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THE TERM STRUCTURE OF CURRENCY CARRY TRADE RISK PREMIA

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Introduction

- ✓ Returns of FX carry trades, according to uncovered interest rate parity (UIP), should be zero, but empirically they are positive
- ✓ The paper explores the properties of FX carry trades across all maturities, not only in the front end of the term structure
- ✓ As the maturity of the bonds increases, the average excess return of carry trades declines to zero
- ✓ The downward-sloping term structure of carry trade risk premia challenges existing models in international finance
- ✓ The paper derives a preference-free condition that dynamic no-arbitrage models must satisfy to replicate carry trade risk premia, which none of the models considered satisfy and therefore cannot fully replicate this empirical findings

Data

- ✓ The benchmark sample consists of developed countries with liquid bond markets, including Australia, Canada, Germany, Japan, New Zealand, Norway, Sweden, Switzerland, and the UK, with the US as the domestic country
- ✓ Data on bond returns are obtained from Global Financial Data, including total return bond indices for 10-year government bonds and Treasury bills, in both US dollars and local currency.
- ✓ Inflation rates and sovereign credit ratings are collected from Global Financial Data and Standard & Poor's, respectively, to analyze their impact on bond and currency returns

Notation

- ✓ P_t^k is the price of the zero-coupon bond with k maturity. Hence, its continuous yield is given by $y_t^k = -\frac{\log(P_t^k)}{k}$, its is given by $R_{t+1}^k = \frac{P_{t+1}^k}{P_t^k}$, and the risk-free rate is given by $R_t^f = R_{t+1}^1 = \frac{1}{P_t^k}$. The exchange rates (USDXXX) is given by S_t

- ✓ The log excess return on the domestic (US) zero-coupon bond with maturity *k* is then given by $rx_{t+1}^k = \log(\frac{R_{t+1}^k}{R_t^f})$

- ✓ The log return on a foreign bond position (in USD) in excess of the domestic (US) risk-free rate is:

$$rx_{t+1}^{(k),\$} = \log\left[\frac{R_{t+1}^{(k),*}}{R_t^f}\frac{S_t}{S_{t+1}}\right] = \log\left[\frac{R_{t+1}^{(k),*}}{R_t^{f,*}}\frac{R_t^{f,*}}{R_t^f}\frac{S_t}{S_{t+1}}\right] = \log\left[\frac{R_{t+1}^{(k),*}}{R_t^{f,*}}\right] + \log\left[\frac{R_t^{f,*}}{R_t^f}\frac{S_t}{S_{t+1}}\right] = rx_{t+1}^{(k),*} + rx_{t+1}^{FX}.$$

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Notation

- ✓ The log currency excess return is given by

$$rx_{t+1}^{FX} = \log\left[\frac{S_t}{S_{t+1}}\frac{R_t^{f,*}}{R_t^f}\right] = r_t^{f,*} - r_t^f - \Delta s_{t+1},$$

- ✓ Prior research suggesting that higher returns are earned on foreign bonds when the yield curve slope is higher than average for the respective country, rates carry, but not in cash bonds in USD returns

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Time-Series Predictability of Foreign Bond Returns

- ✓ Regress the 10Y dollar bond log excess return differential $rx_{t+1}^{10,\$} - rx_{t+1}^{10}$ with fixed effects on:

- ✓ Panel A: the short term interest rate differential $rx_t^{f\,*} - rx_t^f$

- ✓ Panel B: the yield curve slope differential $(y_t^{10\,*} - y_t^{1*}) - (y_t^{10} - y_t^1)$

- ✓ Both use post-Bretton Woods sample period Jan75 to Dec 15

- ✓ Newey-West standard errors with six lag + heteroskedasticity correction

- ✓ **Strategy**: For each country, go long/short the foreign country bond and short/long the US bond when the foreign short-term interest rate is higher/lower than the US interest rate (or the foreign yield curve slope is lower/higher than the US yield curve slope), and go long/short the US bond and short/long the foreign country bond when the US interest rate is higher/lower than the country's interest rate (or the US yield curve slope is lower/higher than the foreign yield curve slope)

