Currency Risk in the Long Run

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Introduction

Banks' have increased their appetite for sovereign debt

- To satisfy post-crisis liquidity requirements as government bonds are easy and quick to sell during times of distress,
- Government bonds carry very little risk-weight and banks are not required to raise much extra capital to hold them.

Pension funds and insurers are another major source of demand

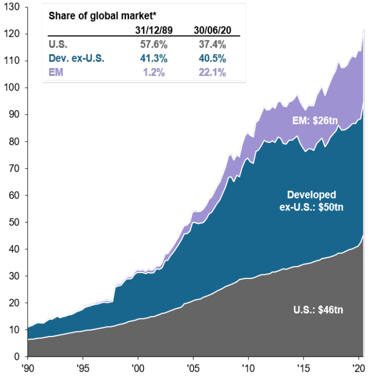
- Centrally-cleared derivatives more expensive after post-crisis rules.
- These players buy long-term bonds to hedge interest rate risk.

Carry strategy implemented with long-term bonds in foreign currencies

- Returns fall with bond maturity (Lustig, Stathopoulos & Verdelhan, 2020),
- Positive post-crisis returns (Andrews, Croce, Colacito & Gavazzoni, 2021).

Facts About the Bond Market

(a) Source: Financial Times (2017)



(b) Source: JP Morgan Asset Management (2020)

Motivation

Modern financial economics has little to say about the risk of long-term bonds

- Investors would naturally hold short-term bonds and demand a premium to hold long-term bonds (e.g., Keynes, 1930; Hicks, 1946),
- Investors who value the stability of income require a premium to go short, not to go long (Modigliani & Sutch, 1966),
- Viceira & Wang (2016) find that the portfolio risk of a bond portfolio declines with the investment horizon.

Investment decisions are based upon return forecasts

- Investors' knowledge is limited (true parameters are unknown),
- Observable predictors deliver an imperfect proxy for future returns,
- Predictive variability of returns differ from true variability, thus affecting the perceived risk across investment horizons.

Summary of the Paper

What we do ...

- We take the perspective of a US investor and estimate the predictive variance of a bond-based currency strategy over long-horizons,
- We estimate a predictive system with imperfect predictability using long-span data akin to Pastor & Stambaugh (2009),
- We decompose the predictive variance into five components using closed-form expressions by building on and extending Pastor & Stambaugh (2012).

What we find (so far) ...

- Long-horizon predictive variance is upward sloping for all G10 countries,
- Future uncertainty about conditional returns is a critical driver,
- Real interest rate differential and real exchange rate returns play a major role for the predictive variance of our excess returns.

A Simple Currency Strategy

A **global strategy** from the perspective of a US investor

- She borrows at the short-term interest rate at home,
- She invests in the constant-maturity bond abroad
- Akin to Andrews, Croce, Colacito & Gavazzoni (2021).

The **excess return** of this strategy can be then written as

$$rx_{t+1} = y^{\star}_{t+1} + \Delta s_{t+1} - i_t$$

- $rx_t \rightarrow$ one-month excess return in dollars,
- $y^{\star}_t \rightarrow$ one-month return on the foreign bond,
- $\Delta s_t \rightarrow$ one-month nominal exchange rate return,
- $i_t \rightarrow$ one-month deposit rate in dollars.

We work with long-span data (more than 200 years)

- Different monetary policy and exchange rate regimes.

We can equivalently rewrite our excess return in real terms as

$$rx_{t+1} = \underbrace{y^{\star}_{t+1} - i^{\star}_{t}}_{\substack{\textit{foreign bond}\\ \textit{excess return}\\ r_{1,t+1}}} + \underbrace{(i^{\star}_{t} - \rho^{\star}_{t+1}) - (i_t - \rho_{t+1})}_{\substack{\textit{real interest}\\ \textit{rate differential}\\ r_{2,t+1}}} + \underbrace{\Delta s_{t+1} + \rho^{\star}_{t+1} - \rho_{t+1}}_{\substack{\textit{real exchange}\\ \textit{rate retun}\\ r_{3,t+1}}}$$

- $i^{\star}_{t} \rightarrow$ one-month deposit rate in foreign currency,
- $\rho_t \rightarrow$ one-month US inflation rate,
- $\rho^{\star}_{t} \rightarrow$ one-month foreign inflation rate.

