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Financial Economics

Session 4: CAPM

Applicability, empirics and extensions

Postgraduate Class 2017
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DEPARTMENT OF ECONOMICS

News this week: 2014

- African Bank Investment Ltd (ABIL) had a rough old week…
  - After the shock resignation of CEO Leon Kirkinis on Wednesday (*following an exceptionally poor trading statement once again – a headline loss of over R6.4bn for the year to September, requiring R8.5bn in new capital*)– the share price plummeted from **R6.88** last Tuesday, to **30c** by Friday… shrinking the market value of ABIL from R10bn to R465mn in one week!
  - Although ABIL's problems emerged last year with a report and fine by the SA NCR.

News this week: 2014

- ABIL was yesterday placed under curatorship by the SARB.
  - The SARB acted quickly and highly effectively in dealing with the matter, as e.g. Kokkie Kooyman said:
  - *"I am impressed with the whole exercise and clarity of the Reserve Bank's communication.... What they have done is bought time for the curator and managers to resolve outstanding issues and eventually give shareholders a better basis on which to make a decision on whether to put more capital on African Bank.*
  - The SARB split the Bank into a "Good bank" and a "Bad Bank" – buying the bad part at a discount (paid R7bn for the R17bn part of the book – while the big four banks and Investec and the PIC bought the "Good Part" of the book for R26bn.
  - Trading of ABIL shares have been suspended on the JSE – and plans are being drawn up to let it trade as the good bank part in time (to let investors opt in or out).

News this week: 2015

- Big News: China devalues its currency.
  - This follows sustained strengthening of the dollar which has put strain on the Chinese currency (Yuan) which largely tracks it.
  - What does this imply?
    - Could it signal structure weakness in the Chinese economy and that commodity demand might be lower in the future?
    - It might lead to the Fed postponing its rate hikes (as this would lead to a further strengthening of the US$, and might lead to further relative Yuan depreciation – which in turn could potentially hurt US trade competitiveness… Although this VOX article suggests the US is in a better space today than it was in 2009, when the Chinese were blamed for its competitive devaluation policies:

http://www.vox.com/2015/8/13/9149953/chinese-currency-devaluation-explained)

News this week: 2015

- Chinese devaluation stirs our market:
  - The JSE had a rough ride this week following two days of consecutive devaluations by Chinese authorities.
  - Resources bounced back somewhat, but Naspers in particular took shots due to its large Chinese market exposure…
  - <u>The two sides of the devaluation:</u>
    - China's imports are hurt – impact on commodity prices and the rand.
    - US' relative export competitiveness might lead the Fed not to raise rates in September following better economic environment, as this could lead to further Chinese devaluations…

News this week

- Tencent rally brings valuation of Naspers into sharp perspective…
  - Its one third holding of Chinese tech giant, Tencent, which saw excellent results boost the share price tremendously this past year – is worth roughly R1.8trn.
  - Yet Naspers currently has a Market Cap of roughly R1.27trn.
  - THUS: You are getting paid well to hold all the other companies in the Naspers stable.

  - What's going on here (and has been for years)?!
  - Is Naspers (at close to R3000 per share) undervalued, or is the tech industry (particularly the fickle Chinese market) – experiencing a bubble?

ANNOUNCEMENT: Essay!

- The essay will be due last Friday of September.
- <u>The following applies:</u>

  - **Topic to be finalized and communicated to me the week after the term break**
    - **Needs to be finance focussed**
    - **Maximum of 2500 words.**
    - **Marks awarded based on quality of writing, depth of research, innovative thinking / strength of reasoning, how well you addressed and covered your topic**
  - Turnitin submission on or before the final date.
  - The topic needs to be interesting and informative – the idea being that you teach yourself something that falls outside the scope of this course, but which interests you.
  - See it as an opportunity to spend time tooling up on an area in finance that you are interested in
  - Read the FT, Bloomberg News, VoxEU, finance blogs, etc. to get some idea of what interests you!

Plan for today

- CAPM's empirical performance.
  - Growth vs Value assets
- CAPM's use in practice: How its values are determined and by whom
- Extensions of CAPM
- Empirical performance.
- Anomalies in finance

CAPM's major contribution

- The asset pricing equation that we derived last session, CAPM, provided investors with an important insight – in that **the expected excess return on holding a security is directly proportional to its systematic (market) risk**, as given by its β, and is **not** related to its **idiosyncratic** (asset-specific) **risk**.
  - This may sound completely un-intuitive… but consider this:
  - Such idiosyncratic risk is not compensated for, as such risk is assumed to be completely eliminated in an efficient market by combining the asset with other imperfectly correlated assets in a diversified portfolio.
  - Outperforming the market, therefore, requires investors to take on higher than unity β assets in theory – thereby accepting higher risk in hope of getting higher return

$$R_k = R_{RF} + \beta_k \cdot (R_M - R_{RF})$$

How are the parameters used calculated in practice?

- Several firms in SA offer services that provide key measures to their clients with which to calculate the relevant risk-adjusted returns of financial assets and portfolios.