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Time-Series Predictability of Foreign Bond Returns

	Bond dollar return difference $rx^{(10),\$} - rx^{(10)}$					Currency excess return rx^{FX}					Bond local currency return diff. $rx^{(10),*} - rx^{(10)}$					Slope Diff.	Obs.
	α	s.e.	β	s.e.	$R^2(\%)$	α	s.e.	β	s.e.	$R^2(\%)$	α	s.e.	β	s.e.	$R^2(\%)$	p-value	
Panel A: Short-Term Interest Rates																	
Australia	0.01	[0.03]	-0.15	[0.97]	-0.20	-0.02	[0.02]	1.29	[0.62]	0.56	0.03	[0.02]	-1.44	[0.60]	1.51	0.21	492
Canada	0.02	[0.02]	-1.10	[0.69]	0.11	-0.01	[0.01]	1.22	[0.53]	0.46	0.03	[0.01]	-2.32	[0.46]	3.64	0.01	492
Germany	0.01	[0.02]	1.52	[1.21]	0.37	0.02	[0.02]	2.49	[0.99]	1.71	-0.01	[0.01]	-0.97	[0.60]	0.48	0.53	492
Japan	0.06	[0.03]	2.37	[0.84]	1.13	0.07	[0.02]	3.11	[0.67]	3.48	-0.01	[0.02]	-0.74	[0.52]	0.13	0.49	492
New Zealand	-0.03	[0.04]	0.69	[0.87]	-0.03	-0.07	[0.03]	2.23	[0.49]	3.14	0.04	[0.03]	-1.54	[0.66]	1.62	0.12	492
Norway	-0.02	[0.02]	0.72	[0.62]	0.08	-0.02	[0.02]	1.74	[0.57]	2.26	0.01	[0.01]	-1.02	[0.41]	0.97	0.23	492
Sweden	-0.00	[0.02]	-0.64	[0.91]	-0.02	-0.02	[0.02]	0.89	[0.91]	0.25	0.01	[0.01]	-1.53	[0.49]	2.02	0.23	492
Switzerland	0.02	[0.02]	1.16	[0.82]	0.33	0.05	[0.02]	2.45	[0.78]	2.43	-0.03	[0.01]	-1.29	[0.43]	1.69	0.25	492
United Kingdom	-0.02	[0.03]	1.02	[1.18]	0.04	-0.05	[0.02]	2.69	[0.95]	2.44	0.03	[0.02]	-1.67	[0.66]	1.39	0.27	492
Panel	–	–	0.65	[0.49]	-0.05	–	–	1.98	[0.44]	1.82	–	–	-1.34	[0.30]	1.37	0.00	4428
Joint zero (p-value)	0.44		0.04			0.00		0.00			0.00		0.00			0.04	
Panel B: Yield Curve Slopes																	
Australia	0.06	[0.02]	3.84	[1.56]	1.54	0.00	[0.02]	-1.00	[1.17]	-0.02	0.05	[0.02]	4.84	[0.92]	7.65	0.01	492
Canada	0.04	[0.02]	4.04	[0.98]	2.25	-0.00	[0.01]	-0.72	[0.66]	-0.07	0.04	[0.01]	4.76	[0.63]	9.09	0.00	492
Germany	0.00	[0.02]	0.50	[1.77]	-0.18	-0.01	[0.02]	-3.05	[1.37]	1.15	0.01	[0.01]	3.55	[0.97]	4.07	0.11	492
Japan	0.00	[0.02]	-0.32	[1.38]	-0.19	-0.01	[0.02]	-4.18	[1.08]	2.91	0.01	[0.01]	3.85	[0.82]	3.96	0.03	492
New Zealand	0.08	[0.04]	2.94	[2.04]	1.26	-0.01	[0.03]	-1.60	[1.18]	0.62	0.09	[0.03]	4.55	[1.19]	7.41	0.05	492
Norway	-0.00	[0.02]	0.59	[1.03]	-0.12	-0.01	[0.02]	-2.03	[0.92]	1.33	0.01	[0.01]	2.62	[0.59]	3.35	0.06	492
Sweden	0.02	[0.02]	3.12	[1.23]	2.12	-0.00	[0.02]	-0.13	[1.14]	-0.20	0.02	[0.01]	3.25	[0.71]	5.29	0.05	492
Switzerland	0.00	[0.02]	0.97	[1.17]	-0.06	-0.02	[0.02]	-3.59	[1.26]	1.97	0.02	[0.01]	4.55	[0.78]	8.82	0.01	492
United Kingdom	0.02	[0.03]	1.59	[1.53]	0.17	-0.02	[0.02]	-3.17	[1.37]	2.11	0.04	[0.01]	4.75	[0.83]	7.95	0.02	492
Panel	–	–	1.94	[0.84]	0.42	–	–	-2.02	[0.73]	0.83	–	–	3.96	[0.50]	6.08	0.00	4428
Joint zero (p-value)	0.07		0.00			0.96		0.00			0.00		0.00			0.00	