Imperfect Predictability

Each return component, for $s = \{1, 2, 3\}$, can be described as

$$r_{s,t+1} = \mu_{s,t} + u_{s,t+1}$$

- $\mu_{s,t} \rightarrow$ expected return conditional on all information at time t,
- $u_{s,t+1} \rightarrow$ unexpected return with zero mean and constant variance.

We model the expected return as Pastor & Stambaugh (2009)

$$\mu_{s,t} = a_s + b_s x_{s,t} + \pi_{s,t}$$

- $x_{s,t} \rightarrow$ observable predictor,
- $\pi_{s,t} \rightarrow$ unobservable predictor with zero-mean.

The true expected return captures more information than we observe

- An observable predictor is likely to be imperfect,
- We may understate the variance of future returns.

Predictive Variance

Define the k-period return between times $T+1$ and $T+k$ as

$$r_{s,T}^{k} = \sum_{\ell=1}^{k} r_{s,T+\ell}$$

- $r_{s,T+\ell} \rightarrow$ one-period return between $T+\ell-1$ and $T+\ell$.

We study the predictive variance of rx over long horizons as

$$\mathbb{V}ar(rx_T^k \mid D_T) = \sum_{i=1}^{3}\sum_{j=1}^{3} \mathbb{C}ov(r_{i,T}^k, r_{j,T}^k \mid D_T)$$

- $D_T \rightarrow$ information set used for predictability at time T.

D_T includes the full history of returns and observable predictors

- No information about the unobservable predictor π and parameters ϕ governing the relationship between returns and predictors.

Predictive Variance

Each predictive covariance can be decomposed as

$$
\begin{aligned}
\mathbb{C}ov(r^k_{i,T}, r^k_{j,T} \mid D_T) &= \underbrace{\mathbb{E}[\mathbb{C}ov(r^k_{i,T}, r^k_{j,T} \mid \pi_T, \phi, D_T) \mid D_T]}_{\substack{\textit{Expectation of the conditional} \\ \text{covariance of the } k\text{-period returns}}} \\
&+ \underbrace{\mathbb{C}ov[\mathbb{E}(r^k_{i,T} \mid \pi_T, \phi, D_T), \mathbb{E}(r^k_{j,T} \mid \pi_T, \phi, D_T) \mid D_T]}_{\textit{Covariance of the conditional expected } k\textit{-period returns}}
\end{aligned}
$$

An investor who knows π_T and ϕ only cares the conditional covariance

- An investor who ignores π and ϕ also cares about its expectation,
- She also accounts for the covariance of the conditional expected returns,
- The perceived variance can be higher, in absolute terms, at long horizons.

Predictive System

Consider the following predictive system

$$r_{t+1} = a + bx_t + \pi_t + u_{t+1}$$
$$x_{t+1} = \theta + \gamma x_t + v_{t+1}$$
$$\pi_{t+1} = \delta \pi_t + \eta_{t+1}$$

- $r_t \rightarrow$ vector of returns,
- $x_t \rightarrow$ vector of observable predictors modeled as an AR(1) process,
- $\pi_t \rightarrow$ vector of unobservable predictors as a driftless AR(1) process.

The role of observable predictors

- capture the direct/indirect effects of monetary policy decisions.

The role of unobservable predictors

- capture aspects of monetary policy **not contained in bond yields**,
- structural variations due to **different exchange rate regimes**.

DECOMPOSITION

The **expectation of the conditional covariance** consists of three terms

- *i.i.d.* uncertainty ▸ details
- mean reversion ▸ details
- future conditional mean uncertainty ▸ details

The **covariance of the conditional expectation** consists of two terms

- current conditional mean uncertainty ▸ details
- estimation risk ▸ details

We then calculate the covariance ratio of each component

$$CR(k) = \frac{\mathbb{C}ov(r^k_{i,T}, r^k_{j,T} \mid D_T)}{k\,\mathbb{C}ov(r^1_{i,T}, r^1_{j,T} \mid D_T)}$$

to determine the shape of the long-horizon covariance curve.

