Concealed Carry

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↪ **Possible interpretation:** no heterogeneity over the long-run
↪ **Our view:** the carry/heterogeneity is **concealed**

Empirical Contribution #1

In G10-country data:

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  - Portfolio **composition changes** before and after 08/2008
- **Traditional Carry**: Average excess return shrunk sizeably over time

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Theoretical Contribution

- We study an international macrofinance model to rationalize our results.
  - Two key dimensions:
    1. **Heterogeneous** exposure to global growth news shocks

       $\Rightarrow$ Explains/Drives for the Traditional Carry
    2. **Heterogeneous** exposure to global inflation news shocks

       $\Rightarrow$Explains/Drives the Slope Carry
  - Negative news shocks to global growth and inflation $\rightarrow$
    (i) traditional carry declines
    &
    (ii) slope carry premium increases.

Empirical Contribution #2

Using G10-country data, we provide **novel** evidence:

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- heterogeneous exposure to global inflation news $\neq$ heterogeneous exposure to global growth news
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NOTE: we use these results to **discipline the calibration** of our model (it's an 'input' in our model).

Global Inflation: a familiar concept ...

The Economist
Menu
Weekly edition
Search
Briefing
Jul 10th 2021 edition
People can be pricey
Will surprisingly high global inflation last?
Don't panic. But keep a watchful eye

THE WALL STREET JOURNAL.
ECONOMY
Red-Hot U.S. Economy Drives Global Inflation, Forcing Foreign Banks to Act
Central banks are raising rates to fend off a rise in inflation as policy makers respond to the booming U.S. economy

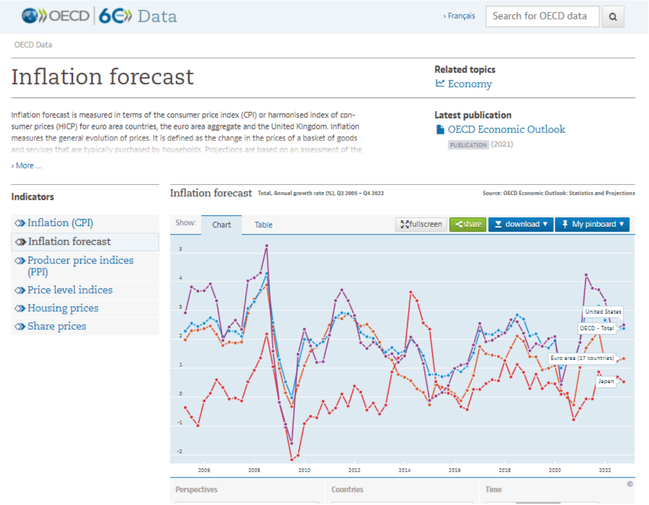
THE TIMES OF INDIA
City Bhopal Mumbai Delhi Bengaluru Hyderabad Kolkata Chennai Agra Agartala Ahmedabad Ajmer Allahabad ...
POLITICS CIVIC ISSUES CRIME SCHOOL AND COLLEGES MP ELECTIONS WEATHER EVENTS
NEWS / CITY NEWS / BHOPAL NEWS / Centre Trying To Address Rising Inflation: Union Minister

Centre trying to address rising inflation: Union minister

TNN / Updated: Aug 21, 2021, 08:04 IST

BHOPAL: Union minister of social justice and empowerment Virendra Kumar Khatik on Friday said that rising inflation is a global problem and the government is trying to find a solution for this.

Our Contribution: Studying Heterogeneity



Why? heterogeneous mon pol. rules and/or Phillips curves...