- No predictability for 10Y bond return differentials (in USD), except for Japan
- FX returns are forecastable by interest rate differentials
- Local currency bond return differentials are also predictable by interest rate differentials
- Yield curve slope differentials can forecast both FX and local currency bond excess returns

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Time-Series Predictability of Foreign Bond Returns

	Bond dollar return difference $rx^{(10),\$} - rx^{(10)}$					Currency excess return rx^{FX}					Bond local currency return diff. $rx^{(10),*} - rx^{(10)}$				
	Mean	s.e.	Std.	SR	s.e.	Mean	s.e.	Std.	SR	s.e.	Mean	s.e.	Std.	SR	s.e.
Panel A: Short-Term Interest Rates															
Australia	1.28	[2.23]	14.27	0.09	[0.16]	3.55	[1.75]	11.40	0.31	[0.16]	-2.27	[1.34]	8.46	-0.27	[0.15]
Canada	-0.46	[1.42]	9.10	-0.05	[0.16]	0.86	[1.13]	6.97	0.12	[0.16]	-1.31	[0.85]	5.50	-0.24	[0.15]
Germany	2.19	[1.93]	12.45	0.18	[0.16]	3.86	[1.72]	11.13	0.35	[0.16]	-1.67	[1.16]	7.30	-0.23	[0.16]
Japan	0.93	[2.19]	14.31	0.07	[0.16]	1.54	[1.73]	11.31	0.14	[0.16]	-0.61	[1.43]	9.03	-0.07	[0.16]
New Zealand	0.65	[2.56]	16.91	0.04	[0.16]	3.84	[1.87]	12.25	0.31	[0.17]	-3.19	[1.76]	11.47	-0.28	[0.16]
Norway	0.69	[1.98]	13.00	0.05	[0.16]	3.17	[1.60]	10.61	0.30	[0.16]	-2.48	[1.42]	8.99	-0.28	[0.16]
Sweden	-0.40	[2.03]	12.85	-0.03	[0.15]	2.30	[1.73]	11.14	0.21	[0.16]	-2.71	[1.38]	8.68	-0.31	[0.16]
Switzerland	0.57	[2.05]	12.84	0.04	[0.16]	1.14	[1.97]	12.22	0.09	[0.15]	-0.57	[1.13]	7.62	-0.07	[0.16]
United Kingdom	0.89	[2.00]	12.76	0.07	[0.15]	3.09	[1.59]	10.26	0.30	[0.16]	-2.20	[1.25]	8.21	-0.27	[0.15]
Equally-weighted	0.70	[1.00]	6.36	0.11	[0.16]	2.59	[0.87]	5.55	0.47	[0.17]	-1.89	[0.60]	3.73	-0.51	[0.16]
Panel B: Yield Curve Slopes															
Australia	-1.88	[2.22]	14.26	-0.13	[0.16]	2.89	[1.80]	11.41	0.25	[0.17]	-4.76	[1.34]	8.37	-0.57	[0.14]
Canada	-2.07	[1.41]	9.08	-0.23	[0.15]	1.23	[1.10]	6.97	0.18	[0.16]	-3.30	[0.83]	5.43	-0.61	[0.16]
Germany	1.98	[1.92]	12.46	0.16	[0.16]	5.17	[1.71]	11.09	0.47	[0.16]	-3.19	[1.14]	7.25	-0.44	[0.15]
Japan	-0.71	[2.21]	14.31	-0.05	[0.16]	4.60	[1.73]	11.24	0.41	[0.16]	-5.31	[1.42]	8.90	-0.60	[0.16]
New Zealand	-0.18	[2.57]	16.91	-0.01	[0.16]	3.49	[1.90]	12.26	0.28	[0.17]	-3.67	[1.77]	11.45	-0.32	[0.15]
Norway	-0.56	[2.05]	13.00	-0.04	[0.15]	2.84	[1.73]	10.61	0.27	[0.16]	-3.40	[1.39]	8.97	-0.38	[0.15]
Sweden	-3.62	[1.99]	12.81	-0.28	[0.16]	1.32	[1.75]	11.15	0.12	[0.17]	-4.94	[1.38]	8.60	-0.57	[0.16]
Switzerland	0.47	[2.00]	12.84	0.04	[0.15]	4.80	[1.91]	12.15	0.40	[0.15]	-4.33	[1.17]	7.51	-0.58	[0.16]
United Kingdom	-2.73	[1.95]	12.73	-0.21	[0.16]	2.06	[1.61]	10.29	0.20	[0.16]	-4.79	[1.30]	8.12	-0.59	[0.16]
Equally-weighted	-1.03	[1.24]	7.82	-0.13	[0.16]	3.16	[1.08]	6.68	0.47	[0.16]	-4.19	[0.80]	5.04	-0.83	[0.16]