Long-Span Data

Sample and Source

- Monthly observations from January 1800 to June 2017,
- Unbalanced dataset from Global Financial Data.

Dataset

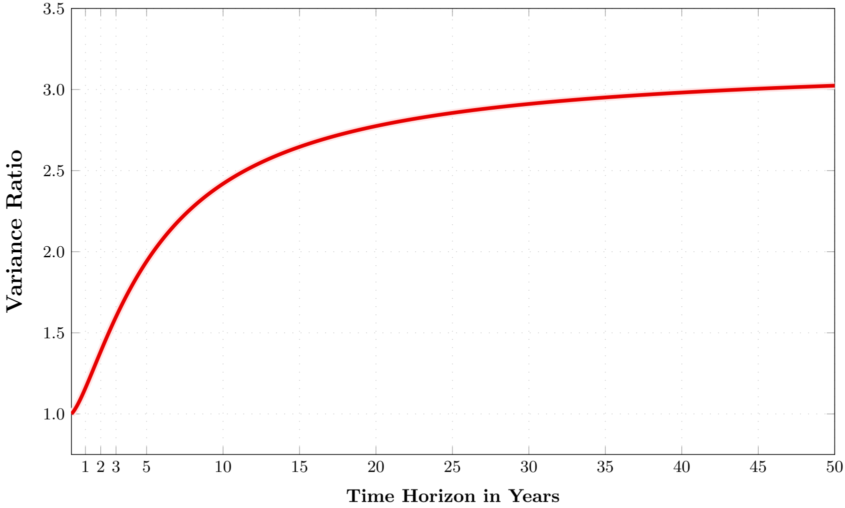
- **Bond returns**: 10-year constant-maturity treasury bond returns,
- **Deposit rates**: 3-month Treasury bills,
- **Exchange rates**: bilateral US dollar spot exchange rates,
- **Price indices**: year-on-year inflation rates

G-10 Countries

- Australia, Canada, Germany/Euro Area, Japan, New Zealand, Norway, Sweden, Switzerland, UK, and US.