- The one we will focus on today is that of the BNP Paribas report (available on the course web page)

Portfolio's Beta

- For many institutional investors and firms alike, calculating the weighted β of a portfolio's shares is an important indication of the amount of risk the portfolio is exposed to (for fund managers, investors and regulators alike).
  - This also allows investors to assess the ***relative*** performance of a portfolio.
- The relative performance of a portfolio is an important concept that uninformed investors tend to ignore.
  - In the past (and even still today) many investors evaluated the performance of a portfolio based on its returns only.
  - This is, however, a dangerous exercise as risk-unadjusted performance measures ignore the risks taken to achieve the return.
  - A portfolio that has a higher risk exposure should, by definition, offer investors higher returns – otherwise they are not compensated for the potential downside to the investment strategies employed.

Portfolio's Beta

- The premium paid (i.t.o. fees) to asset managers that attempt to outperform the market → are (in theory) justified by their ability to correctly predict the movement of the market (or individual assets).
  - Shifting the weighted Beta of a portfolio is vital in correctly "timing" the market (move to high beta stocks in bull market / low beta stocks in bear markets…)
- Thus, in theory – in a closed universe where investors face only a choice of risky equities and the RF asset – if a portfolio **A** has weighted $\boldsymbol{\beta = 1.5}$ and portfolio B has weighted $\boldsymbol{\beta = 0.8}$, we expect portfolio A to outperform portfolio B on aggregate, **due to the larger risk undertaken** (very broadly speaking)
  - If A earns 7% and B 6%, how do we assess which portfolio delivered the **best relative performance**?

Portfolio's Beta

Comparing the risk-adjusted returns of different portfolios by:

1 Divide annual return by the portfolio Beta.

This is known as the **Treynor Ratio**:

$$\mathrm{T} = \frac{R_P - R_F}{\beta_{portfolio}}$$

A **higher Treynor** ratio implies a portfolio having a **higher risk-adjusted return**.

The problem with this measure is that it implies that a portfolio is well diversified (so that $\beta =$ good measure of the un-diversifiable risk the portfolio is exposed to)

2 We could also i.s.o. β (which assumes a very well diversified portfolio) use the **Sharpe ratio**

$$\mathrm{S} = \frac{R_P - R_F}{\sigma_{portfolio}}$$

Portfolio's Beta

- Notice that the **Sharpe ratio** measures performance relative to the CML, while the **Treynor ratio** measures performance relative to the SML.
- Although **T** is easier to compute (easy to find weighted β), **S** is a better comparable figure (although it assumes the risk is accurately reflected in past variation…)
  - In our closed universe, a weighted portfolio β of 0.7 should by definition yield the same as a portfolio consisting of 70% M and 30% RF assets.

- Another measure widely used to compare portfolios is Jensen's Alpha:
  - Here we compare two portfolios that have the **same $\boldsymbol{\beta}$**, and determine their α's.
  - Remember from the previous session that **$\boldsymbol{\alpha}$** was an indication of **excess return** (above expected). Thus if true return = R_P, then:

Jensen's Measure: $\alpha_P = (R_P - R_{CAPM}) = R_P - \{R_F - \beta_P(R_M - R_F)\}$

Portfolio's Beta

- Now suppose a portfolio manager earned a high α in the last year.
  - This implies that the return on his portfolio was higher than expected (or **above-average** considering the **risk-objectives**)
- Is this in any way an indication of future positive and high α?
  - Not even close.
  - Perhaps it was luck. Or perhaps the manager hid some of the risk the portfolio was exposed to (remember 2008 – many portfolio managers scampered to stock up their funds with high earning "Super Safe" MBS instruments… clearly belying their **true** portfolio risk and creating the ***illusion*** of superior $\alpha's$).
  - Or perhaps (and I'm sure the manager will agree…), it was just down to unique skill…