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Cross-Sectional Properties of Foreign Bond Returns

- **Strategy**: they sort countries into 3 portfolios of 10Y bond indices based on the short term interest rate differential $rx_t^{f\,*} - rx_t^{f}$ and the yield curve slope differential $(y_t^{10\,*} - y_t^{1*}) - (y_t^{10} - y_t^{1})$, but they subtract the past 10-year rolling mean of the sorting variable

- Portfolios are rebalanced every month and those formed at date t only use information available at that date

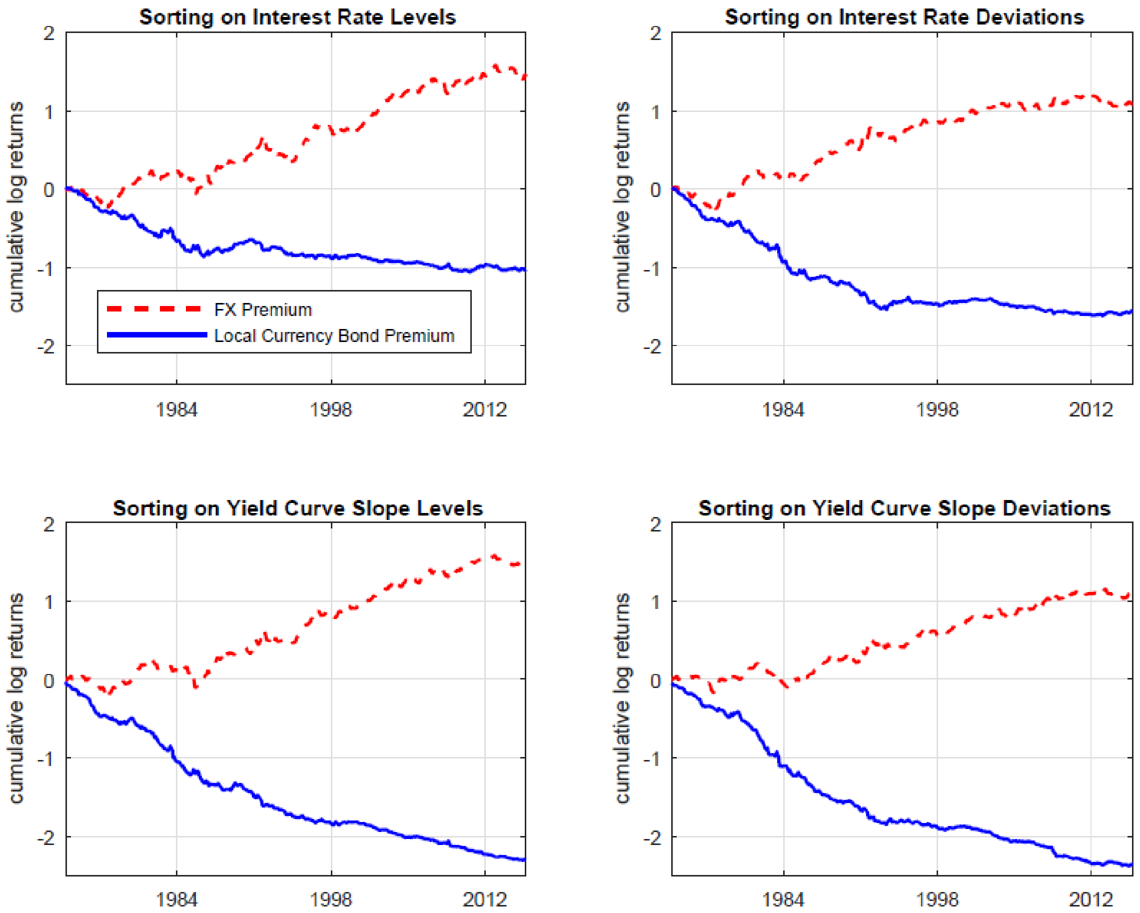
- Portfolio-level log excess returns are obtained by averaging country-level log excess returns across all countries in the portfolio

