Global Currency Hedging with Common Risk Factors

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Background: Foreign Investments and Diversification Gains

Figure 1. United States

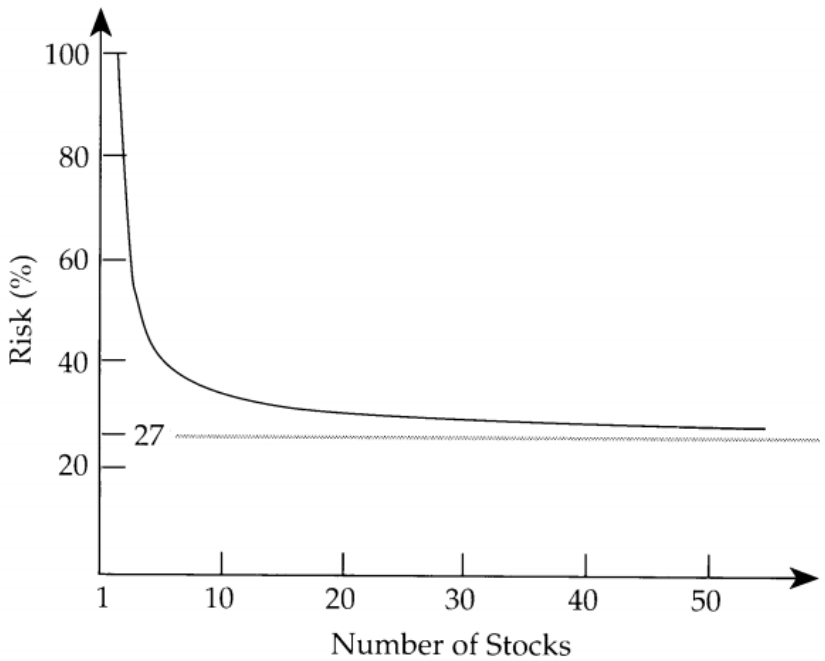
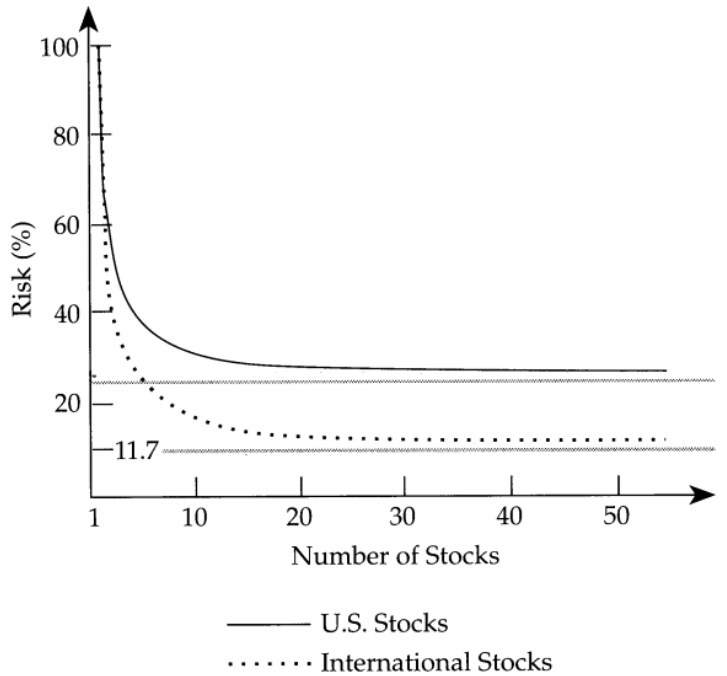


Figure 9. International Diversification



(a) U.S. diversification...