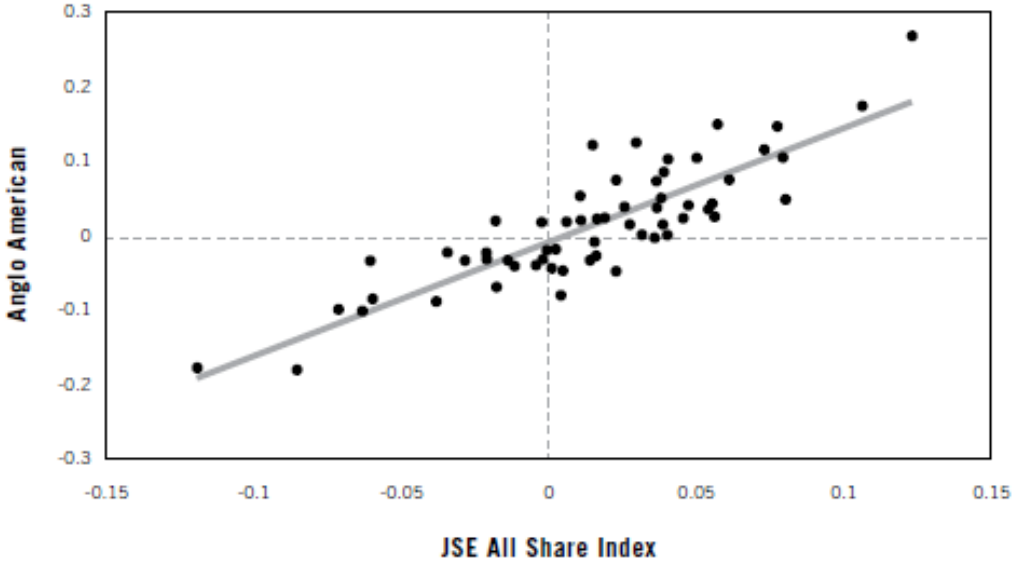
What it then boils down to…

- Active investment strategies then boils down to **chasing alphas**.
- This chase can, however, yield an unfruitful exercise on aggregate → as the costs erode the return on aggregate.
- The problem then is – in the short run your manager might have a high α, but over the long term will probably return the market return – minus costs, it would leave you in a negative sum game…

- ***See Bogel's cynical, yet insightful paper on investments, as well as Nassim Taleb's interesting insight on the difference between noise and information - posted on the site… is chasing alpha based on noisy patterns a wise thing?***

How are these measures computed in practice?

- As mentioned, we will now look at how industry calculates the parameters that we can use to evaluate assets and portfolios.
- First, the monthly (or whichever you have available) returns are calculated for each of the relevant shares on the JSE, while the corresponding returns of the JSE/FTSE ALSi (All Share Index) are also calculated.
- They then regress the two series as follows (For Anglo Am & JSE ALSi):



Source:
Cadiz:
Equity Risk Service on the JSE

How are these measures computed in practice?

- The individual shares and separate indexes (including, among many, the JSE Top 40-, Financial-, Venture Capital-, AltX-, Listed Property-, Value- & Growth Indexes and also all the shares listed) are then regressed relative to the **Benchmark**
  - The Benchmarks in the report are: the JSE/FTSE ALSi, Financial and Industrial Index, Resource top 20 Index & the JSE Top 40 index.
- Several key indicators are then provided for stock / indexes relative to the Benchmark used:
  1. β → the regression line fitted using the regression techniques: This is (as hammered home by now) an indication of the sensitivity of a share / index's price change relative to the benchmark (market).
  2. **Annualised** α → Avg return if the Benchmark had a zero change (thus the intercept of the regression line): proxying excess returns for holding this share…

How are these measures computed in practice?

3. **SE(β)** → This is an indication off the reliability of the estimate of β. This is used to construct a C.I. that we assume with 95% assurance contains the true β. By definition, a low SE indicates an accurate estimate of β.

4. **Annualized Total risk** = σ_{Returns} : This measures the share / index's total risk in % (but remember our contention about risk measured as % deviation of returns…). To make the monthly adjustment – divide the % by 12.

5. **Annualized Unique risk** = Fluctuations due to events unique to the company (strikes, bad management, law suits…)

6. $\mathbf{R^2}$ → Proportion of total risk accounted for by the **market** (**systematic**) **risk**.

A **high** $\boldsymbol{R^2}$ implies much of the variation in Assets returns are caused by the Market's variation. **Low** $\boldsymbol{R^2}$ → large proportion of movements due to unique factors

A few such examples of **Indexes** relative to **JSE ALSi (Dec 2014)**

Index	β	SE(β)	Ann Total Risk (σ%)	Ann Unique Risk (%)	R^2
JSE ALSi	1.00	0.00	18.7	0	100%
Top 40	1.06	0.01	18.7	1.7	99%
Resource top 20	1.3	0.08	26.7	11	83%
Industrial top 25	0.78	0.07	17.3	9.2	71%
Financial top 15	0.74	0.11	21.1	15.8	43%
Venture Capital Index	1.5	0.49	**72.4**	**66.2**	15%
Alt X	**0.61**	0.17	26.1	23.3	19%
Value Index	0.94	0.04	18.3	5.1	93%
Growth Index	1.07	0.04	20.8	5.4	92%

Expected total monthly variation: $72.4\%/12 = 6\%$

A few such examples of **Shares** relative to **JSE ALSi (Dec 2014)**

Share	β	SE(β)	Ann Total Risk (σ%)	Ann Unique Risk (%)	R^2
ABSA	0.56	0.16	24.5	22	18%
FNB	0.78	0.18	28.9	24.7	25%
Nedbank	0.65	0.16	25.9	22.7	22%
Standard Bank	0.74	0.17	28	24.1	25%
Capitec	0.63	0.2	30.2	27.6	15%
Old Mutual	1.18	0.22	33.6	25.1	43%
Sanlam	0.81	0.14	25.1	19.8	37%
Anglo Am	1.67	0.16	37.8	21.2	68%
Shoprite	0.38	0.17	24.1	22.8	8%
MTN	0.84	0.16	27.1	22	34%
Vodacom	0.3	0.22	17.9	17.1	6%
Sasol	1.05	0.11	24.6	14.8	63%