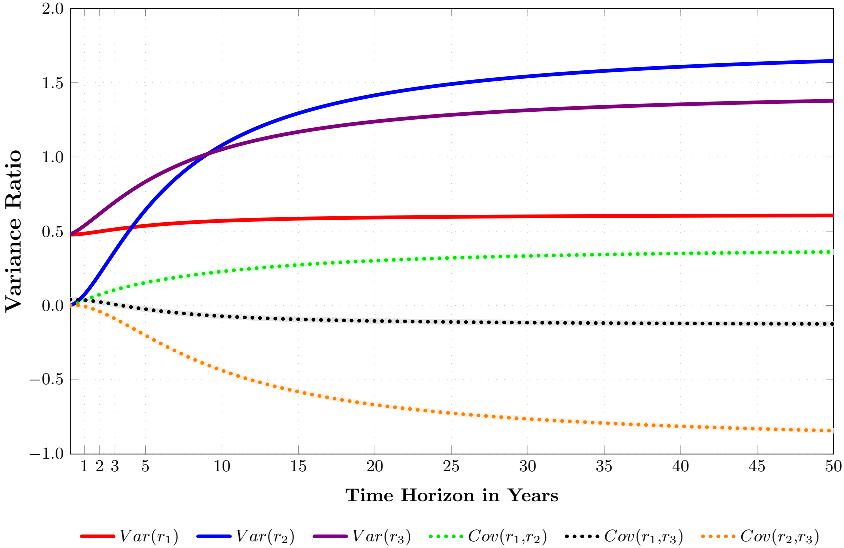
▸ r_t ▸ x_t ▸ π_t

Total Predictive Variance: US/UK

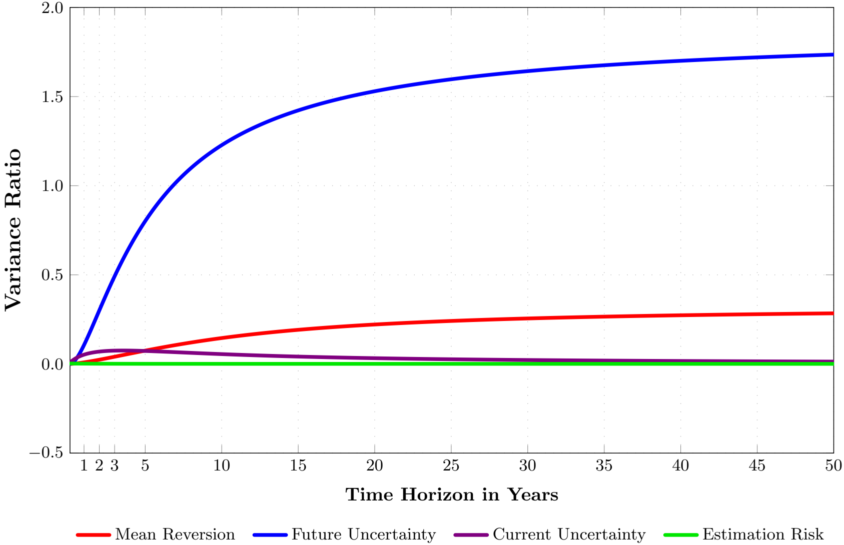


▸ Global ▸ Germany ▸ Japan

Predictive Variance Decomposition: US/UK

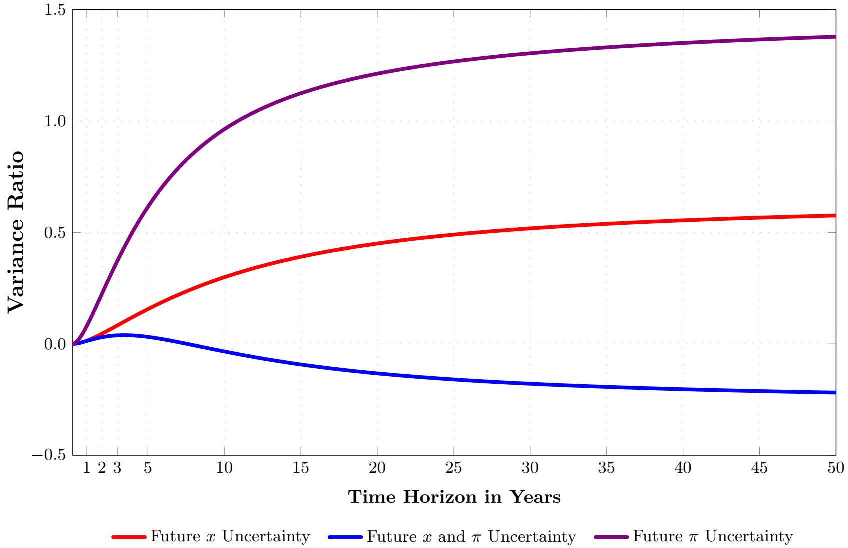


Predictive Variance Decomposition: US/UK



Mean Reversion

Future (Conditional Mean) Uncertainty: US/UK



To Sum Up

Main message

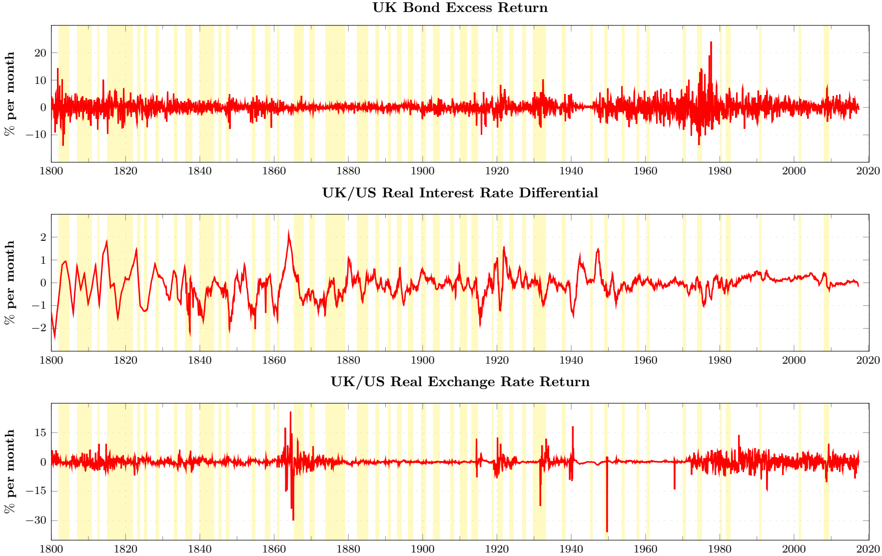
- The predictive variance of a bond-based currency strategy can be large,
- The largest portion of variance risk is related to real interest rate differential and real exchange rate returns.
- Uncertainty about future returns is the dominant component of the predictive variance.