(b) enhanced with foreign stocks

Source: Solnik (1974)

Motivation: U.S. Foreign Investments Growing Rapidly

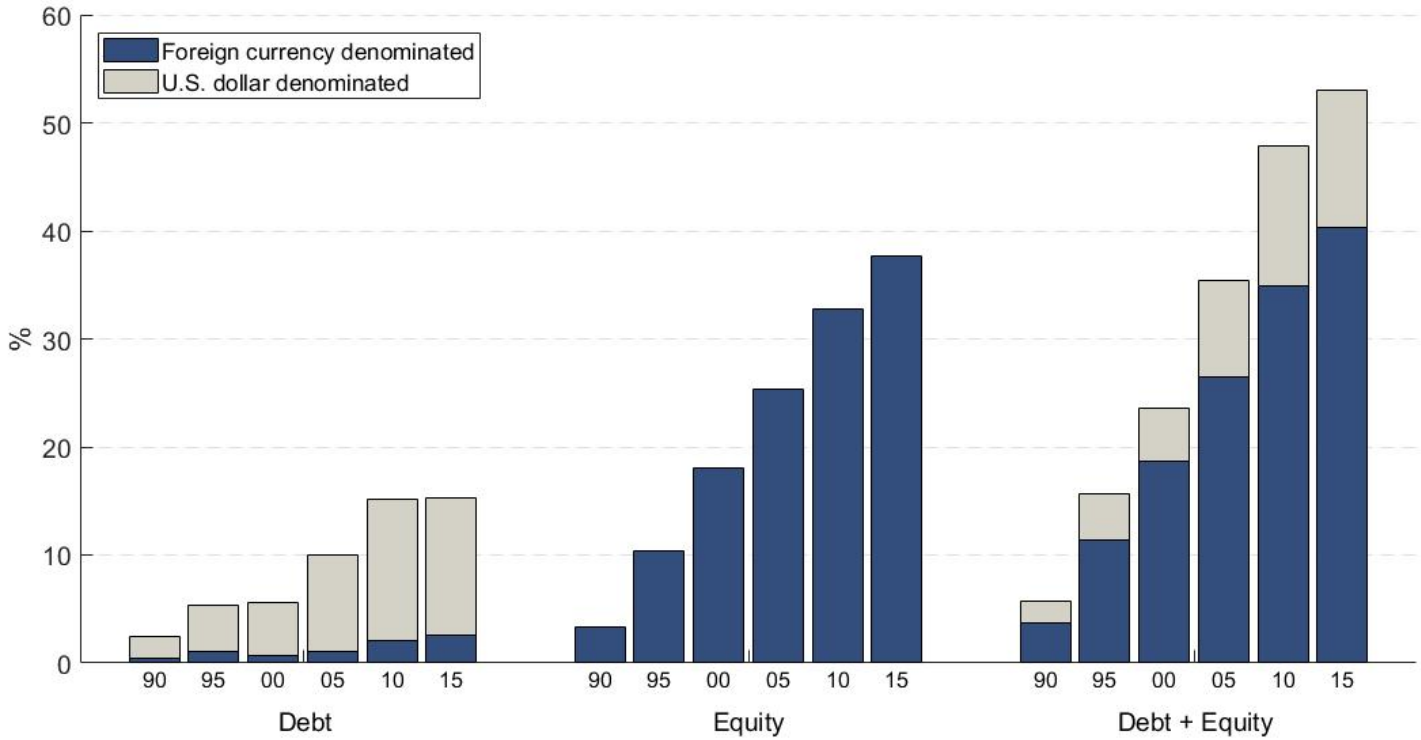


Figure: U.S. Domestically Owned Foreign Assets (% GDP)

The Impact of Foreign Currency on International Portfolios

- Foreign exchange exposure impacts the local currency return and risk profile of foreign investments,

$$r_t \approx r_t^* + e_t; \qquad var(r_t) \approx var(r_t^*) + var(e_t) + 2cov(r_t^*, e_t)$$

where, r_t is the local-currency-denominated return, r_t^* is the foreign-currency-denominated return, e_t is the FX return

- Can hedge FX exposure using FX forwards:
  - $e_{t,h} = \frac{F_{t-1}}{S_{t-1}} - 1 \approx r_{f,t-1} - r_{f,t-1}^*$
  - $var(r_{t,h}) = var(r_t^*)$
  - BUT... is this the best option?
    - Does not necessarily lower volatility
    - Limits upside to total return if currency return is predictable