Considerations when using such quantitative indicators

- For shares that are thinly traded, the estimate of β will be less accurate – the Cadiz report controls for this.
- **Time horizon** → the report uses 5 years of monthly data (60 data points), which might be subject to small sample biases – but the trade-off is that a monthly frequency is subject to less noise and errors than higher frequency (weekly / daily).
- **Stability of Betas** → as mentioned before, Betas can and do change over time. This can be problematic for investors hoping to "cash in" on a high beta asset in a bull market, only to find a dampened upside and an intensified downside made the Beta look large…
- (for more details on the practitioners guide to calculating this measure… See: EstBeta.pdf on webpage)

Considerations when using such quantitative indicators

- As these indicators are based on past co-movements of the shares and the market, several factors may **influence its accuracy** in determining future co-movements:

  - **Accuracy** of **past data** – can be questioned as the past five years include a heavily distorting global financial crisis.
  - Intensified **interconnectedness** of certain shares in your portfolio at times, that negate the diversification benefits and causes the portfolio to vary less than in accordance to the market.
  - **Unexpected events** / **unique factors** of a business might become more pronounced in the future – thus investors should be aware of this and keep it in consideration. This emphasizes the need for **qualitative evaluations** and forecasted quantitative evaluations too.
  - Some businesses listed on the JSE might be **more influenced** by **external factors** / macroeconomic factors that do not necessarily influence the market. This can be seen by viewing the low R^2, which may not necessarily be a good indication of this.

Market Beta = Naspers?!

- Today the Beta measure has often been criticized as implying the comovement largely with Naspers (and a few other stocks).
  - Which, indirectly, implies the comovement with the Chinese market via tencent.
- A couple of years ago Beta was tilted towards the resource sector (and thus showed high comovement with commodity prices).

Examples of how we can use the indicators.

- Suppose you were provided with the tables above as given.
- Calculate the **Beta and Risk** of a portfolio that consists of the following asset distribution (the nice thing about finding the $\beta_{Portfolio}$ is that it can simply be added with the respective weightings):

SHARE	% of portfolio
ABSA	30
ANGLO AMERICAN	20
MTN	10
JSE ALSi	30
R157 Bond	10

Portfolio Beta : $\sum(\text{Weight}) \,.\, (\beta_{Shares})$

$$\beta_P = 0.3(0.56) + 0.2(1.67) + 0.1(0.84) + 0.3(1) + 0.1(0) = 0.886$$

Examples of how we can use the indicators.

Calculate the total Portfolio Risk:

Total Risk = Systematic (market) Risk + Non-Systematic (unique) Risk

$$Total\ Risk^2 = Market\ Risk^2 + Unique\ Risk^2$$

$$Total\ Risk^2 = R^2(Total\ Risk)^2 + (1 - R^2)(Total\ Risk)^2$$

∴ Market risk of this proposed portfolio:

Market risk $= \beta_P.(Total\ risk\ of\ the\ Market\ index) = \beta_P.(\sigma_{JSE\_ALSi})$

$$= 0.886(18.7) = \mathbf{16.56\%}$$

Unique Risk of the portfolio: (bit more complicated)

Unique Risk = $\sum(Weight).(\sqrt{[(1 - R^2) * (Ann\ Total\ Risk)]^2})$

$$= 0.3 * \sqrt{[(1 - 0.18).(24.5)]^2} + 0.2 * \sqrt{[(1 - 0.68).(37.8)]^2}$$

$$+0.1*\sqrt{[(1 - 0.34)(27.1)]^2} = \mathbf{13.2\%}$$

Calculating the total Portfolio Risk:

Total Risk = Systematic (market) Risk + Non-Systematic (unique) Risk

$$Total\ Risk^2 = Market\ Risk^2 + Unique\ Risk^2$$

$$= 16.56^2 + 13.2^2 = 448.4$$

Thus the Total Risk of the portfolio that we proposed would be:

$$\sqrt{448.4} = \mathbf{21.17\%\ P.A}$$

And the portfolio's $R^2 = \frac{Market\ risk}{Total\ portfolio\ Risk} = \frac{16.56^2}{448.4} = 0.61$

$$\& \therefore (1 - R^2) = 0.39$$

So that the movement in the JSE ALSi explains approx. $\mathbf{61\%}$ of the movement in our portfolio – implying great scope left to diversify portfolio further & make the $(1 - R^2)$ statistic less (and thus be less exposed to unique risks!!)