Literature Review

- **Traditional FX Carry:** *among others,* Lustig, Roussanov, Verdelhan (2011), Della Corte, Sarno, and Tsiakas (2011), ...
  - **Here:** sizable decrease in its profitability
- **Slope FX Carry:** *among others,* Ang and Chen (2010), Lustig, Stathopoulos, Verdelhan (2019), ...
  - **Here:** distinct pattern in dynamics and portfolio composition
- **Macrofinance models of international finance:** *among others,* Bansal and Shaliastovich (2013); Colacito, Croce, Gavazzoni, Ready (2018) Lewis and Liu (2014), Zviadadze (2014) ...
  - **Here:** Heterogeneity in the exposure to both global growth and inflation long-run risk to explain empirical evidence

FX Excess Returns

Data

- Countries: G-10 most liquid currencies (AUS, CAN, GER, JPN, NZD, NOR, SWE, CHF, UK, US)
- Period: January 1995 - May 2018
- We split the sample in July 2008
  - Results are robust to different month's selection

Slope Carry

▸ Robustness

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	1 (flat)	**2**	**3** (steep)	**3−1** (steep − flat)
Whole Sample				
Mean	4.08	2.01	6.69	2.62 [1.17]
Sharpe Ratio	0.38	0.20	0.66	0.24

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Pre-08/2008				
Mean	6.42	3.67	6.29	−0.13
				[-0.04]
Sharpe Ratio	0.67	0.37	0.58	−0.01
Recurrent countries:	UK (75%) Aus (72%)	Jpn (43%)	Jpn (55%)	

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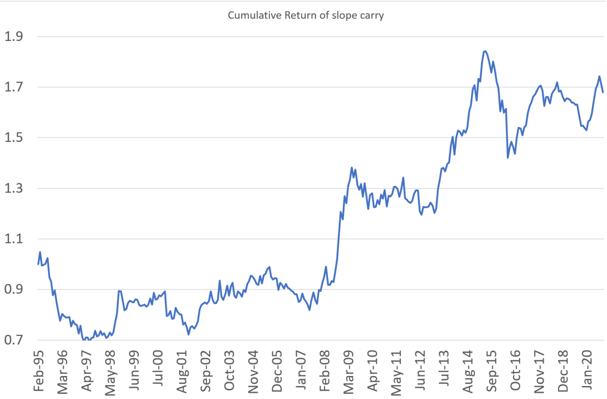
Post-08/2008				
Mean	1.05	−0.15	7.22	6.17
				[1.86]
Sharpe Ratio	0.09	−0.01	0.79	0.58
Recurrent countries:	Aus (75%) Jpn (78%)		UK (76%)	

Slope Carry In A Chart (Cumulative Returns) ▸ 2021



Traditional Carry

▸ Robustness

	1 (low)	2	3 (high)	3−1 (high − low)
Whole Sample				
Mean	−2.03	−0.05	2.90	4.93
				[2.36]
Sharpe Ratio	−0.24	−0.01	0.28	0.48
Pre-08/2008				
Mean	−3.24	2.44	4.88	8.12
				[3.25]
Sharpe Ratio	−0.36	0.35	0.67	0.89
Recurrent countries:	Jpn (100%)	UK (34%)	Aus (90%) UK (66%)	
Post-08/2008				
Mean	−0.47	−3.28	0.32	0.79
				[0.23]
Sharpe Ratio	−0.06	−0.38	0.02	0.07
Recurrent countries:	Jpn (63%)	UK (94%)	Aus (100%)	

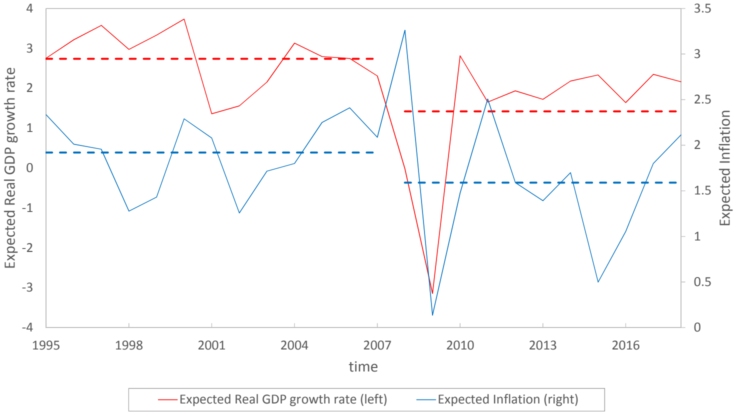
Global News Shocks

Macro Expectations

- Source:
  1. OECD (2020), Real GDP forecast indicator
  2. OECD (2020), Inflation forecast indicator
- Sample:
  1. Real GDP: 1961-2018
  2. Inflation: 1991-2018
- Definition of global expectations:
  - **GDP weighted average** of expectations across G-10 countries