Motivation: Foreign Exchange Exposure Matters

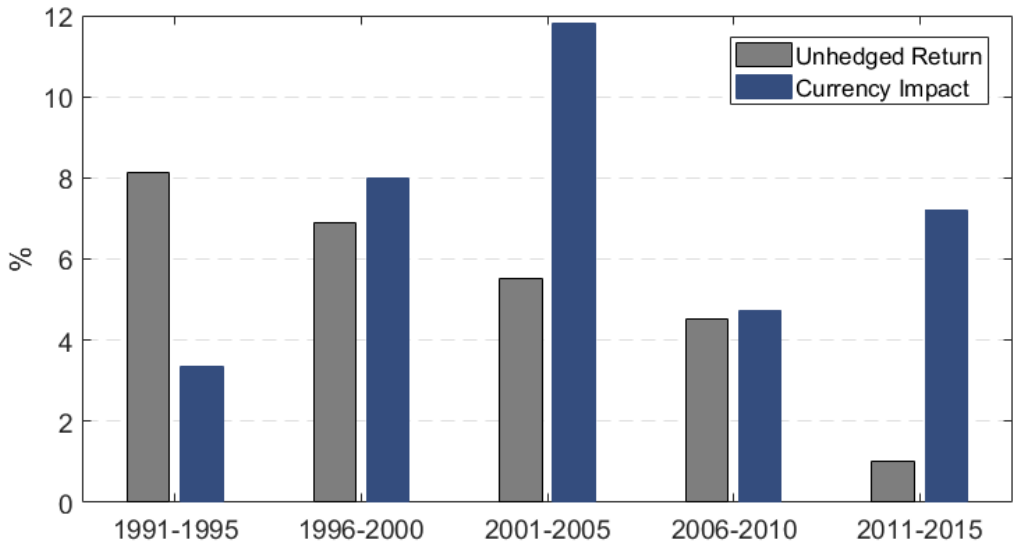


Figure: MSCI World Returns and the Impact of Foreign Currency

- Average unhedged MSCI World return = 5.2%
- Average impact of foreign currency = 7.2% (absolute difference between fully hedged and unhedged return)

Motivation: The Problem

- How should we manage FX exposure?
  - One of the largely unresolved questions in international finance

1. Adopt mean-variance (MV) optimization
   - 1.1 Glen and Jorion (1993) Campbell et al. (2010)
   - 1.2 MV usually fails out-of-sample because of estimation error (Jorion (1985) DeMiguel et al. (2009))
   - 1.3 The big problem is estimating expected currency returns (Gardner and Stone, 1995; Larsen, Jr and Resnick, 2000)
2. Avoid MV optimization
   - Construct a separate currency portfolio
   - Combine currency carry, value and momentum strategies (see, Asness et al. (2013), Kroencke et al. (2014))
   - Secondary issue: institutional investors often required to overlay existing portfolio with FX forwards

What We Do

- We propose a novel method for hedging foreign exchange exposure using common risk factors in currency markets
  - *Dollar* and *carry* factors can predict currency excess returns in the *cross section* (Lustig, et al., 2011; Verdelhan, 2018)
  - Factor premia are predictable in the *time series* (see e.g., Bakshi and Panayotov, 2013; Ready, et al., 2017)

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- We take the perspective of a mean-variance U.S. investor with an existing position in either foreign equities or bonds
  - Investors need to estimate expected currency returns and the cross-asset covariance matrix
  - We form expected currency returns conditionally via common risk factors

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- Dynamic Currency Factor (DCF) hedging: determine FX hedges using expected currency returns in MV optimization

A Mean-Variance Investor

We select FX forward positions that maximize the risk-return trade-off for a MV investor:

$$\mu_{p,t} - \frac{\gamma}{2}\sigma^2_{p,t} \tag{1}$$

$\mu_{p,t}$: expected portfolio return, $\sigma^2_{p,t}$: portfolio risk, γ: risk aversion

