Discussion at: Pricing currency risks Weat Owney, Mayas Dehysik at Lan Lakatee Kat Danaf ''anakae waa waa waa Wat 191 Maren Prava Janafaa Newiga 1924 at 201

10 minute discussion.

- 1. Very cool paper.
- 2. Interesting idea; beautifully empirical analysis
- 3. I'm going to make a few comments, and relate this a bit to the literature on equity factors that Lars mentioned.
- 4. There is a lot of really good analysis that I won't cover.
 - Multi-Horizon Regression (MHR); Currency denomination analysis

Discussion of: Pricing currency risks Mikhail Chernov, Magnus Dahlguist, and Lars Lochstoer

Kent Daniel[†]

[†]Columbia Business School & NBER

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Basic Idea

What determines the currency covariance structure (Σ) ?
 What is the link between μ and Σ ?

Basic Idea

- Three characteristics are interest rate differentials, momentum/trend, and longer-term (\sim 5 year) mean-reversion in PPP differentials.
- (Answers 2) Note that no combination of strategies can price the UMVE portfolio.

Basic Idea

Key Questions:

- What matters in determining currency expected returns (µ)?
- What determines the currency covariance structure (Σ) ?
- What is the link between μ and Σ ?

Answers:

- Three characteristics determine expected currency returns.
 - $\bullet\,$ interest rate differentials, 1 yr. momentum/trend, and ${\sim}5$ yr. mean reversion in PPP differentials
- A UMVE based on a linear-characteristics model explains the returns of nine standard strategies extremely well.
 - The converse is not true.
- μ does not line up with the first few PCs of Σ
 - $\bullet~$ for Σs for currency returns and for strategy returns.
- At least 85% of the risk in standard currency strategies ("factor-portfolios") is unpriced.
 - Suggests that extant explanations for currency premia are problematic
 - Priced component is correlated with consumption growth.



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-Notation & Basics

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Definitions:
a \mathbf{r}_{t+1} is the N_t -vector of realized excess currency returns from $t \to t+$
 Expected return; covariance matrix:
$\mu_{t} = E_{t}[t_{t+1}]$
$\Sigma_r = E_t[(\mathbf{r}_{t+1} - \mu_t)(\mathbf{r}_{t+1} - \mu_t)']$
 Conditional MVE portfolio:
$\label{eq:wc} \begin{array}{rcl} \mathbf{w}_{t}^{c} &=& \boldsymbol{\Sigma}_{t}^{-1} \boldsymbol{\mu}_{t} \\ & & & & \\ & & & & \\ \kappa_{t+1}^{c} &=& \mathbf{w}_{t}^{c'} \mathbf{r}_{t+1} \end{array}$ w Pricing equation:
$\mathbf{r}_{l+1} = \beta \mathbf{r}_{l+1}^{C} + \mathbf{e}_{l+1}, \mathbb{E}[[\mathbf{e}_{l+1}]] = 0$
where $\beta_l = \frac{\mu}{\mu' \Sigma^{-1} \mu}$
 Pricing Kernel formulation (Hansen and Richard, 1987):
$m_{l+1} = 1 - (r_{l+1}^C - \mu_l^C) \implies \mathbb{E}_l[m_{l+1}r_{l+1}] = 0$

- · Everything bold is a vector or matrix; non-bold is a scalar
- \mathbf{w}_t^C can of course be scaled up or down
 - It is the portfolio that captures the premium in this universe of securities with minimum variance.
 - Thus, everything orthogonal to this portfolio earns zero premium
 - Thus, you can decompose any security's return into some MVE portfolio, and a residual which earns zero premium.
- Note that the denominator of the projection coefficient $(\mu' \Sigma^{-1} \mu)$ is both the expected return and the squared Sharpe-ratio of the CMVE portfolio.

Notation & Basics

Definitions:

- \mathbf{r}_{t+1} is the N_t-vector of realized excess currency returns from $t \to t+1$.
- Expected return; covariance matrix:

$$\begin{aligned} \boldsymbol{\mu}_t &= & \mathbb{E}_t[\mathbf{r}_{t+1}] \\ \boldsymbol{\Sigma}_t &= & \mathbb{E}_t[(\mathbf{r}_{t+1}-\boldsymbol{\mu}_t)(\mathbf{r}_{t+1}-\boldsymbol{\mu}_t)'] \end{aligned}$$

• Conditional MVE portfolio:

$$\mathbf{w}_t^C = \mathbf{\Sigma}_t^{-1} \boldsymbol{\mu}_t$$
$$r_{t+1}^C = \mathbf{w}_t^{C'} \mathbf{r}_{t+1}$$

Pricing equation:

where

$$egin{aligned} \mathbf{r}_{t+1} &= eta_t \mathbf{r}_{t+1}^{\mathcal{C}} + \epsilon_{t+1}, \quad \mathbb{E}_t [\epsilon_{t+1}] = \mathbf{0} \ & eta_t = rac{\mu}{\mu' \Sigma^{-1} \mu} \end{aligned}$$

• Pricing Kernel formulation (Hansen and Richard, 1987):

$$m_{t+1} = 1 - (r_{t+1}^C - \mu_t^C) \Rightarrow \mathbb{E}_t[m_{t+1}\mathbf{r}_{t+1}] = \mathbf{0}$$

-Factor Pricing Models

actor Pricing Models



- For the pricing equation on the last page to work, the returns on the right side have to give you exposure to the sources of premium with minimum risk.
- If you form the factor portfolios using just the characteristics (which capture μ), and not Sigma, you won't generally get exposure with minimum variance.

