What Does the Yield Curve Tell Us About Exchange Rate Predictability?

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Motivation

Decades of empirical exchange rate research has led us to numerous empirical exchange rate puzzles:

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- Meese-Rogoff (1983)puzzle:
  - Fundamental-based models cannot consistently out-perform a random walk in out-of-sample forecasts, especially at short-horizons
- Uncovered Interest Parity (UIP) puzzle:
  - Currencies of high interest rate countries tend to appreciate subsequently, contrary to the forex market efficiency condition

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How about side-stepping (2) and letting the data tell us what these expectations are?

Our proposal: look at information in the term structure of interest rates

The Term Structure of Interest Rates

> *"The term structure factors summarize expectations about future short rates, which in turn reflect expectations about the future dynamics of the economy. With forward-looking economic agents, these expectations should be important determinants of current and future macroeconomic variables."*
>
> *Rudebusch and Wu (2008)*

We apply this idea to the exchange rate.

Outline

- The asset pricing models of nominal exchange rate and the macro fundamentals
- Macro-finance literature: the yield curve contains information about future macro fundamentals
- The Nelson-Siegel (1987) factors summarize informatoin in the yield curve effectively
- The *relative* N-S factors explain exchange rate returns and currency risk premium
- An intuitive explanation for the uncovered interest rate parity puzzle
- Conclusion

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The Present Value Approach to ER Determination

- The net present value relationship:

$$s_{t+1} = \lambda \sum_{j=0}^{\infty} \psi^j E_t(f_{t+j}|I_t)$$

$f_t \in \{(i_t - i_t^*), (y_t - y_t^*), (\pi_t^e - \pi_t^{*e}), (m_t - m_t^*), \rho ...\}$ is model dependent

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Results of numerous structural models, for example

- The canonical monetary models of Mussa (1976), Frankel (1979), Mark (1995), Chinn et al (2004). . .
- More recent Taylor rule models: Engel and West (2005), Mark (2007), Papell and Molodtsova (2008)

e.g. the Taylor Rule Exchange Rate Model

- Home monetary policy rule: $i_t = \mu_t + \beta_y y_t^{gap} + \beta_\pi \pi_t^e$
- Foreign monetary policy rule: $i_t^* = \mu_t^* + \beta_y y_t^{*,gap} + \beta_\pi \pi_t^{*e} - \delta q_t$ where $q_t = s_t - p_t + p_t^*$
- Risk-adjusted UIP: $i_t - i_t^* = E_t \Delta s_{t+1} + \rho^H$
- $\implies s_t = \gamma f_t^{TR} + \psi E_t s_{t+1}$
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- use the **yield curves** to proxy the discounted sum: $\sum_{j=1}^{\infty} \psi^j E_t(\Delta f_{t+j} | I_t)$

Summarizing a Yield Curve: Nelson-Siegel (1987) Factors

$$i_t^m = L_t + S_t\left(\frac{1 - e^{-\lambda m}}{\lambda m}\right) + C_t\left(\frac{1 - e^{-\lambda m}}{\lambda m} - e^{-\lambda m}\right)$$

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- **Level** L_t: loading on 1 $\longrightarrow$ shifts the whole yield curve
- **Slope** S_t (term spread): loading starts from 1 and decreasing $\longrightarrow$ moves short end of the yield curve
- **Curvature** C_t: loading increases and then drops $\longrightarrow$ moves middle part of the yield curve
- $\lambda = 0.0609$
- Fit ≈ 0.99