Partition the expected return vector and associated covariance matrix (see, e.g. Anderson and Danthine, 1981)

$$\mu = \begin{pmatrix} \mu_x \\ \mu_f \end{pmatrix}, \quad \Sigma = \begin{pmatrix} \Sigma_{xx} & \Sigma_{xf} \\ \Sigma_{fx} & \Sigma_{ff} \end{pmatrix} \tag{2}$$

The Optimal FX Forward Positions

The optimal weights in FX forwards are given by:

$$w^*_{f,t}(f|x) = \frac{1}{\gamma}\left(\Sigma^{-1}_{ff,t}\mu_{f,t}\right) - \delta_t w_{x,t} \tag{3}$$

$w_{x,t}$: vector of pre-determined underlying security weights,

δ_t: regression coefficient obtained from projecting underlying asset returns on currency returns, i.e, $\delta_t = \Sigma^{-1}_{ff,t}\Sigma_{fx,t}$

We constrain each element of $w^*_{f,t}$ to be between $-w_{x,t}$ (100% hedge) and zero (0% hedge)

Common Risk Factors

Substantial recent developments in currency research. We now have a much better understanding of the common risk factors driving currency returns than we did even 10 years ago

Lustig et al. (2011) and Verdelhan (2018) show that currency returns are function of two factors: *dollar* and *carry* risk

$$\mathbb{E}[R_{i,t}] = \beta_i^{dol} \lambda^{dol} + \beta_i^{car} \lambda^{car} \tag{4}$$

- *Dollar*: average return of a basket of foreign currencies against the US dollar
- *Carry*: returns to the currency carry trade (long high interest rate currencies, short low interest rate currencies)

Expected Currency Returns

Estimate currency returns using a conditional version of the model

- Allow both betas and factor premia to vary over time

$$\mu_{f,t} = \begin{bmatrix} \mathbb{E}_t R_{1,t+1} \\ \mathbb{E}_t R_{2,t+1} \\ \vdots \\ \mathbb{E}_t R_{K,t+1} \end{bmatrix} = \begin{bmatrix} \beta_{1,t}^{dol} E_t \lambda_{t+1}^{dol} + \beta_{1,t}^{car} E_t \lambda_{t+1}^{car} \\ \beta_{2,t}^{dol} E_t \lambda_{t+1}^{dol} + \beta_{2,t}^{car} E_t \lambda_{t+1}^{car} \\ \vdots \\ \beta_{K,t}^{dol} E_t \lambda_{t+1}^{dol} + \beta_{K,t}^{car} E_t \lambda_{t+1}^{car} \end{bmatrix} \tag{5}$$

- Betas are estimated using a rolling 60-month window
- Expected factor returns are formed using theoretically motivated predictor variables

Predicting Currency Factor Returns

$$E_t \lambda^j_{t+1} = \varsigma_{j,t} + \psi_{j,t} X_t;\ j = \{dol, car\}, \tag{6}$$

- We use theoretically motivated predictor variables X_t to forecast the following month's currency factor returns:
  - Average forward discount: $\overline{fd_t} = \frac{1}{N} \sum_{i=1}^{N} fd_{i,t}$
    - Lustig et al. (2014)
  - FX volatility: $\Delta\sigma_t^{FX} = \frac{1}{3} log\left(\frac{\sigma_t^{FX}}{\sigma_{t-3}^{FX}}\right)$
    - Merton (1973); Menkhoff et al. (2012)
  - TED spread: $\Delta TED_t = \frac{1}{3} log\left(\frac{TED_t}{TED_{t-3}}\right)$
    - Brunnermeier et al. (2009)
  - Commodity returns: $\Delta CRB_t = \frac{1}{3} log\left(\frac{CRB_t}{CRB_{t-3}}\right)$
    - Bakshi and Panayotov (2013), Ready et al. (2017)