Ongoing research

- Robustness across different priors, samples, and predictors,
- A model to understand the asset pricing and asset allocation implication.
- Working on the narrative of our results (e.g., monetary policy events).

Appendix

Dependent Variables: UK



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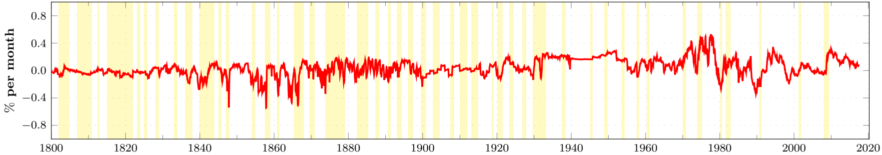
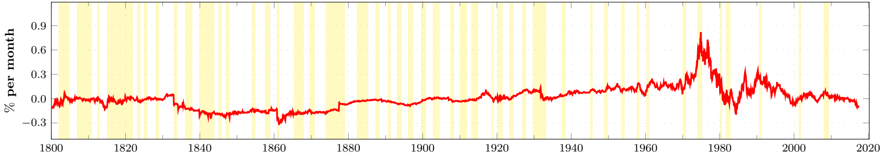
Observable Predictors: UK

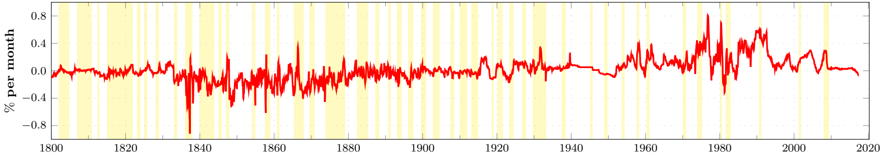
UK Term Spread



UK/US Long-Term Yield Differential



UK/US Short-Term Yield Differential



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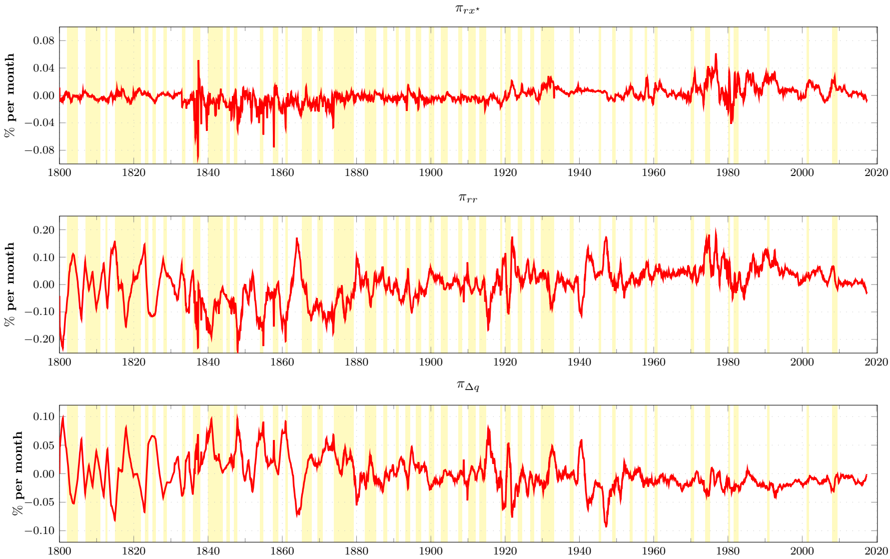
Unobservable Predictors: UK