The decline in G10 macro expectations ▸ Robustness

- Expected Global Real GDP growth: x_c
- Expected Global Inflation: x_π



Exposures

Estimate:

1. $E_t\left[\Delta GDP^{i}_{t+1}\right] = \mu + \beta^{i}_{c} \cdot E_t\left[\Delta GDP^{G10}_{t+1}\right] + \varepsilon_t, \quad \forall i \in G10$
2. $E_t\left[Inflation^{i}_{t+1}\right] = \mu + \beta^{i}_{\pi} \cdot E_t\left[Inflation^{G10}_{t+1}\right] + \varepsilon_t, \quad \forall i \in G10$

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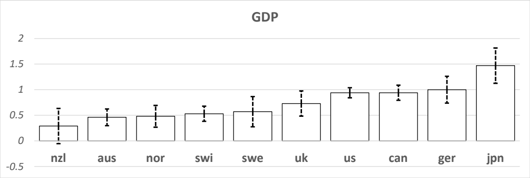
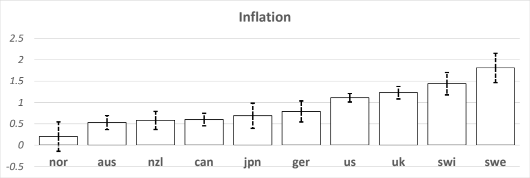
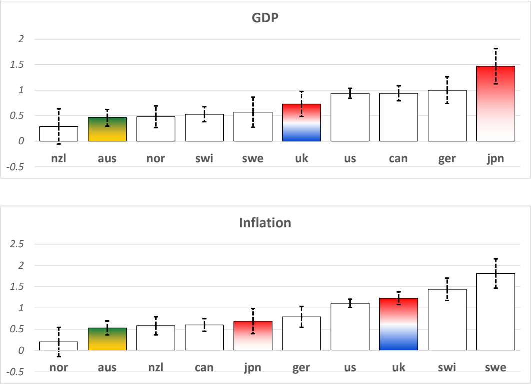




Exposures

Focus on Aus, UK, and Jpn:

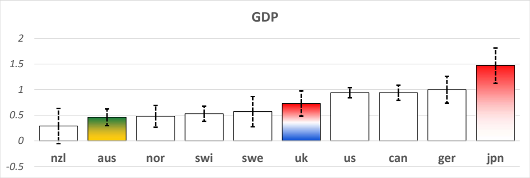


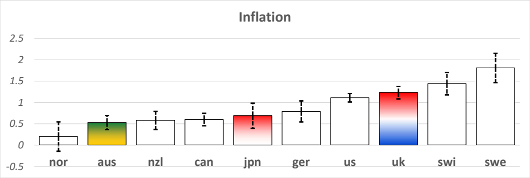
Exposures

Focus on Aus, UK, and Jpn:

$$\Delta GDP: \quad \beta_c^{jpn} - \beta_c^{aus} = \underset{(0.21)}{1.01^{***}}, \quad \beta_c^{jpn} - \beta_c^{uk} = \underset{(0.30)}{0.74^{**}}$$

$$Inflation: \quad \beta_\pi^{uk} - \beta_\pi^{aus} = \underset{(0.33)}{0.70^{**}}, \quad \beta_\pi^{uk} - \beta_\pi^{jpn} = \underset{(0.27)}{0.54^{**}}$$