Abnormal Portfolio return

- Suppose you are given the following returns information at the **end of the year.**

SHARE	Return
ABSA	15 %
ANGLO AMERICAN	-3 %
MTN	10 %
JSE ALSi (R_M)	8 %
R157 Bond (R_{RF})	5.5 %

- Calculate the portfolio's **abnormal** return:

Remember: $\beta_P = 0.886$

This implies the benchmark risk-adjusted return (i.e. of a portfolio having 88.6% invested in JSE ALSi and 11.4% invested in R157 Bond) is:

$$0.886\ (8\%) + (1 - 0.886)(5.5\%) = \mathbf{7.715}\%$$

Abnormal Portfolio return

SHARE	Portfolio Weight	Return
ABSA	30%	15 %
ANGLO AMERICAN	20%	-3 %
MTN	10 %	10 %
JSE ALSi	30%	8 %
R157 Bond	10%	5.5 %

- Our portfolio return would then be:

$$0.3(15\%) + 0.2(-3\%) + 0.1(10\%) + 0.3(8\%) + 0.1(5.5\%) = \mathbf{7.85}\%$$

The Abnormal Return of our portfolio is thus:

$$7.85\% - 7.715\% = 0.135\%$$

Abnormal Portfolio return

- Before applauding the portfolio manager too much, perhaps this abnormal return of $\mathbf{0.135\%}$ needs to be put into perspective…

  - Although the Market risk of our Portfolio and the Benchmark portfolio (on the SML in the CAPM) is identical, our portfolio has more ***unique risk*** ($\mathbf{13.2\%}$ compared to the $\mathbf{0\%}$ of the benchmark portfolio having 88.6% in M and 11.4% in RF).
  - This implies that investors are merely compensated (with 0.135%) for holding more unique risk in a **less** diversified portfolio…
  - This follows as there is **no compensation for holding unique risk** → the core of the CAPM insights!!

Abnormal Portfolio return

- We can now calculate the two measures mentioned earlier:

$$\mathrm{T} = \frac{R_P - R_F}{\beta_{portfolio}} = \frac{7.85 - 5.5}{0.886} = 2.65$$

$$\mathrm{S} = \frac{R_P - R_F}{\sigma_{portfolio}} = \frac{7.85 - 5.5}{21.17} = 0.11$$

- As mentioned earlier, however, due to the portfolio not being **highly diversified** – it is better to use the **Sharpe ratio** in this case (as the β used in T assumes a sufficiently diversified portfolio).

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CAPM's Relevance today:

Survey of SA businesses

Correia and Cramer (2008)

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CAPM's relevance in SA

- CAPM, most likely due to its simplicity and applicability – is still very much a useful starting point for any quantitative analysis of a financial asset's value, and forms the basis for more advanced techniques.
- In fact, according to Correia and Cramer (2008: 41) the vast majority of companies in SA use CAPM (or some basic derivative thereof) to determine the fair cost of equity.
  - The extensions thereof, such as APT and the dividend discount model, are almost never used in the valuation of equity in practice
- The authors indicate a great movement toward explicitly valuing equity i.t.o. CAPM (both in SA and abroad) over the last 15 years.

CAPM's relevance in SA: RF

- What do firms use as the Risk Free rate?
  - Correia and Cramer found the choice of bond yields to use in acting as a proxy for the RF is quite varied. Although McKinsey & Co. recommend the use of longer term bond yields that are less volatile, firms used a great variation of bond yields (such as the R157 (maturing 2015), R201 (2014), R186 (2026)*,,…) as a proxy for the RF. In fact, SA firms have shown to be more inclined to use the shorter term yield (R157).
  - Clearly there are no clear consensus of which bond yield to use as RF proxy (which of course changes the pricing of equity between firms… necessarily a bad thing for market liquidity?)

    - *These are names of bonds with different maturities*
    - We will be covering it in more detail in a later session, but for now you can check out table 11.4 in the textbook for a more thorough indication.

CAPM's relevance in SA: Equity premium

- The **equity market premium** of the CAPM: $(\boldsymbol{R_M - R_{RF}})$, reflects the additional return that investors require for investing in the market portfolio (or for holding equity in general).
- As with the proxy for RF, there is no clear consensus as to the calculation of the **equity premium** for SA.
- Firms in SA have shown to use an equity premium of roughly **5.35**%, while the median is 5%.
    - This is more or less consistent with the literature, with Kruger (2005) estimating it at 5 – 5.5% and Dimson, *et al* (2003) at 5.2% historically.

CAPM's relevance in SA: β

- Calculating accurate Betas of firms in SA seems an onerous task, considering all the pitfalls and caveats..
  - Lack of liquidity (of smaller firms whose assets do not trade as often as larger firms), arbitrary time horizons and random occurrences that may not repeat in the future all cause inaccuracies of the calculations of β.
  - As seen earlier, firms can use the services of Cadiz / Bloomberg / McGregor / various other sources – to calculate SA firm Betas .
    - The most popular are **Cadiz** (25%), **Bloomberg** (25%) and **McGregor** (20%), while less than 5% make in-house calculations].
    - Correia & Cramer (2007)'s survey does, however, suggest that 44% of companies ***do make some adjustments*** to their supplied Betas.
  - The market portfolio (**M**) that is most widely used is the **JSE ALSi** (77%), but some firms see this index as over-weighted toward large institutions (that assert strong individual influence on the market outcome) and rather use the Financial and Industrial Index (**FINDI**) (roughly 23%)

CAPM's relevance in SA

- Correia & Cramer (2008)'s survey therefore indicate that SA firms "mostly adhere to practices that are consistent with finance theory" – which reflects a highly developed corporate and financial sector comparable with the US.