How much unpriced risk could there be?

Let's look at what contributes to the variance of Fama and French's HML portfolio.

Factor Pricing Models

- In the last few decades, the standard has become the use of "factor" models, based on characteristic-sorts.
- Such models dominate the asset pricing literature devoted to pricing equities, but are also used in currency pricing models.
 - See, e.g., Fama and French (1993, 2015); Carhart (1997); Daniel and Moskowitz (2016); Pástor and Stambaugh (2003); Daniel and Titman (2006); Lustig, Roussanov, and Verdelhan (2011); Asness, Moskowitz, and Pedersen (2013)
- The models will only price the full cross-section if the resulting set of factor-portfolios span the MVE portfolio.
 - They may, however, successfully price other characteristic-sorted portfolios. See Lewellen, Nagel, and Shanken (2010) and Daniel and Titman (2012).
- Specifically, the problem is that these factor-portfolios ignore information about the covariance structure.
 - Thus, the resulting portfolios will contain both priced and unpriced risk.

-Time-Varying Industry Loadings of HML



Time-Varying Industry Loadings of HML

Daniel, Mota, Rottke, and Santos (2020), Figure 2:



 R^2 of 126-day rolling regressions of HML on 12 Fama and French industries

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-Money Industry R²



- I should show the *R*² from regressing HML on both Money and BusEq; this is above 90% in 2010.
- Note that the adjusted-*R*² is about zero before the start of the financial crisis.
- However, with the onset of the financial crisis, many large financial firms fall in price and become value firms
 - in a value-weighted portfolio.
- In addition, the portfolio of financial firms become really volatile.
- This leads to the correlation of HML with Money jumping above 90% for a period of time.
- So, HML gives you exposure to the *priced* value factor, but a lot of the risk in HML can be hedged-out without affecting the return
 - It is unpriced.
- To separate out the priced and unpriced risk, you need information both about the expected returns (from the characteristics), and the covariance/correlation structure.

Money Industry R²

Daniel, Mota, Rottke, and Santos (2020), Figure 5:



R² of 126-day rolling regressions of HML on Money industry

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Building the CMVE and UMVE Portfolios



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- What we do in our RFS paper is to show how to hedge out the unpriced risk via an iterative procedure.
- Lars, Mike and Magnus instead build an MVE portfolio directly using an estimated covariance matrix, in addition to the characteristics.
- The estimated CMVE portfolio is just based on the estimated $\hat{\Sigma}$ and $\hat{\mu}$.
- The Unconditional MVE portolio (UMVE), just levers this up or down based on the (estimated) squared-Sharpe ratio of the MVE portfolio.

Building the CMVE and UMVE Portfolios

$$\hat{\mathbf{w}}_{t}^{C} = \hat{\Sigma}_{t}^{-1} \hat{\boldsymbol{\mu}}_{t}, \quad \boldsymbol{r}_{t+1}^{C} = \hat{\mathbf{w}}_{t}^{C'} \mathbf{r}_{t+1}$$
$$\boldsymbol{r}_{t+1}^{U} = \frac{\boldsymbol{r}_{t+1}^{C}}{1 + \hat{\boldsymbol{\mu}}_{t}' \hat{\boldsymbol{\Sigma}}_{t}^{-1} \hat{\boldsymbol{\mu}}_{t}}$$

- Building a good MVE portfolio based on an estimated $\hat{\Sigma}$ is tricky.
 - $\bullet\,$ e.g., use of a sample covariance matrix will result in an estimated MVE which lines up with small eigenvalues of $\hat{\Sigma}$
 - There are some techniques, starting with Black and Litterman (1991), designed to resolve these problems.
- However here, with a much smaller universe, the problem is not as severe.
 - $\hat{\Sigma}_t^{-1}$ is estimated using an exponential-weighted moving average applied to daily data with shrinkage, following Ledoit and Wolf (2020).
 - This seems to work pretty well in forecasting the covariance structure.
 - Would it be useful to use different decay rates for correlations and volatilities?

