPM.
Finance academics called this an "Anomaly"
Only an "anomaly" relative to a strict interpretation of the CAPM, though.

Adding anomalies ..

Another "anomaly": *Momentum* – past behaviour of stock prices could predict returns.

- Short term continuation: Jegadeesh and Titman [1993] – stocks with high returns over the past three to twelve months (winners) outperform stocks with low recent returns (losers) over the next three to twelve montsh.
- Long term reversals: DeBondt and Thaler [1985] – Winners over the past three to five years underperform losers.

And another: Book/Market – Sorting on Book/Market has predictive information for future returns.

What is best in explaining the crossection?

Fama and French [1992]: US crossection from 1926 till 90.
Summarize results as

- β does a poor job in explaining cross–section of asset returns.
- Size and B/M does a much better job.

Starting the "Beta is dead" debate.

An alternative asset pricing model: Fama and French 3 factor model

Fama and French [1996] then formulate a model that they claim can account for most of the crossectional variation, where they add the two Fama and French factors `SMB` and `HML` that accounts for size and B/M differences.
The resulting model is essentially the CAPM plus two additional terms:

$$E[er_{it}] = \beta_i er_{mt} + b^{SMB} SMB_t + b^{HML} HML_t$$

These variables are best remembered from their mnemonics:

- SMB - Small Minus Big (i.e. small minus big companies)
- HML - High Minus Low (i.e. high B/M minus low B/M

The FF Factors

For the construction they split data for the US stock market as this:

		Book/Market		
		L (30%)	M (40%)	H(30%)
Size	Small (50%)	S/L	S/M	S/H
	Big (50%)	B/L	B/M	B/H

The pricing factors are then constructed as:

$$\texttt{SMB} = \text{average}(S/L, S/M, S/H) - \text{average}(B/L, B/M, B/H)$$

$$\texttt{HML} = \text{average}(S/H, B/H) - \text{average}(S/L, B/L)$$

The FF Factors - construction - investability

Note an important property of the all these factors: They are (in theory) tradable.
They are zero investment investment strategies, a long position minus a short position.

$$\texttt{SMB} = \text{average}(S/L, S/M, S/H) - \text{average}(B/L, B/M, B/H)$$

One can construct SMB by

- A long position in $EW(S/L, S/M, S/H)$
- A short position in $EW(B/L, B/M, B/H)$.

Using "canned" FF Factors

In estimation settings we need thus need the two factors SMB and HML.
These are typically downloaded from Ken French homepage.
He has constructed such factors for

- The US
- Global investments

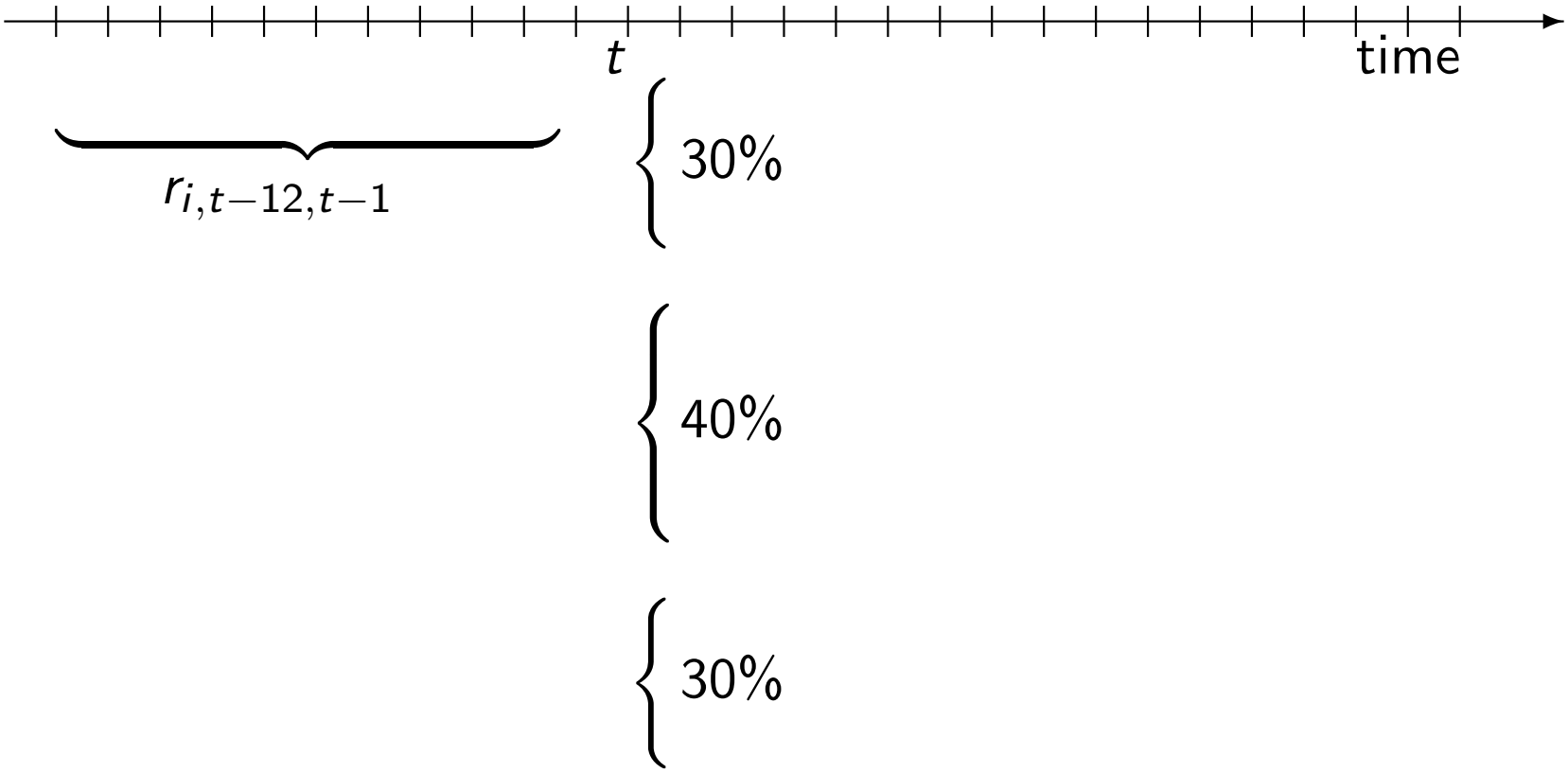
For Norway get corresponding factors from my homepage.