- They also suggest widespread use of key financial ratios in determining the value of firms. This is important in order to provide further quantitative assessments of the fundamental valuations of firms.
- These ratios, and other important aspects, will be discussed in two sessions' time.

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Variations of CAPM

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Backward looking syndrome

- As became clear again following the recent financial turmoil, assuming normality of returns in stock markets and implicitly assuming that what happened in the past is a good indication of what will happen in the future → are two of the most pertinent problems with modern financial modelling.

- The CAPM (and many subsequent models of which it's theory is at the core), does not describe or predict the **source** of **risk** (i.e. it does not specify what causes the risk premiums), but merely predicts its correlation with the market return, and then provides from it a forecast basis for future risk premiums.[39]

Introducing the second APM: Arbitrage Pricing Theory (APT)

- The APT approach seeks to remedy this problem by specifying various independent macro-economic variables which predict certain sources of risk (and hence deducing the fair price from it).
- **APT – Ross (1976):**
  - Uses **linear Factor Analysis** to identify **common factors** in the risk of security returns
  - These **factors** are **used** to **explain** the **unsystematic** (or idiosyncratic) **risk** of securities
  - Returns **do not** have to be assumed jointly **normally distributed** as this is achieved through the linearity of the factor analysis (addresses some shortcoming of the CAPM)

APT – underlying assumptions

- It assumes that returns can be described in terms of a **linear factor** model.
- In this model, the return on any security, *k,* is dependent on many factors, not just the market (→ having in total G independent factors that influence the random return of asset k) :

$$\tilde{R}_k = R_M + \beta_{k,1}\tilde{f}_1 + \ldots + \beta_{k,G}\tilde{f}_G + \tilde{\varepsilon}_k, \ \forall k$$

$$\text{With}: [\beta_{k,g}] = \text{the sensitivity of the security } (k)\text{'s return to the volatility (risk) of factor (g)}$$

$\tilde{R}_k$ → Expected return of (k)
R_M → Expected market return
$\tilde{f}_1$ → deviation of factor 1 from its expected (mean)value
→ $\tilde{f}_1 > 0$ is thus a shock that is not priced in ($E(\tilde{f}_1) = 0$)
$\tilde{\varepsilon}$ → Noise, which we assume can be diversified away!

APT further….

- To simplify we use (the concept of) factor-specific '**mimicking portfolios**' (i.e. create portfolios which **mimic** the key factors)
  - Hence a portfolio is created which is **perfectly correlated** with the specific ***factor,*** but has **zero correlation** with all the other factors in the model.
  - This is because the model requires independent factors as causal variables
  - The mimicking portfolio then has a sensitivity, β_g, of (close to) 1 to the specific factor [g], and (close to) 0 to the other factors in the model
  - We view the deviations $[\tilde{f}_g = \tilde{F}_g - \overline{F}_g]$ as the **returns** to these portfolios…
- NB: this is a **functional**, **not** a **causal** relationship
  - The **factors** (or mimicking portfolios) are only ***correlated*** with the measured asset k's returns – they **don't** necessarily **cause the returns**
  - They are usually **macro-type** factors

Example of APT: Macro-Factors

- An example of this could be: if asset (k) is an Anglo American (gold mining company) share, while factors influencing it could be:
- $g = (Gold\ Price, R/\$\ Exchange, GDP, \dots)$
  - ***Notice*** : That each of these factors are not necessarily **drivers** (Like company profit / …) of the share value directly, but merely **correlated** with the value of the shares.
- They, in a sense, provide a proxy for potential **deviations** from the **expected returns** of holding the Anglo American share.
- [Note too : *Gold Price* → In this case captures only the deviation from the **expected mean** of the price of gold, not its level changes.]

Example of APT: Smart Beta

- The advent of Smart Beta products imply investors define certain characteristics of companies in a systematic way.
- This implies adding additional Betas to the CAPM equation in a structured, linear way.
- E.g., suppose investors want to invest in the **highest Quality** (ROE, ROA, ROIC, etc), **best Momentum** (say 120day MovingAvg), **most stable** (lowest 120 SD) **best Value** (EbitDA / EV) stocks, one could assign scores for each stock based on these factors, and create a portfolio based on such factors:
- $\boldsymbol{R_k = R_{RF} + \ \beta_k \ . \ (R_M - R_{RF}) + \beta_k Q + \beta_k Value + \beta_k Momentum + \beta_k Vol}$

APT

- We will return to APT as an investment vehicle after our discussions of financial instruments in the next few sessions.
- This will enable us to throw around some of the lingo to get an understanding of how we can apply some of the insights provided in the APT framework to designing an actual investment vehicle:
  - not by using immeasurable / abstract factors, but by specifying actual factor proxies and thereby designing portfolio weights.