Cross-Sectional Properties of Foreign Bond Returns

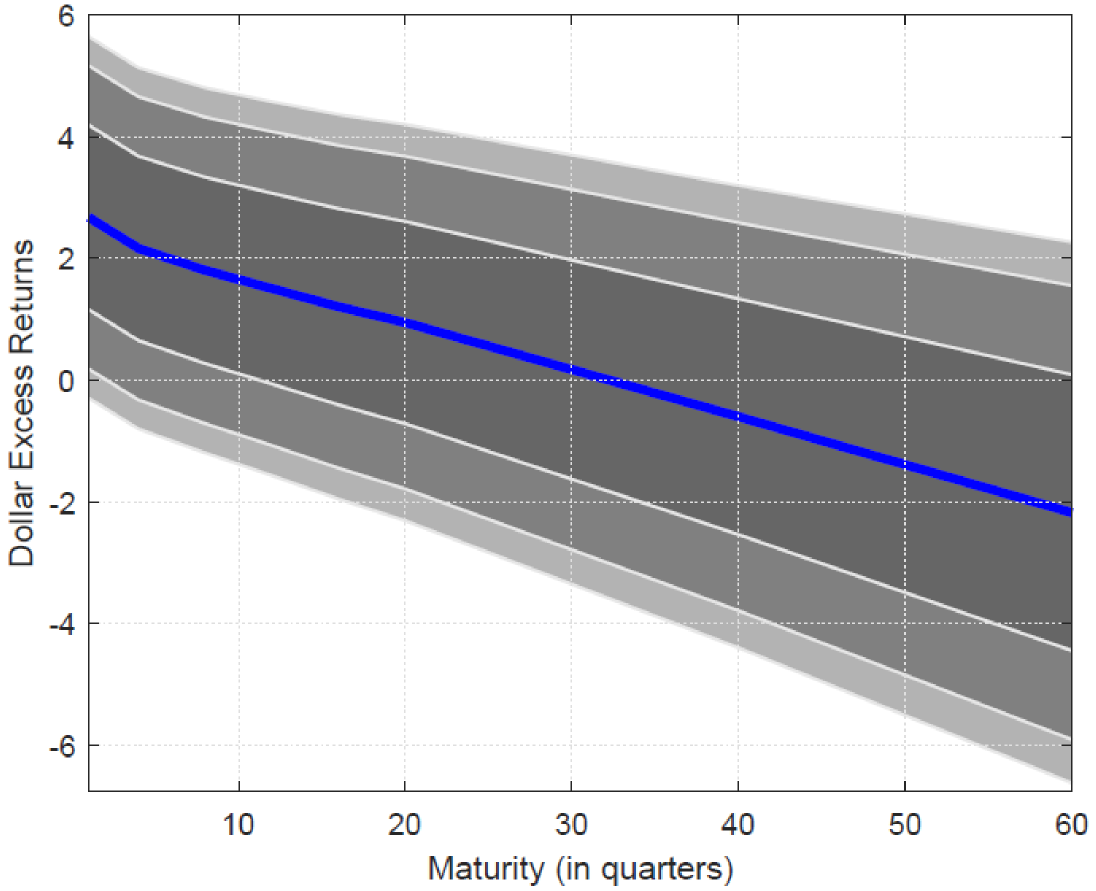
Portfolio		Sorted by Short-Term Interest Rates 1	2	3	3 − 1	Sorted by Yield Curve Slopes 1	2	3	1 − 3
		Panel A: Portfolio Characteristics							
Inflation rate	Mean	2.90	3.45	4.81	1.91	4.89	3.41	2.87	2.02
	s.e.	[0.16]	[0.19]	[0.23]	[0.20]	[0.23]	[0.19]	[0.18]	[0.19]
	Std	1.03	1.23	1.48	1.30	1.39	1.16	1.20	1.26
Rating	Mean	1.45	1.25	1.49	0.04	1.54	1.38	1.28	0.25
	s.e.	[0.02]	[0.02]	[0.02]	[0.04]	[0.02]	[0.02]	[0.02]	[0.03]
Rating (adj. for outlook)	Mean	1.50	1.37	1.84	0.33	1.84	1.50	1.37	0.47
	s.e.	[0.03]	[0.02]	[0.02]	[0.04]	[0.02]	[0.02]	[0.02]	[0.03]
$y_t^{(10),*} - r_t^{*,f}$	Mean	1.52	0.92	-0.44	-1.96	-0.81	0.85	1.96	-2.76
		Panel B: Currency Excess Returns							
$-\Delta s_{t+1}$	Mean	-0.44	0.11	-0.60	-0.16	-0.95	0.38	-0.36	-0.58