Model

Preferences and Financial Markets

- N countries indexed by i
- Each country populated by a representative investor
- Preferences

$$U_{i,t} = (1-\delta)\log C_{i,t} + \delta\theta \log E_t \exp\left\{\frac{U_{i,t+1}}{\theta}\right\}, \quad \theta = \frac{1}{1-\gamma} < 0$$

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Consumption and Inflation

- Country-specific exposures to expected global growth and inflation

$$\begin{aligned} \Delta c_{i,t+1} &= \mu_{i,c} + \beta_i^c \cdot x_{c,t} + \sigma_c \eta_{i,t+1}^c \\ \pi_{i,t+1} &= \mu_{i,\pi} + \beta_i^\pi \cdot x_{\pi,t} + \sigma_\pi \eta_{i,t+1}^\pi, \end{aligned}$$

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- Global components co-move:

$$\underbrace{\begin{bmatrix} x_{\pi,t} \\ x_{c,t} \end{bmatrix}}_{x_t} = \underbrace{\begin{bmatrix} \rho_\pi & 0 \\ \rho_{c\pi} & \rho_c \end{bmatrix}}_{K} \cdot \begin{bmatrix} x_{\pi,t-1} \\ x_{c,t-1} \end{bmatrix} + \underbrace{\begin{bmatrix} \sigma_{x,\pi} & 0 \\ 0 & \sigma_{x,c} \end{bmatrix}}_{\Sigma} \begin{bmatrix} \varepsilon_{\pi,t} \\ \varepsilon_{c,t} \end{bmatrix}$$

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  - $\rho_{c\pi}$ governs the correlation between expected growth and inflation ($\rho_{c\pi} < 0$)

- $\eta_{i,t}$ shocks are orthogonal within and across countries

Extended Model

In the manuscript, we also study:

- EIS $\neq 1$: results on carry returns improve
- Demand shock: Global inflation news shocks explain a moderate share of the variance of local yields (10%) and FX variation (25%)

Results

Nominal SDF ▸ More

$$m_{i,t+1} - E_t\left[m_{i,t+1}\right] = \underbrace{- \underbrace{k_{\eta c}}_{>0} \sigma_c \eta^c_{i,t+1} - \underbrace{k_{\eta\pi}}_{>0} \sigma_\pi \eta^\pi_{i,t+1}}_{\text{Local Shocks}}$$

$$\underbrace{-\beta^c_i \underbrace{k_{\varepsilon c}}_{>0} \sigma_{xc}\varepsilon_{c,t+1} - \left(-\beta^c_i\right) \underbrace{k_{\varepsilon\pi}}_{>0} \sigma_{x\pi}\varepsilon_{\pi,t+1}}_{\text{Global Shocks}}$$

- Expected real growth and expected inflation have prices of risk with opposite signs when $\rho_{c\pi} < 0$:

$$k_{\varepsilon\pi} = \frac{\delta^2 (1-\gamma)\rho_{c\pi}}{(1-\delta\rho_\pi)(1-\delta\rho_c)} > 0.$$

- The prices of global news shocks depend only on β^c_i

Nominal SDF

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- The prices of global news shocks depend only on β^c_i
- $E_t\left[m_{i,t+1}\right] = \bar{m}^\$_i - \beta^c_i x_{c,t} - \beta^\pi_i x_{\pi,t}$, key drivers of the yield curve

Slope and Excess Return

- Affine term structure model: yields are linear $x_{c,t}$ and $x_{\pi,t}$
- Focus on infinite maturity slope:

$$slope_{i,t}^{\infty} = \overline{slope}_i^{\infty} - \beta_i^c \cdot x_{c,t} - \beta_i^{\pi} \cdot x_{\pi,t}$$