Other variants of the CAPM: ICAPM

- The traditional CAPM (when used in a multi-period context) assumes:
  - **Interest rates** and relative **commodity prices** are **fixed** (In order for two period assumption to hold)
  - **Share returns** are **i.i.d**. Normally distributed
  - It isolates consumption risk by the single state variable: the **variance in return**
- **Merton** (1973a) **extends** the **CAPM** to a **continuous** time framework known as the ICAPM.
  - It assumes that: **Changes** in the aggregate pricing risk can be described by the **interest rate** → which is assumed the **only variable required** to **represent changes** in the investment **opportunity set** over time.

ICAPM

- Intuitively the ICAPM takes account of the covariance of the ***asset*** return with the ***market*** return (as earlier implied by the CAPM, being regarded as compensation for holding non-diversifiable risk due to changes in the market)
- BUT also of the ***asset*** and the market ***interest rate*** (proxied for by the **derivative portfolio [z]**).
- The **rate of interest** can be though of as compensation for the non-diversifiable changes in **consumption risk over time** … i.e. changes in the consumption- or investment opportunity set of consumers that change over time)

CCAPM

- All the variations of the standard portfolio theory done so far assume that all income is generated from the same source (that of the investment portfolio).
- CCAPM seeks to remedy this by using instead of the Market portfolio a proxy for **aggregate consumption capabilities** of investors.
  - The model assumes that income (in whichever capacity earned) is a good indication of consumption ability… and therefore the argument is made to study a portfolio's returns relative to investors' consumption abilities (as mimicked by an aggregate income portfolio).

Comparison of the variations of MPT pricing theory models

Model	Strengths	Weaknesses
CAPM	• Single factor identified in the model • Simple to use and data easily available	• Various (mentioned earlier)
ICAPM	• Dynamic version of (static) CAPM, i.e. CAPM through time	• Nature of factors not specified in the model • No other sources of income
CCAPM	• Single factor identified in the model	• Difficult to measure changes in aggregate consumption accurately
APT	• Not forced to use single factor • Potentially more accurate	• Nature of factors not specified in the model. • This is then especially open to data-mining problems

Alternatives to MPT

- Modern Portfolio Theory and the subsequent asset pricing models derived from the MVF framework have some serious shortcomings.
  - Yet it is still widely used in practice, despite several other frameworks that have emerged as more accurate representations of investor behaviour.
- One such framework is the **PMPT** (Post MPT) framework that optimizes a portfolio based on returns vs ***downside*** risk.
- Risk as defined by variance is a poor proxy for the human perception of risk – which is the fear of an inferior outcome to that which is expected (i.e. downside failure).

Alternatives to MPT

- Despite the clear benefits to more improved theoretic foundations possible and better descriptions of risk, the MVF framework is still the most widely used means of describing investor preferences.
- The question is then why the foundation of finance remains these simple definitions and are used to guide portfolio decisions.
- Swisher & Kasten (2005) asks this question, and compares it to the reluctance of the erstwhile medical industry in the 1900s to adopt the use of sterilization – implying there is **always reluctance to adopt better paradigms**, even when we know full well they are superior...

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Empirical performance of Asset Pricing Models

- In addition to some of the shortcomings mentioned in the previous session regarding CAPM's stringent assumptions – several other problems emerged in the literature that questioned the validity of the models.
  - A large body of literature emerged that tested the use of these models in providing quantitative assessments of the fair price of equity in the market – and showed that at times certain inconsistencies and anomalies emerge.
  - Some of the problematic assumptions that were subsequently exposed (in addition to those mentioned earlier) include:

How robust are the assumptions? What are the implications of relaxing them?

Assumption	Validity?	Implications if we relax the assumption
Investors are risk averse	**Very robust**	The problem is not so much that investors do not display some aversion to risk, rather that they can *at times and for a portion of their portfolio* welcome risk in an effort to gain higher returns.
Future consumption is funded solely by future returns from portfolios of securities	**Not valid**	**CCAPM** developed in attempt to correct for this assumption
Returns are joint normally distributed	**Not valid – fat tails exist** (Black Swan events can & do happen)	Can't describe returns in terms of mean and variance only! Market returns can and do at times behave very differently to what its historical record shows.

How robust are the assumptions? What are the implications of relaxing them?

Assumption	Validity?	Implications?
Homogenous expectations	**Unlikely** due to **costly information**	No single risk pricing model can exist – because all agents have unique pricing models based on their information sets (but we care more about the subjective Efficient Frontiers and CML & SML!)
No constraints on short sales/borrowing	Not valid for **all markets/securities**	**CML** becomes **non-linear above market portfolio** – can **only invest** in risky assets beyond this point **Arbitrage** may be **limited** = presence of abnormal returns which is inconsistent with model's pricing equation
Presence of a risk-free security	**Not perfectly valid (We listed 3 reasons earlier…)**	Can adapt the model by "creating" a RF asset through bundling → e.g. Black's (1972) zero Beta portfolio creation.