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-Linear Characteristics Model $(\hat{\mu}_t)$

Linear Characteristics Model ($\hat{\mu}_t$)

 $\hat{\mu}_{t} = \gamma_{t} \cdot \left(\frac{\mathbf{S}_{t} - \mathbf{F}_{t}}{\mathbf{F}_{t}}\right) + \delta_{t} \cdot \mathbf{Z}_{t}^{2} + \phi_{t} \cdot \left(\frac{\mathbf{S}_{t}}{\mathbf{S}_{t-12}}\right)$

a µ_i is based on a linear characteristics model: The RWH coefficient > = 1 The coefficient on the REP and momentum signals, 4_i and 4_i, are estimated with an expanding window, and after the first low years are table.

 Note that CDL are very much "hanging that hat" on this linear-charantamicitocinsativ-containt-containtmans-charantamicitocinsativ-containt-containt.
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 Should then bany finitig instruments?
 Should the contilicence the a lunction of the currencise?

The three terms are:

- 1. The Random Walk Hypothesis (i.e., the expected change in the spot rate is zero).
 - If the spot rate is 2% higher than the future, then the expected return is 2%.
- 2. High (real) prices adjust mean revert via exchange rate depreciation.
 - relative to 5 years before
- 3. Currencies that have appreciated over the last year keep appreciating.

To these suggestions:

- A simple model is robust. This is about as simple as it gets.
- You might expect the "model" to change over time, to work better in come conditions than others, etc.
- I'm guessing that this should work "better" for emerging currencies than developed. Suggests that coefficients should vary with currency characteristics.

Linear Characteristics Model $(\hat{\mu}_t)$

$$\hat{\boldsymbol{\mu}}_{t} = \gamma_{t} \cdot \left(\frac{\mathbf{S}_{t} - \mathbf{F}_{t}}{\mathbf{F}_{t}}\right) + \delta_{t} \cdot \mathbf{z}_{t}^{Q} + \phi_{t} \cdot \left(\frac{\mathbf{S}_{t}}{\mathbf{S}_{t-12}}\right)$$

- $\hat{\mu}_t$ is based on a linear characteristics model:
 - The RWH coefficient $\gamma_t = 1$
 - The coefficients on the RER and momentum signals, δ_t and ϕ_t , are estimated with an expanding window, and after the first few years are fairly stable.
- Note that CDL are very much "hanging their hat" on this linear-characteristic/constant-coefficient model specification.
 - Note that any evidence of factor timing here arises as a result of time variation in the (1) characteristic loadings of the factor portfolios and (2) the covariance structure.
 - Should there be any timing instruments?
 - Should the coefficients be a function of the currencies?



• Blue bars are the Sharpe ratios of each of the 9 strategies

Priced and Unpriced Components of Strategies

- To hedge, you "pull out" the part of the strategy returns that is unpriced based on their model (orange, labeled "hedging")
 - In theory, this should have an SR of zero
- What is left should have a higher SR.
 - This is bigger in sample, for 9/9 strategies.

Priced and Unpriced Components of Strategies

Figure 1 – Sample Sharpe Ratios of original, hedging, and hedged strategies



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-Principal Components Analysis: Individual Currencies

Principal Components Analysis: Individual Currencies



- Note that the return of the CMVE portfolio lies in the space spanned by the returns of the nine currencies
- However, this chart shows that the UMVE returns are only minimally explained by the nine PCs.
 - The reason is that the weights on the nine currencies are not static, they are constantly rotating depending on μ and Σ .

Principal Components Analysis: Individual Currencies

• UMVE returns are only minimally explained by individual-currency PCs



Figure 3 – analysis based on monthly return data, 1985:01–2020:05

-Principal Components Analysis: Strategy Returns

Principal Components Analysis: Strategy Returns



- The UMVE portfolio lines up much better with the strategy returns
 - This suggests that the UMVE is pretty well explained by a portfolio with static weights on the nine-strategies.
 - However, the R^2 is still far from 100%.

Principal Components Analysis: Strategy Returns

- UMVE returns are better explained by strategy PCs, showing value of currency timing
 - *But*, the UMVE portfolio still times the factor-portfolios (based on their characteristic exposure and their estimated risk)



Figure 3 - analysis based on monthly return data, 1985:01-2020:05

-Pushing the Empirical Analysis

Pushing the Empirical Analysis

- It may be interesting that the constations of carry with intermediary capital and global values? The constation with the supposed construction provides interpretent of connersity relations in constand with construction grants.
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 Are then additional instruments that could enhance terring?
 What factors due S2.
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 But what is it?
 Is it regional factors? Is it related to trade?

Pushing the Empirical Analysis

- It is really interesting that the correlations of carry with intermediary capital and global volatility results from a correlation with the *unpriced* component.
- CDL find that the priced component of currency returns is correlated with consumption growth.
 - The R^2 for quarterly Δc is about 3%; for three-year Δc it is about 7%.
 - t-statistics are 2.5 and 3.2, respectively.
 - What should we expect here?
- Are there additional instruments that could enhance timing?
- What factors drive Σ_t
 - CDL show that it is not the factors that explain expected returns.
 - But what is it?
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-References

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