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- Excess return of holding for one period the infinite maturity bond of country i (in the *base* country, $\beta_c = \beta_\pi = 1$):

$$\log E_t\left[RX_{i,t+1}^{\infty}\right] = \underbrace{\log E_t\left[RX_{i,t+1}^{1}\right]}_{\text{FX Risk (Traditional Carry)}} - \underbrace{\beta_i^c\left[\frac{k_{\varepsilon c}\sigma_{xc}^2}{1-\rho_c} - \frac{\rho_{c\pi}k_{\varepsilon\pi}\sigma_{x\pi}^2}{(1-\rho_c)(1-\rho_\pi)}\right]}_{\text{Interest rate risk (Growth)}} + \underbrace{\beta_i^{\pi}\frac{k_{\varepsilon\pi}\sigma_{x\pi}^2}{1-\rho_\pi}}_{\text{Interest rate risk (Inflation)}}$$

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- **Notice**: Quantitatively, **the inflation risk channel** dominates

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Data

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- Conditional risk premium:

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- Unconditional risk premium: null! (Lustig et al 2019)

Traditional Carry: Risk Free Rate and Excess Return

- One-period risk free rate

$$r^i_{1,t} = \overline{r}_i + \beta^c_i x_{c,t} + \beta^\pi_i x_{\pi,t}$$

where

$$\overline{r}_i = (\mu_{i,c} + \mu_{i,\pi}) - \log\delta - \left(\frac{1}{2} - \frac{1}{\theta}\right)\sigma^2_c - \frac{1}{2}\sigma^2_\pi$$

- We spread the unconditional level of the one-period risk free rates using country specific $\mu_{i,c}$ and $\mu_{i,\pi}$
- Excess return of holding for one period the one-period bond of country i:

$$\log E_t\left[RX^1_{i,t+1}\right] = V_t\left[m^b_{t+1}\right] - \beta^i_c(k^2_{\varepsilon c}\sigma^2_{xc} + k^2_{\varepsilon\pi}\sigma^2_{x\pi})$$

- Going long in countries with low β_c is risky

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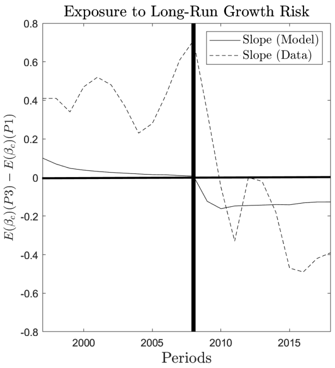
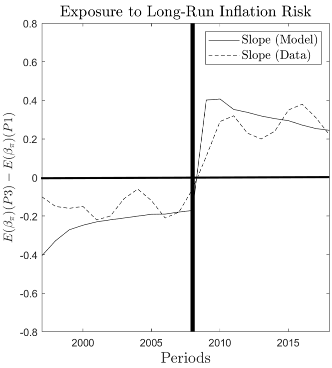
Model Simulation

- We simulate the model for 100 quarters. Consistent with the empirical evidence:
  1. In the first half of the sample x_c and x_π are above average
  2. At the breakpoint, x_c and x_π drop to the new lower average
  3. In the second half of the sample, x_c and x_π remain around new lower average
- Calibration of preference parameters: standard Calibration
- Cross-section of β_c and β_π consistent with the data Macro Moments
- Implied level and slope of the YCs as in the data Yield Curves

Slope Carry: Portfolio Exposures

- Spread in portfolio betas: $(P3 - P1)$





Results

	Traditional Carry		Slope Carry	
	Data	Model	Data	Model
$E(carry)$ (Full Sample)	4.93	2.35	2.62	2.05
	(2.09)		(2.24)	
$E(carry)$ (Post-08/07)	0.79	0.88	6.17	7.36
	(3.43)		(3.32)	
$E(sorting\ var)$ P3 - $E(sorting\ var)$ P1	4.02	1.85	1.52	1.73
	(0.07)		(0.03)	
$E(sorting\ var)$ P3 - $E(sorting\ var)$ P1 (Post-08/08)	2.93	1.47	1.24	1.94
	(0.07)		(0.04)	
$E(\Delta FX)$ P3 - $E(\Delta FX)$ P1	0.76	0.53	0.85	2.21
	(0.61)		(0.59)	
$E(\Delta FX)$ P3 - $E(\Delta FX)$ P1 (Post-08/08)	-2.66	-0.53	3.49	3.80
	(1.02)		(0.99)	
$E(\beta_c)$ P3 - $E(\beta_c)$ P1	-0.68	-0.16	0.14	-0.06
$E(\beta_c)$ P3 - $E(\beta_c)$ P1 (Post-08/08)	-0.64	-0.05	-0.26	-0.20
$E(\beta_\pi)$ P3 - $E(\beta_\pi)$ P1	-0.09	0.30	0.04	0.15
$E(\beta_\pi)$ P3 - $E(\beta_\pi)$ P1 (Post-08/08)	-0.35	-0.04	0.27	0.55