Momentum

Carhart [1997] introduced an additional factor that accounts for momentum.

Calculate returns over the previous eleven months.

Split stocks into three portfolios: The top 30%, the median 40% and the bottom 30%.



The momentum factor

The Carhart [1997] factor `PR1YR` is the difference between the average return of the top and the bottom portfolios.
This factor is also a zero investment portfolio.
One can replicate it by a long position in winners and a short position in losers (calculated over the previous 11 months).
Feature of this portfolio: It needs to be rebalanced often (each month).

Is the three(four) factor model sufficient?

By 2000, academics use either the three or four factor models by default in any setting investigating the US crossection.
But it was not a satisfactory situation.
Essentially, the factors that are added to market are proxies for some unknown source of risk.
Theoretially, it is hard to see the link between these factors and any economic model.
Researchers keep trying alternative ways of sorting the crossection

- Either trying to replace the FF factors with ones more understandable in terms of economics.
- Or finding factors with additional/better explanatory power. (Factor Fishing)

Examples of avenues of research

Examples of things that are tried

- Macro Variables - can they replace the FF factors [Liew and Vassalou, 2000]
- Liquidity [Amihud and Mendelson, 1986] (size may be a proxy for illiquidity)
- Firm Investments (Looking for real options)
- ...

Thinking about stock pricing

There are also some ways one can rationalize some of the observed effects by other means.
A cute example is provided by Jonathan Berk [1995], that may explain some of the size effect.
The net present value intuition is always useful.
Suppose we have two firms i, j with identical annual future cash flows X. They are then priced as

$$P_i = \frac{X}{r_i} \qquad\qquad P_j = \frac{X}{r_j}$$

The more risky firm (j,say) will have higher cost of capital r_j.
Since we are dividing by a larger number r_j, the *Price* P_j is *lower* than P_i. The lower price $\rightarrow$ Lower firm value.
Potential mechanical link between firm size and riskiness.
Small firms may just be more risky, a riskiness we may not identify by other means.

The last word in factor models – Fama French again

A recent step on the "lets add factors" road is Fama and French [2015].
In this article Fama and French add two more variables to their three factor model, giving the Fama French Five Factor Model. These are again zero investment portfolios, but sorted on two different *accounting* variables.

- Operating profitability, OP, in the sort for June of year t is measured with accounting data for the fiscal year ending in year $t-1$ and is revenues minus cost of goods sold, minus selling, general, and administrative expenses, minus interest expense all divided by book equity.
- Investment, Inv, is the rate of growth of total assets from the fiscal year ending in year $t-2$ to the fiscal year ending in $t-1$."

The Fama French five factor model (2015)

Doing the usual double sort, Fama and French then introduce the additional factors

- RMW – Robust Minus Weak (profitability)
- CMA – Conservative Minus Aggressive (investments)

Resulting in their five factor model

$$\begin{aligned} E[r_{i,t}] &= r_{f,t} + \beta_i E[er_{m,t}] + b_i^{SMB} SMB_t + b_i^{HML} HML_t \\ &\quad + b^{RMW} RMW_t + b^{CMA} CMA_t \end{aligned}$$

So, where are we today?

Four decades of research given us a "menu" of possible ways to describe the cross-section of asset returns (and the resulting expected return of an asset).
Best known

- CAPM
- Fama-French 3 factor
- Fama-French 3 factor + Momentum
- Fama-French 5 factor

How are these models used?

Leaving out the academic side,
Where are these more complicated primarily used in practice?

- Investment Allocation (large portfolios)
- Investigating Portfolio Performance.

Where are factors *not* used? Corporate Finance / Valuation.

- Whenever we start estimating cost of capital for valuation purposes – back to the CAPM.
  One reason for this: Estimation Uncertainty.
  Estimating parameters of five factors inherently a noisy process.

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