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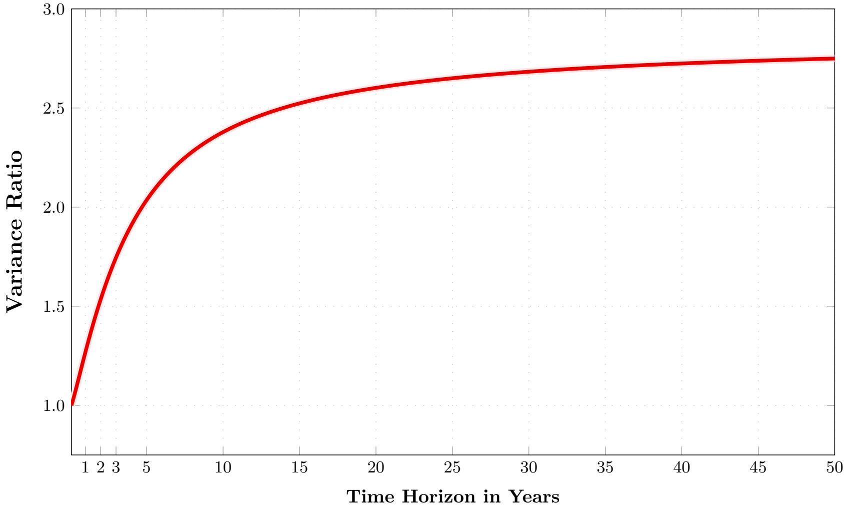
Total Predictive Variance: Global



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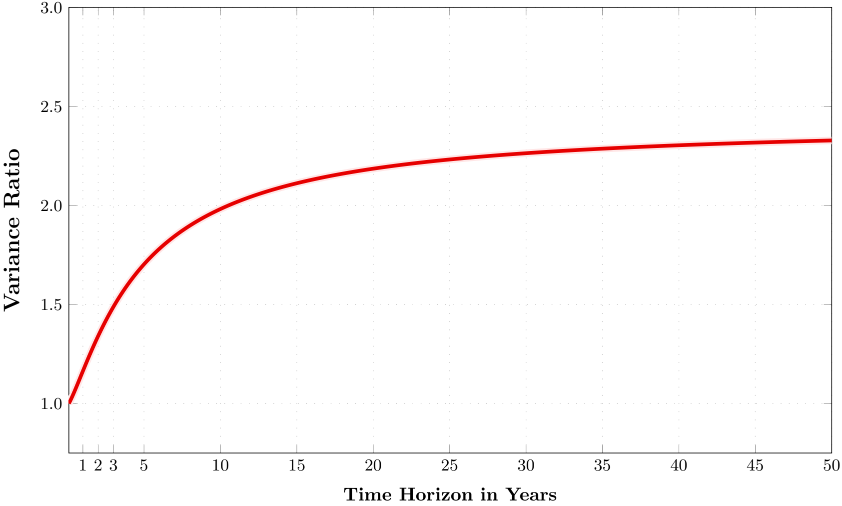
Total Predictive Variance: Germany/Euro Area