Alternative Hedging Frameworks

- We evaluate *DCF* hedging against a set of alternative currency hedging frameworks, split into three groups:
  - Naive hedges
  - Characteristic hedges
  - Mean-variance hedges
- Naive hedges (simple rules, no optimization)
  - No hedging: 0% hedge ratios
  - Full hedging: 100% hedge ratios
- Characteristic hedges (exploits currency return predictability)
  - Carry: hedge currencies with lower interest rates
  - Value: hedge currencies that are overvalued based on PPP
  - Momentum: hedge currencies that depreciated over 3 month

Alternative Hedging Frameworks (cont)

- Mean-variance hedges (exploits returns and covariances)
  - Uses similar information to *DCF* hedging
  - Recall that *DCF* hedging is based on estimating:

$$w_f^*(f|x) = \frac{1}{\gamma}\left(\Sigma_{ff}^{-1}\mu_f\right) - \delta w_x$$

γ, Σ_{ff}^{-1}, δ and w_x are the same but μ_f changes

  - UIP: expected currency return is zero
  - Random walk: expected currency return is forward discount
  - Interest rate: expected currency return is extracted after first estimating the OLS regression

$$R_{i,t+1} = a_i + b_i(i_t^* - i_t) + e_{i,t+1}$$

  - Model combo: combine forecasts from multiple regressions
    - Predictor variables: average forward discount, commodity returns, FX volatility, TED spread, carry, value, momentum, equity volatility, and the output gap

Performance Measures

We compare the performance of *DCF* hedging against alternative schemes using statistical and economic performance measures

- Statistical performance measures
  - Focus on the Sharpe ratio

$$\widehat{SR}_k = \frac{\hat{\mu}_k^e}{\hat{\sigma}_k},$$

  - also calculate Sortino ratio, "manipulation-proof" theta measure (Ingersoll et al., 2007), and information ratio
- Economic performance measures
  - Focus on the Certainty Equivalent (CEQ) return

$$\widehat{CEQ}_k = \hat{\mu}_k^e - \frac{\gamma}{2}\hat{\sigma}_k^2,$$

  - also calculate the performance fee a mean-variance investor would pay to switch to *DCF* hedging

Data

Data is collected for G10 economies: Australia, Canada, Germany, Japan, New Zealand, Norway, Sweden, Switzerland, UK, and US

Sample period: January 1987 – July 2017

- Foreign exchange rate data
  - Daily spot and 1-month forward rates from Barclays
  - Daily spot rate data from Olsen Financial Technologies
  - Incorporate transaction costs following Darvas (2009)
- Common currency risk factors
  - *Dollar* and *carry* returns from website of Adrien Verdelhan
  - We update the factors until end of our sample
- Underlying security returns
  - Daily MSCI country equity indices from *Datastream*
  - Daily government 10-year bonds from *Global Financial Data*

Global Equity Portfolio: A U.S. Investor's Perspective

		Naive		*Characteristic*			*Mean-Variance*			
	DCF	UH	FH	CAR	VAL	MOM	UIP	RW	IR	MC
				Statistical performance evaluation						
mean (%)	7.93	4.92	5.10	6.46	4.95	6.21	5.10	5.62	5.83	6.11
std (%)	15.3	17.9	13.9	16.5	15.2	15.4	13.6	14.5	15.2	15.1
Sharpe	0.52	0.27	0.37	0.39	0.33	0.40	0.38	0.39	0.38	0.40
Δ*Sharpe*	-	**-0.25**	**-0.15**	**-0.13**	**-0.19**	**-0.12**	**-0.14**	**-0.13**	**-0.14**	**-0.12**
skew	-0.58	-0.79	-0.88	-0.81	-0.70	-0.62	-0.84	-1.02	-1.00	-1.02
MDD (%)	52.2	60.8	49.7	58.3	50.3	50.1	48.7	55.8	56.6	57.03
Sortino	0.76	0.38	0.50	0.54	0.45	0.57	0.52	0.53	0.53	0.56
theta (%)	4.28	-0.20	2.04	2.16	1.33	2.52	2.20	2.27	2.16	2.47
$IR_{unhedged}$	0.15	-	0.01	0.11	0.00	0.07	0.01	0.03	0.05	0.06
IR_{hedged}	0.16	-0.01	-	0.07	-0.01	0.07	0.00	0.05	0.05	0.07
				Economic performance evaluation						
CEQ	4.40	0.12	2.19	2.39	1.48	2.66	2.33	2.45	2.38	2.69
Δ*CEQ*	-	**-4.28**	**-2.21**	**-2.01**	**-2.92**	**-1.74**	**-2.07**	**-1.95**	**-2.02**	**-1.71**
ϕ	-	3.30	2.70	1.60	2.97	1.73	2.67	2.23	2.08	1.80