Graphical Illustration of the Factor Loadings

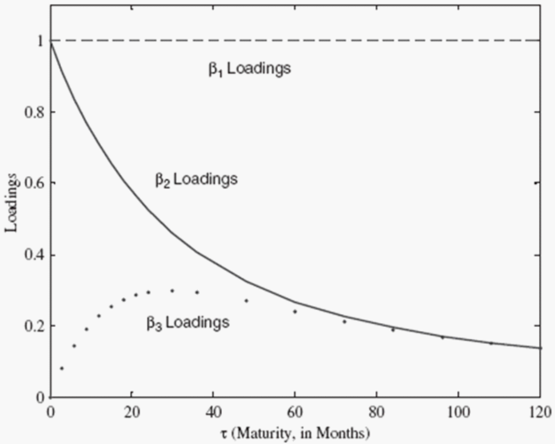
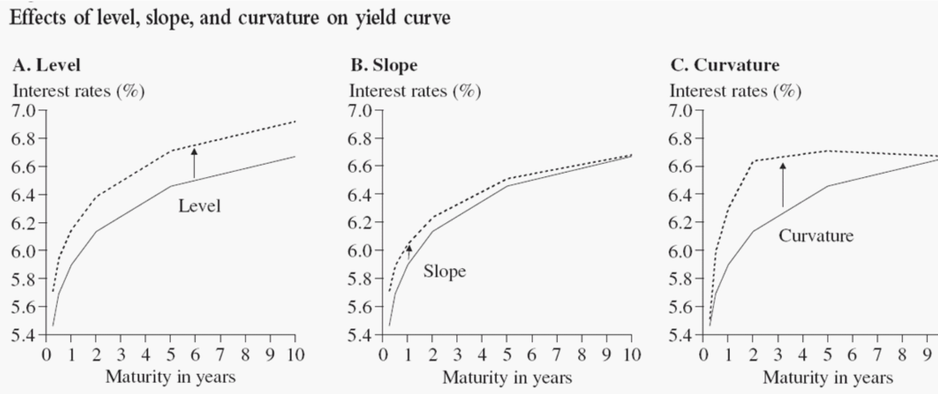


Fig. 1. Factor loadings. We plot the factor loadings in the three-factor model,

$$y_t(\tau) = \beta_{1t} + \beta_{2t}\left(\frac{1-e^{-\lambda_t \tau}}{\lambda_t \tau}\right) + \beta_{3t}\left(\frac{1-e^{-\lambda_t \tau}}{\lambda_t \tau} - e^{-\lambda_t \tau}\right),$$

where the three factors are β_{1t}, β_{2t}, and β_{3t}, the associated loadings are 1, $(1-e^{-\lambda_t \tau})/\lambda_t \tau$, and $(1-e^{-\lambda_t \tau})/\lambda_t \tau - e^{-\lambda_t \tau}$, and τ denotes maturity. We fix $\lambda_t = 0.0609$.



Effects of level, slope, and curvature on yield curve
A. Level
Interest rates (%)
7.0
6.8
6.6
6.4
6.2
6.0
5.8
5.6
5.4
0 1 2 3 4 5 6 7 8 9 10
Maturity in years
Level
B. Slope
Interest rates (%)
Maturity in years
Slope
C. Curvature
Interest rates (%)
Maturity in years
Curvature

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- Level factor L_t captures expected longer-run inflation
  - Mishkin (1990), Barr and Campbell (1997), Dewachter and Lyrio Rud(2006), Rudebusch and Wu (2007)...
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- A **higher level** indicates higher expected long run inflation
- Slope factor S_t forecasts GDP growth, recession, monetary policy...
  - Estrella and Mishkin (1996), Hamilton and Kim (2002), Ang, Piazzesi and Wei (2006), Rudesbusch and Wu (2008)...
- A **flatter slope** reflects expected GDP slowdown

For ER: use *relative* Nelson-Siegal factors

- ER is a relative price reflecting the cross-country differences in fundamentals and their expectations
- Look at yield curve *differences* across countries:

$$i_t^m - i_t^{m*} = L_t^R + S_t^R\left(\frac{1 - e^{-\lambda m}}{\lambda m}\right) + C_t^R\left(\frac{1 - e^{-\lambda m}}{\lambda m} - e^{-\lambda m}\right)$$

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- Do expectations, as captured in the YC factors, affect **currency risk premium?**

$$rx_{t+m} = i_t^{m*} - i_t^m + \Delta s_{t+m}$$

- Excess currency returns (for foreign currency) captures risk premium: $rx = \rho^F$

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Data & Specifications

- Monthly data: August 1985 to July 2005 for the US, Canada, Japan, and the United Kingdom (
- Fama-Bliss zero-coupon yields for maturities 3, 6, 9, 12, 15, 18, 21, 24, 30, 36, 48, 60, 72, 84, 96, 108 and 120 months
- Fit the relative Nelson-Siegel yield curve by OLS; Reject unit root for most of the factors

$$1200\frac{(s_{t+m} - s_t)}{m} = \beta_{0,m} + \beta_{Lm} L_t^R + \beta_{Sm} S_t^R + \beta_{Cm} C_t^R + \varepsilon_{t+m}$$