Conclusion

- The **Slope Carry** shows a distinct pattern:
  - Slightly negative before 08/08
  - Strongly positive afterwards
  - Different composition of countries per/post 2008
- The average excess return **Traditional Carry** shrinks after 08/08

Conclusion

- The **Slope Carry** shows a distinct pattern:
  - Slightly negative before 08/08
  - Strongly positive afterwards
  - Different composition of countries per/post 2008
- The average excess return **Traditional Carry** shrinks after 08/08
- We reconcile these facts with a macrofinance model featuring a novel dimension: heterogeneous exposure to global inflation news shocks

Thank you!

Appendix

Calibration ▸ Back

Description	Parameter	Value	Estimate/ Moment
Subjective discount factor	δ	0.997	$\text{Avg.}_i\left[E(r^f)\right]$
Risk Aversion	γ	10	$E(carry^S)$
Cross-country average consumption growth	$\bar{\mu}_c$	0.49%	0.54%
			(0.05%)
Volatility of cons growth short-run shock	σ_c	0.46%	$\text{Avg.}_i\left[\sigma(\Delta c)\right]$
Volatility of cons growth long-run shock	σ_{xc}	0.11%	$\text{Avg.}_i\left[ACF_1(\Delta c)\right]$
Autocorr. cons growth long-run risk	ρ_c	0.810	0.570
			(0.110)
Cross-country average inflation growth	$\bar{\mu}_\pi$	0.25%	0.41%
			(0.05%)
Volatility of inflation short-run shock	σ_π	0.55%	$\text{Avg.}_i\left[\sigma(\pi)\right]$
Volatility of inflation long-run shock	$\sigma_{x\pi}$	0.11%	$\text{Avg.}_i\left[ACF_1(\pi)\right]$
Aucocorr inflation long-run risk	ρ_π	0.988	0.910
			(0.040)
Cons growth / inflation long-run feedback	$\rho_{c\pi}$	-0.050	-0.050
			(0.030)

Macro Moments

▸ Back

	X-sec mean			X-sec vol / X-sec mean		
	Estimate	**(s.e.)**	**Model**	**Estimate**	**(s.e.)**	**Model**
β_c	0.77	*(0.06)*	0.64	0.57	*(0.13)*	0.33
$E(\Delta c)$	2.22	*(0.14)*	2.64	0.34	*(0.04)*	0.15
$\sigma(\Delta c)$	1.05	*(0.09)*	0.97	0.26	*(0.05)*	0.04
$Autocorr(\Delta c)$	0.24	*(0.09)*	0.42	0.17	*(0.04)*	0.06
β_π	1.00	*(0.14)*	0.99	0.51	*(0.18)*	0.39
$E(\pi)$	1.70	*(0.15)*	0.99	0.41	*(0.06)*	0.39
$\sigma(\pi)$	1.02	*(0.15)*	1.84	0.22	*(0.04)*	0.24
$Autocorr(\pi)$	0.14	*(0.11)*	0.53	0.18	*(0.04)*	0.35
$Corr(\Delta c, \pi)$	−0.22	*(0.10)*	−0.11	−0.26	*(0.05)*	−0.25

Average Yield Curves ▸ Back

Table: Unconditional Levels and Slopes

Country	β_c	β_π	Short Rate	Slope
AUS	0.48	0.87	4.94	1.34
CAN	0.90	0.50	3.75	1.33
GER	0.50	1.30	5.33	1.39
JPN	0.80	0.50	3.95	1.29
NOR	0.78	0.52	4.00	1.36
NZL	0.47	1.00	5.09	1.32
SWE	0.48	1.45	5.52	1.05
SWI	0.47	1.30	5.39	1.16
UK	0.50	1.50	5.53	1.15
US	1.00	1.00	4.06	3.75

Notes - This table reports the unconditional mean of the short-term rate and the yield curve slope for our 10 countries.