$r_t^{f,*} - r_t^f$	Mean	-0.17	0.54	2.65	2.81	3.35	0.55	-0.88	4.23
rx_{t+1}^{FX}	Mean	-0.61	0.66	2.05	2.66	2.41	0.92	-1.24	3.65
	s.e.	[1.35]	[1.44]	[1.36]	[1.14]	[1.48]	[1.38]	[1.40]	[1.18]
	SR	-0.07	0.07	0.23	0.36	0.26	0.11	-0.14	0.49
		Panel C: Local Currency Bond Excess Returns							
$rx_{t+1}^{(10),*}$	Mean	3.53	2.60	-0.25	-3.78	-1.01	2.29	4.61	-5.61
	s.e.	[0.69]	[0.69]	[0.73]	[0.77]	[0.76]	[0.69]	[0.70]	[0.74]
	SR	0.80	0.58	-0.05	-0.77	-0.21	0.53	1.00	-1.18
		Panel D: Dollar Bond Excess Returns							
$rx_{t+1}^{(10),\$}$	Mean	2.92	3.26	1.80	-1.12	1.40	3.21	3.36	-1.96
	s.e.	[1.56]	[1.58]	[1.57]	[1.33]	[1.64]	[1.57]	[1.62]	[1.38]
	SR	0.29	0.32	0.18	-0.13	0.14	0.33	0.32	-0.22
$rx_{t+1}^{(10),\$} - rx_{t+1}^{(10)}$	Mean	0.14	0.48	-0.98	-1.12	-1.38	0.43	0.59	-1.96
	s.e.	[1.64]	[1.64]	[1.73]	[1.33]	[1.81]	[1.63]	[1.75]	[1.38]