How robust are the assumptions? What are the implications of relaxing them?

Assumption	Validity?	Implications?
Taxes and transaction costs	**Not valid**	Can **cause non-unique results**, but **only if** there are different marginal tax rates and opportunity costs – usually ignored in practice…
Two time periods	Only if interest rates and relative prices **stay constant** and security returns are **IID** (Thus independent of state) – very unlikely!	Merton's (1972) Intertemporal CAPM (ICAPM) developed to remedy this problem…
Type of asset does not matter	Not valid: Various studies found certain anomalies (e.g. **size**, **type**, **value** of assets do in fact **matter!)**	Assets perform different to what the CAPM predicts after controlling for Beta – extensions to the models made to account for these anomalies (e.g. including firm size / other indicators)

Early empirical tests

- Early empirical tests studied the **ability** of the models (esp. the CAPM) to explain the risk in security returns in practice
- **Black *et al.*** (1972) sorted **NYSE** shares from **1931 - 1965** into 10 decile portfolios and estimated the coefficients on the CAPM equation for these portfolios. They then tested the following simple hypothesis:

$$[R_{True} - R_{RF}] = \lambda_0 + \lambda_1 \beta_k + \varepsilon_k$$

With the hypothesis that :

$$[\lambda_0 = 0] \text{ and } [\lambda_0 = R_m - R_{RF}] : \text{If the CAPM holds}$$

- **They found that:**
  - $\boldsymbol{\lambda_0 > 0}$ and $\boldsymbol{\lambda_1 < (i_M - i)}$ $\rightarrow$ $\therefore$ shares with low (high) Betas pay higher (lower) returns than predicted by the CAPM
  - It also found that, compared to other more advanced derivatives of the CAPM, the simple version's β is still the best performing risk measure.

Early empirical tests continued

- **Roll's (1977) critique:**

  - As mentioned before, the tests of the CAPM are based on an assumption that the ***market portfolio*** is correctly specified *ex ante*
  - All subsequent empirical tests of the CAPM are therefore **joint tests** on the: **CAPM & M**
  - *BUT specifying the latter is impossible* in practice (i.e. using history) – so no tests are (or ever can be) valid!

Further empirical tests

- Fama and French (1993) also showed that a risk model which includes measures such as ***firm size*** & ***book to market*** equity ratios, in conjunction with **Beta**, provided the best explanation of the cross-sectional variability of security returns

  - Fama and French, e.g., showed that firms that are small and firms with low P/E ratios tend to out-perform the market on a risk-adjusted basis, concluding that in many cases outperformance by assets is **uncorrelated** with their relative sensitivity to market movements: β.
  - F&F also suggested that **Value** stocks (**Low P/Book or P/E ratio**) tend to outperform **Growth** stock (**High Expected Earnings, thus often having high P/E's**) irrespective of the **Betas**.

Further empirical tests

- These F&F findings have in subsequent years been repeated across various time-frames and various markets. It seems to clearly suggest that more than one systematic risk (in addition to the market risk) impacts the price of assets, in addition to relative market risk.
- Although F&F's work did have some criticism – notably that size factors do not **explicitly** relate to risk (else small firms would merely unite with other small firms and thus reduce the size premium), while value factors is based on equal weighting of small and large firms…. –
- Their later work still defiantly show that: **P/E**, **Size**, **Debt/Equity**, **Price/Book** add to the explanation of expected stock returns given by β… Which is kind of stating the obvious…

Pricing Puzzles

- **Mehra and Prescott (1985)** approached the testing problem in a fundamentally ***different*** way:
  - They looked at the **relationship** between the values of the Constant relative risk aversion measure (**CRRA)** and the (constant) **rate of time preference** that's **implied** in the observed patterns of security returns, and whether they **were consistent** with those identified in **experimental evidence** (Thus are people as risk averse as the models imply?)
- <u>Well.. they weren't (not by a long way)!! –Two puzzles emerged:</u>

Pricing Puzzles

- The **equity premium puzzle** – investors require a far **larger premium** for **holding shares, as compared to bonds**, than expected in theory (CRRA needs to be at least 5 times larger than experimental evidence suggests it should be)
- The **risk free rate puzzle** – the **observed RF** rate is **much lower than** the **SML would predict** (for the minimum req'd rate), or the CCAPM would predict for a realistic CRRA, and even more so when the required CRRA (to solve the equity risk premium puzzle) is used.

- Hasan and van Biljon (2009) also study these puzzling inconsistencies from the SA perspective and find that it delivers similar inconsistencies.

Summary

- Despite exhibiting at times poor empirical results (although the CAPM's performance have shown some of the best results, even against far more advanced, technical and intricate pricing models), the standard MPT theoretic framework and the subsequent CAPM asset pricing model – remains at the core of finance today.
- Used widely and successfully in practice, one of its major benefits is its simplicity of calculation and ease of interpretation.
  - It provides investors and investment intermediaries with a good quantitative basis from which to evaluate asset prices.
- Its drawbacks and limitations are clear, yet does not invalidate its use.

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