Global Bond Portfolio: A U.S. Investor's Perspective

		Naive		*Characteristic*			*Mean-Variance*			
	DCF	UH	FH	CAR	VAL	MOM	UIP	RW	IR	MC
				Statistical performance evaluation						
mean (%)	5.21	2.33	2.52	3.88	2.37	3.63	1.94	3.19	3.11	3.28
std (%)	6.81	9.23	4.66	6.84	6.92	6.70	4.61	5.99	6.39	6.53
Sharpe	0.77	0.25	0.54	0.57	0.34	0.54	0.42	0.53	0.49	0.50
Δ*Sharpe*	-	**-0.52**	-0.23	-0.20	**-0.43**	**-0.23**	**-0.35**	**-0.24**	**-0.28**	**-0.27**
skew	0.22	-0.05	0.09	0.07	0.26	0.29	0.08	0.00	-0.03	0.02
MDD (%)	15.2	27.2	10.5	12.2	27.0	17.5	11.5	11.3	15.4	15.3
Sortino	1.32	0.38	0.87	0.92	0.54	0.90	0.65	0.83	0.76	0.78
theta (%)	4.52	1.06	2.19	3.17	1.66	2.96	1.62	2.65	2.50	2.64
$IR_{unhedged}$	0.15	-	0.01	0.11	0.00	0.07	-0.02	0.05	0.04	0.05
IR_{hedged}	0.15	-0.01	-	0.07	-0.01	0.07	-0.12	0.05	0.04	0.05
				Economic performance evaluation						
CEQ	4.52	1.06	2.19	3.18	1.65	2.96	1.62	2.65	2.50	2.64
Δ*CEQ*	-	**-3.46**	**-2.33**	**-1.34**	**-2.87**	**-1.56**	**-2.90**	**-1.87**	**-2.02**	**-1.88**
ϕ	-	3.01	2.62	1.34	2.85	1.58	3.20	1.99	2.08	1.92