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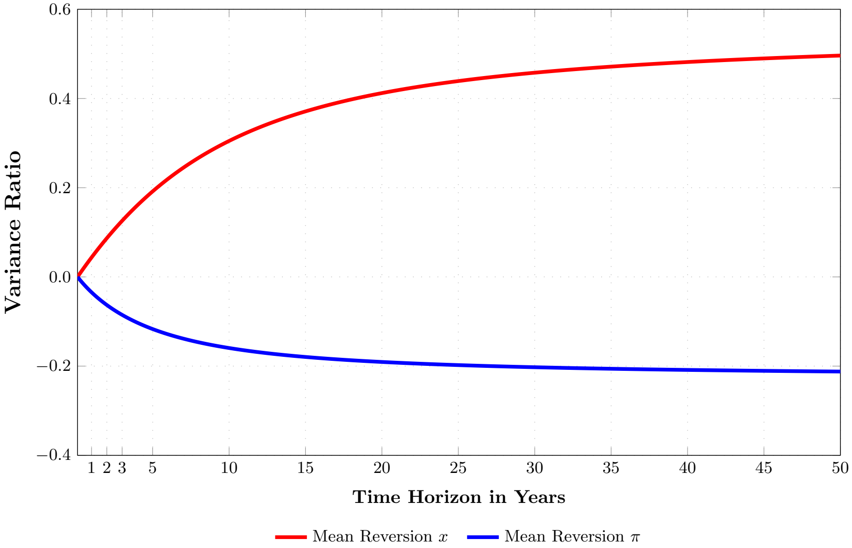
Mean Reversion Decomposition: US/UK



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COMPONENTS

- The *i.i.d.* uncertainty is defined as

$$\mathbb{E}\left[k\sigma_{u_i}\sigma_{u_j}\rho_{u_iu_j} \mid D_T\right]$$

  - ✓ it captures the well-known feature of *iid* returns,
  - ✓ it is proportional to k (i.e., per-period covariance is constant),
  - ✓ it reflects parameter uncertainty,
  - ✓ it reduces to $E[k\sigma^2_{u_i} \mid D_T]$ when $i = j$.

Go back

- The mean reversion is defined as

$$\underbrace{\mathbb{E}\left(k\sigma_{u_i}\sigma_{u_j}\left[b_i\bar{d}_i\rho_{v_iu_j}A_i(k,\gamma)+b_j\bar{d}_j\rho_{u_iv_j}A_j(k,\gamma)\right]\mid D_T\right)}_{\text{mean reversion } \mathbf{x}} +$$

$$\underbrace{\mathbb{E}\left(k\sigma_{u_i}\sigma_{u_j}\left[\bar{e}_i\rho_{\eta_iu_j}A_i(k,\delta)+\bar{e}_j\rho_{u_i\eta_j}A_j(k,\delta)\right]\mid D_T\right)}_{\text{mean reversion } \boldsymbol{\pi}}$$

- **Key properties**
  - ✓ mean reversion x vanishes with no observable predictors, i.e., $b_s = 0$,
  - ✓ mean reversion π disappears with perfect observable predictors, i.e., $\sigma^2_{\pi_s} \to 0$ which directly impact $\bar{e}_s$.

▸ $\bar{d}_s$ ▸ $\bar{e}_s$ ▸ $A(k,\phi)$ ◂ Go back

Components

- The future conditional mean uncertainty is defined as

$$\underbrace{\mathbb{E}\left[k\sigma_{u_i}\sigma_{u_j}b_i b_j \bar{d}_i \bar{d}_j \rho_{v_i v_j} B_{ij}(k,\gamma,\gamma) \mid D_T\right]}_{\text{future } \mathbf{x} \text{ uncertainty}} \quad +$$

$$\underbrace{\mathbb{E}\left(k\sigma_{u_i}\sigma_{u_j}\left[b_i \bar{d}_i \bar{e}_j \rho_{v_i \eta_j} B_{ij}(k,\gamma,\delta) + b_j \bar{e}_i \bar{d}_j \rho_{\eta_i v_j} B_{ij}(k,\delta,\gamma)\right] \mid D_T\right)}_{\text{future } \mathbf{x} \text{ and } \pi \text{ joint uncertainty}} \quad +$$

$$\underbrace{\mathbb{E}\left[k\sigma_{u_i}\sigma_{u_j}\bar{e}_i \bar{e}_j \rho_{\eta_i \eta_j} B_{ij}(k,\delta,\delta) \mid D_T\right]}_{\text{future } \pi \text{ uncertainty}}$$

- **Key properties**
  - ✓ future x uncertainty and future x and π joint uncertainty vanish with no observable predictors, i.e., $b_s = 0$,
  - ✓ future π uncertainty and future x and π joint uncertainty disappears with perfect observable predictors, i.e., $\sigma^2_{\pi_s} \to 0$.