- No reason to favor the long-term bonds of a particular set of countries for USD investors
- Local currency bond premia decrease at the same time as the FX appreciates zeroing the effect on USD foreign bonds
- Inflation and credit risk do not seem to explain the FX and local currency returns

Cross-Sectional Properties of Foreign Bond Returns



The term structure of the carry trade



Macro models

- ✓ The nominal local SDF priced of a zero-coupon bond that promises one currency unit k periods into the future by

$$P_t^{(k)} = E_t\left(\frac{\Lambda_{t+k}}{\Lambda_t}\right)$$

- ✓ The nominal exchange rate corresponds to the ratio of the domestic to foreign nominal SDFs:

$$\frac{S_{t+1}}{S_t} = \frac{\Lambda_{t+1}}{\Lambda_t}\frac{\Lambda_t^*}{\Lambda_{t+1}^*}$$

- ✓ Hence, $E_t\left(rx_{t+1}^{FX}\right) = r_t^{f,*} - r_t^f - E_t(\Delta s_{t+1}) = L_t\left(\frac{\Lambda_{t+1}}{\Lambda_t}\right) - L_t\left(\frac{\Lambda_{t+1}^*}{\Lambda_t^*}\right)$

where $L_t\left(X_{t+1}\right) = \log E_t\left(X_{t+1}\right) - E_t\left(\log X_{t+1}\right)$

- ✓ High interest rate countries must exhibit relatively less volatile SDFs

Macro models

- ✓ Split the nominal local SDF into a permanent and a temporary SDF:

$$\Lambda_t = \Lambda_t^{\mathbb{P}} \Lambda_t^{\mathbb{T}}, \text{ where } \Lambda_t^{\mathbb{T}} = \lim_{k\to\infty} \frac{\delta^{t+k}}{P_t^{(k)}}; \quad \Lambda_t^{\mathbb{P}} = \lim_{k\to\infty} \frac{P_t^{(k)}}{\delta^{t+k}} \Lambda_t = \lim_{k\to\infty} \frac{E_t(\Lambda_{t+k})}{\delta^{t+k}}$$

- ✓ **Theorem**: The foreign term premium on the long-term bond in dollars is equal to the domestic term premium plus the difference between the domestic and foreign entropies of the permanent components of the pricing kernels

$$E_t[rx_{t+1}^{(\infty),\$}] = E_t\left[rx_{t+1}^{(\infty)}\right] + L_t\left(\frac{\Lambda_{t+1}^{\mathbb{P}}}{\Lambda_t^{\mathbb{P}}}\right) - L_t\left(\frac{\Lambda_{t+1}^{\mathbb{P},*}}{\Lambda_t^{\mathbb{P},*}}\right) \qquad R_{t+1}^{(\infty)} = \lim_{k\to\infty} R_{t+1}^{(k)} = \lim_{k\to\infty} P_{t+1}^{(k-1)}/P_t^{(k)} = \frac{\Lambda_t^{\mathbb{T}}}{\Lambda_{t+1}^{\mathbb{T}}}.$$

- ✓ In order to have differences across countries in bond risk premia (in USD) no-arbitrage models need conditional entropy differences in the permanent component of their pricing kernels. If countries share the same common permanent shocks, then there is no term premia in USD on foreign bonds

- ✓ Differences across countries in how temporary shocks affect the marginal utility of wealth, and thus exchange rates, appear as natural way to align no-arbitrage models with the downward-sloping term structure of carry trade risk premia