Results: Cumulative Returns

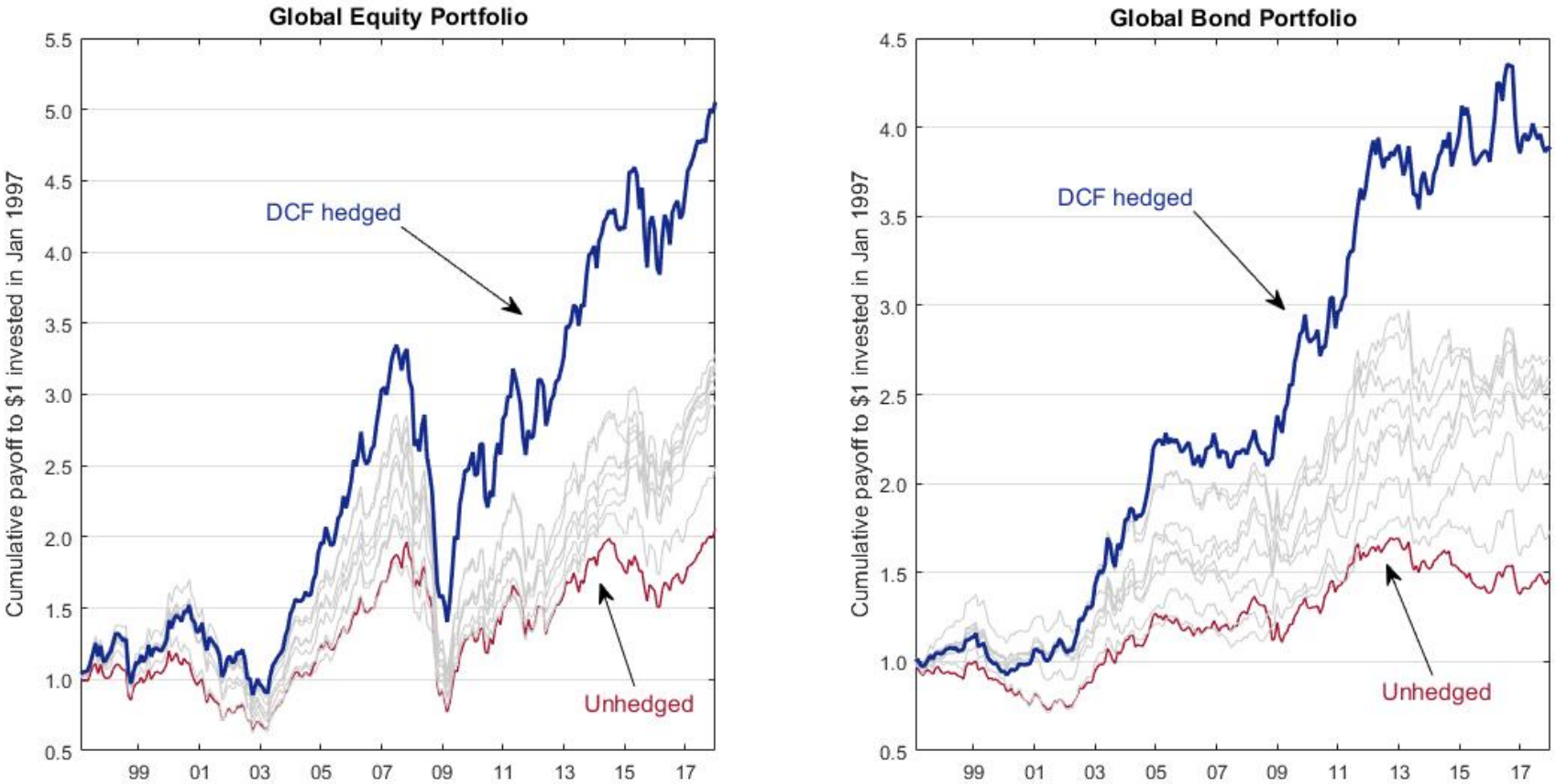

Figure: Cumulative Payoff to Investing in Foreign Portfolios

The Source of Profits: FX Returns or Interest Rates

The return on a currency hedged asset can be expressed as the sum of the unhedged return and the return from currency hedging

$$R_{x,t+1}^{hedged} = R_{x,t+1}^{unhedged} + \underbrace{h_t \left(\frac{F_t - S_t}{S_t} + \frac{S_t - S_{t+1}}{S_t} \right)}_{\text{hedging return}} \tag{7}$$

- h_t is the hedge ratio, $0 < h_t < 1$
- F_t and S_t are the forward and spot exchange rates

Implies investors can generate positive returns from currency hedging *iff* they hedge currencies:

1. trading at a forward premium ($F_t > S_t$)
2. that subsequently depreciate ($S_t > S_{t+1}$)

The Source of Profits: FX Returns or Interest Rates

		Naive Hedges		*Characteristic Hedges*			*Mean-Var Optimized Hedges*			
	DCF	No Hedge	Full Hedge	Carry	Value	Mom.	UIP	Rnd Walk	Int Rates	Model Combo
					Global Equity Portfolio					
mean	3.02	0.00	0.18	1.55	0.04	1.30	0.19	0.70	0.92	1.20
fp	0.23	0.00	-0.23	0.78	-0.40	0.09	-0.47	0.37	0.21	0.24
fx	2.79	0.00	0.41	0.77	0.44	1.21	0.66	0.33	0.71	0.96
					Global Bond Portfolio					
mean	2.88	0.00	0.18	1.55	0.04	1.30	-0.40	0.86	0.78	0.95
fp	0.33	0.00	-0.23	0.78	-0.40	0.09	-0.27	0.70	0.32	0.38
fx	2.55	0.00	0.41	0.77	0.44	1.21	-0.13	0.16	0.46	0.57