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- Note: Overlapping observations for $m > 1$, induces $MA(m-1)$ errors
- Use rescaled t-statistics of Moon, Rubia and Valkanov (2004): $t/\sqrt{m}$
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ER Change (Yen-USD)

$$\frac{1200(s_{t+m} - s_t)}{m} = \beta_{m,0} + \beta_{m,1} L_t^R + \beta_{m,2} S_t^R + \beta_{m,3} C_t^R + u_{t+m}$$

	m=1	m=3	m=6	m=12	m=18	m=24
L^R	-2.606	-1.424	-0.871	-2.155	-1.504	-1.504
$t/\sqrt{m}$	-0.705	-0.467	-0.293	-0.866	-0.590	-0.617
S^R	-4.093*	-4.061*	-3.950*	-3.176*	-2.321*	-2.321*
$t/\sqrt{m}$	-2.173	-2.605	-2.607	-2.506	-1.778	-1.852
C^R	0.535	0.890	0.566	-0.096	-0.565	-0.565
$t/\sqrt{m}$	0.385	0.771	0.504	-0.102	-0.585	-0.609
N. obs.	239	237	234	228	222	216

Non-Overlapping Data (ER Change)

$$\frac{1200(s_{t+m} - s_t)}{m} = \beta_{m,0} + \beta_{m,1} L_t^R + \beta_{m,2} S_t^R + \beta_{m,3} C_t^R + u_{t+m}$$

	m=3	m=6	m=3	m=6	m=3	m=6
	Canada		Japan		UK	
L^R	-3.220*	-1.702	-2.153	0.060	-4.666*	-2.669*
	(1.357)	(1.393)	(2.982)	(2.975)	(1.890)	(1.176)
S^R	-0.550	-0.642	-3.494*	-4.226*	-2.308*	-2.080*
	(0.521)	(0.425)	(1.693)	(1.816)	(0.943)	(0.674)
C^R	-0.794*	-0.791*	0.503	1.024	-1.240*	-0.831*
	(0.443)	(0.442)	(1.258)	(1.255)	(0.563)	(0.325)
N. obs.	79	39	79	39	71	35
Adj. R^2	0.029	0.020	0.029	0.067	0.092	0.194

Out-of-Sample Forecasting

Relating to the Meese-Rogoff (1983) forecast puzzle:

Compare mean squared forecast error (MSFE) with random walk, using Clark-West (2006) statistics

- Rolling window of 5 years; stops at 3 months (sample size gets too small)
- *t*-stats for the null that the model performs equally as the RW:

Horizons	*Canada*	*Japan*	*UK*
$m = 1$	3.860*	2.517*	3.274*
$m = 2$	2.002*	1.475	1.719*
$m = 3$	1.367	1.240	1.128

Intuition

- A country's yield curve is flatter (larger S_t) or its level higher (larger L_t) $\Rightarrow$ expects forthcoming economic downturn or rising inflation
- Its currency depreciates NOW according to present value relation
- Subsequently: appreciates back to LR equilibrium level
- Current yield curve predicts subsequent ER movements
- Note: Contrary to Dornbusch (1976)'s overshooting prediction but consistent with Eichenbaum and Evans (1995) or Gourinchas and Tornell (2004)

Excess Currency Return (CAD-USD)

$$rx_{t+m} = \gamma_{m,0} + \gamma_{m,1} L_t^R + \gamma_{m,2} S_t^R + \gamma_{m,3} C_t^R + v_{t+m}$$

	m=3	m=6	m=12	m=18	m=24
L^R	-3.206*	-2.550*	-2.585	-2.305	-1.721
$t/\sqrt{m}$	-1.817	-1.660	-1.611	-1.339	-0.908
S^R	-1.437*	-1.333*	-1.174*	-0.963	-0.753
$t/\sqrt{m}$	-1.845	-2.038	-1.746	-1.335	-0.949
C^R	-0.828	-0.744	-0.739	-0.771	-0.633
$t/\sqrt{m}$	-1.448	-1.550	-1.472	-1.431	-1.068
N. obs.	172	224	228	222	216