▸ $B_{ij}(k,\phi,\psi)$ ◂ Go back

Components

- The current conditional mean uncertainty is defined as

$$\mathbb{E}\left[\frac{1-\delta_i^k}{1-\delta_i}\frac{1-\delta_j^k}{1-\delta_j}q_{ij,T} \mid D_T\right]$$

where $q_{ij,\,T} = Cov(\pi_{i,T},\, \pi_{j,T} \mid \boldsymbol{\phi}, D_T)$

- **Key properties**
  - ✓ This term vanishes with perfect observable predictors ($\sigma^2_{\pi_s} \to 0$).

▸ $q_{ij,T}$ ◂ Go back

COMPONENTS

- The estimation risk is defined as

$$Cov\left[kE_{r_i} + \frac{1-\gamma_i^k}{1-\gamma_i}(a_i + b_i x_{i,T} - E_{r_i}) + \frac{1-\delta_i^k}{1-\delta_i}c_{i,T},\right.$$
$$\left. kE_{r_j} + \frac{1-\gamma_j^k}{1-\gamma_j}(a_j + b_j x_{j,T} - E_{r_j}) + \frac{1-\delta_j^k}{1-\delta_j}c_{j,T} \mid D_T\right]$$

✓ E_{r_s} $(s = i, j)$ are the unconditional mean returns

▸ E_{r_S} $c_{s,T}$ ◂ Go back

Components

$$\bar{d}_s = \left(\frac{1+\gamma_s}{1-\gamma_s} \frac{R_s^2}{1-R_s^2} \frac{\sigma_{x_s}^2}{\sigma_{r_s}^2 - \sigma_{u_s}^2} \right)^{1/2}.$$

$$R_s^2 = \frac{b_s^2 \sigma_{x_s}^2 + \sigma_{\pi_s}^2 + 2 b_s \sigma_{x_s \pi_s}}{\sigma_{r_s}^2}$$

Go back

Components

$$\bar{e}_s = \left(\frac{1+\delta_s}{1-\delta_s} \frac{R_s^2}{1-R_s^2} \frac{\sigma_{\pi_s}^2}{\sigma_{r_s}^2 - \sigma_{u_s}^2} \right)^{1/2}$$

$$R_s^2 = \frac{b_s^2 \sigma_{x_s}^2 + \sigma_{\pi_s}^2 + 2 b_s \sigma_{x_s \pi_s}}{\sigma_{r_s}^2}$$

Go back

Components

$$A_s(k,\phi) = 1 + \frac{1}{k}\left(-1 - \phi_s \frac{1-\phi_s^{k-1}}{1-\phi_s}\right)$$

Go back

Components

$$B_{ij}(k,\phi,\psi) = 1 + \frac{1}{k}\left(-1 - \phi_i \frac{1-\phi_i^{k-1}}{1-\phi_i} - \psi_j \frac{1-\psi_j^{k-1}}{1-\psi_j} + \right.$$
$$\left. + \phi_i\psi_j \frac{1-\phi_i^{k-1}\psi_j^{k-1}}{1-\phi_i\psi_j}\right)$$

Go back

Components

$$q_{ij,\,T} = Cov(\pi_{i,T},\, \pi_{j,T} \mid \boldsymbol{\phi}, D_T)$$

Go back

COMPONENTS

$$E_{r_s} = a_s + b_s \frac{\theta_s}{1 - \gamma_s}$$

$$c_{s,T} = E(\pi_{s,T} \mid \boldsymbol{\phi}, D_T)$$

Go back