- Majority of return from *DCF* hedging is from timing foreign exchange rate movements

Alternative Investors' Perspectives

	Investor's Home Country								
	DE	JP	GB	CA	AU	CH	SE	NO	NZ
				Global Equity Portfolio					
Sharpe	0.44	0.52	0.47	0.42	0.39	0.41	0.47	0.47	0.47
	[1/10]	[2/10]	[1/10]	[1/10]	[1/10]	[1/10]	[1/10]	[1/10]	[1/10]
CEQ	3.26	4.49	3.64	2.90	2.48	2.71	3.65	3.62	3.67
	[1/10]	[2/10]	[1/10]	[1/10]	[1/10]	[1/10]	[1/10]	[1/10]	[1/10]
ϕ *UH*	0.38	1.24	1.15	1.70	2.39	0.97	0.63	1.66	3.97
ϕ *FH*	1.12	3.06	1.45	1.03	0.59	0.71	1.81	1.98	1.20

- [1/10] indicates that *DCF* hedging generates the highest *out-of-sample* performance measure among all alternative hedging schemes
- ϕ *UH* is the fee a mean-variance investor would pay to switch from an unhedged equity portfolio

Constructing a Separate Currency Portfolio

- A fund manager may be able to construct a separate currency portfolio to diversify a global equity or bond portfolio
  - In the literature currency carry, value and momentum have been found to have useful properties
  - Asness, Moskowitz, and Pedersen (2013); Kroencke, Schindler, and Schrimpf (2014); Barroso and Santa-Clara (2015)
- We form a time-series portfolio each month
  - Long position in currencies with positive expected returns
  - Short position in currencies with negative expected returns
- Evaluate diversification gains from the time-series portfolio
  - Compare with a currency "style" portfolio
  - Includes currency carry, value and momentum

International Diversification via a Pure Currency Portfolio

Panel A: Pure Currency Portfolios

	DEM	JPY	GBP	CAD	AUD	CHF	SEK	NOK	NZD	TS
mean (%)	5.58	1.34	4.26	4.15	8.11	3.66	5.67	7.33	10.86	5.78
std (%)	9.87	10.71	8.53	8.72	12.33	10.33	10.95	10.97	12.76	7.38
Sharpe	0.57	0.13	0.50	0.48	0.66	0.35	0.52	0.67	0.85	0.78
skew	0.08	-0.22	-0.24	0.60	0.41	-0.08	0.14	0.07	0.41	0.20

Panel B: Allocating Capital to Currency Strategies

	Global Equity Portfolios			*Global Bond Portfolios*		
	FH	STYLE	TS	FH	STYLE	TS
	Statistical performance evaluation					
mean (%)	5.10	6.82	10.88	2.52	4.24	8.30
std (%)	13.9	14.9	15.4	4.66	5.46	8.60
Sharpe	0.37	0.46	0.70	0.54	0.78	0.97
Δ*Sharpe*	-	0.09	**0.33**	-	0.24	**0.43**
skew	-0.88	-0.64	-0.52	0.09	-0.08	0.32
	Economic performance evaluation					
CEQ	2.19	3.50	7.30	2.19	3.79	7.19
Δ*CEQ*	-	1.31	5.11	-	1.57	5.00

Additional Analyses

1. alternative out-of-sample estimation periods
2. alternative expanding windows
3. alternative rolling windows
4. including and excluding crises periods
5. role of turnover and transaction costs

Conclusions

- Effective management of foreign exchange exposure is critical
  - Key question in international finance
- MV optimization typically performs poorly *out-of-sample*
  - Estimation error in expected currency returns
- We propose a novel approach to currency hedging
  - Exploits predictability associated with common currency factors
  - Improves estimation of expected currency returns
  - Superior to alternative approaches out-of-sample
- Approach can be used to build independent currency portfolio
  - Diversification benefits relative to currency "style" portfolio

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