Excess Currency Return (Yen-USD)

$$rx_{t+m} = \gamma_{m,0} + \gamma_{m,1} L_t^R + \gamma_{m,2} S_t^R + \gamma_{m,3} C_t^R + v_{t+m}$$

	m=3	m=6	m=12	m=18	m=24
L^R	-2.187	-2.233	-3.151	-3.223	-2.521
$t/\sqrt{m}$	-0.656	-0.752	-1.265	-1.262	-1.031
S^R	-5.787*	-4.967*	-3.899*	-3.160*	-2.846*
$t/\sqrt{m}$	-3.431	-3.281	-3.076	-2.411	-2.260
C^R	1.023	0.463	-0.327	-0.762	-0.852
$t/\sqrt{m}$	0.802	0.409	-0.347	-0.788	-0.915
N. obs.	153	228	228	222	216

Excess Currency Return (GBP-USD)

$$rx_{t+m} = \gamma_{m,0} + \gamma_{m,1} L_t^R + \gamma_{m,2} S_t^R + \gamma_{m,3} C_t^R + v_{t+m}$$

	m=3	m=6	m=12	m=18	m=24
L^R	-4.858*	-4.451*	-3.718*	-3.086*	-2.534*
$t/\sqrt{m}$	-1.959	-2.446	-2.507	-2.134	-1.821
S^R	-3.772*	-2.824*	-2.138*	-1.727*	-1.397*
$t/\sqrt{m}$	-1.926	-2.377	-2.530	-2.249	-1.888
C^R	-0.939	-1.229*	-1.039*	-0.906*	-0.718*
$t/\sqrt{m}$	-0.994	-2.135	-2.363	-2.157	-1.766
N. obs.	108	159	195	198	192

Non-Overlapping Data: Excess Return

$$rx_{t+m} = \gamma_{m,0} + \gamma_{m,1} L_t^R + \gamma_{m,2} S_t^R + \gamma_{m,3} C_t^R + v_{t+m}$$

	m=3	m=6	m=3	m=6	m=3	m=6
	Canada		Japan		UK	
$\mathbf{L^R}$	-2.725	-2.655	-1.450	-0.932	-7.165*	-3.756*
	(1.445)	(1.393)	(3.297)	(2.971)	(3.593)	(1.505)
$\mathbf{S^R}$	-1.561*	-1.503*	-6.893*	-5.049*	-3.477	-3.222*
	(0.587)	(0.430)	(1.430)	(1.808)	(2.226)	(1.029)
$\mathbf{C^R}$	-0.765	-0.916*	1.613	0.867	-2.576	-0.869
	(0.472)	(0.443)	(1.567)	(1.249)	(1.552)	(0.588)
N. obs.	58	39	33	39	35	28
Adj. R^2	0.064	0.161	0.289	0.135	0.131	0.274

The Yield Curves Tell Us A LOT about the Exchange Rates

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Using monthly data for the US, Canada, Japan and the UK over 1985-2005,
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- In-sample: predictability for 1-month to 2-year ahead
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A 1% rise in the overall leve of the yield curve, or flattening of its slope, ceteris paribus,

- leads to a 3-4% appreciation of the currency subsequently (size of response declines as horizon increases)
- significantly raises the "risk premium" for holding the currency

Explaining Currency Risk Premium:

We see that as home faces high L_t^R or S_t^R, ρ^H rises (ρ^F falls)

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1. High inflation lowers the purchasing power, i.e. home currency return low
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- Home currency payoffs in states of nature with low MU: Cov $< 0 \Longrightarrow$ positive risk premium

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1. Home currency depreciates with low Y, so home currency return low
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Risk-adjusted UIP:

$$\Delta s_{t+1} = i_t - i_t^* - \rho_{t+1}^H + \epsilon_{t+1}$$

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  - Risk premium associated with holding AUD is likely large
  - AUD may appreciate relative to YEN

Conclusion

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- Exchange rates are NOT disconnected from macro fundamentals
  - The N-S factors, embodying information about expected fundamentals, provide statistically and economically significant ER predictions both in and out of sample
  - Support the asset approach of ER determination
- The yield curves offer an intuitive and empirically robust explanation for the observed currency risk premium
- The predicted behavior of risk premium helps explain the UIP puzzle