Traditional Carry: Risk Free Rate and Excess Return

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  where

$$\overline{r}_i = (\mu_{i,c} + \mu_{i,\pi}) - \log\delta - \left(\frac{1}{2} - \frac{1}{\theta}\right)\sigma^2_c - \frac{1}{2}\sigma^2_\pi$$

- We spread the unconditional level of the one-period risk free rates using country specific $\mu_{i,c}$ and $\mu_{\pi,c}$
- Excess return
- We set

$$\begin{aligned} \mu_{i,c} &= \overline{\mu}_c + \overline{\mu}_c(1 - \beta^i_c) \\ \mu_{\pi,c} &= \overline{\mu}_\pi - \overline{\mu}_\pi(1 - \beta^i_\pi) \end{aligned}$$

- High β^i_c countries usually have **low** risk-free rates
- High β^i_π countries usually have **high** risk-free rates

Extended Model

Back

Panel A: International Moments	Traditional Carry			Slope Carry		
Demand shock	**yes**	**yes**	**no**	**yes**	**yes**	**no**
Demand shock downward jump	**yes**	**no**	**–**	**yes**	**no**	**–**
$E(carry)$ (Full Sample)	1.17	1.17	1.63	1.08	1.08	4.12
$E(carry)$ (Post-08/07)	0.09	0.09	0.35	5.63	5.63	9.61
$E(sorting\ var)$ P3 - $E(sorting\ var)$ P1	1.69	1.69	1.75	1.65	1.65	1.80
$E(sorting\ var)$ P3 - $E(sorting\ var)$ P1 (Post-08/08)	1.39	1.39	1.39	1.82	1.82	2.18
$E(\Delta FX)$ P3 - $E(\Delta FX)$ P1	-0.50	-0.50	-0.10	1.66	1.66	2.15
$E(\Delta FX)$ P3 - $E(\Delta FX)$ P1 (Post-08/08)	-1.27	-1.27	-1.02	2.70	2.70	3.44

Panel B: Local Moments

Share of volatility due to inflation	hpr^{∞}	$Slope$	ΔFX
With demand shock	9.5%	60%	25%
Without demand shock	79%	82%	28%

Extended Model

Back

- Utility:

$$U_{i,t} = \left\{ (1-\delta)\Lambda_t C_{i,t}^{1-\frac{1}{\psi}} + \delta E_t \left[U_{i,t+1}^{1-\gamma} \right]^{\frac{1-\frac{1}{\psi}}{1-\gamma}} \right\}^{\frac{1}{1-\frac{1}{\psi}}}$$

- Demand shock:

$$\Delta\lambda_{t+1} := \log(\Lambda_{t+1}/\Lambda_t) = x_{d,t} = \rho_d x_{d,t-1} + \sigma_{x,d}\varepsilon_{d,t}$$

- SDF:

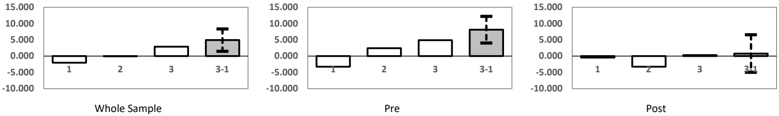
$$m_{i,t+1}^{\text{real}} = \theta \log \delta + \theta \Delta\lambda_{t+1} - \frac{\theta}{\psi} \Delta c_{i,t+1} + (\theta - 1) r_{i,t+1}^{c}$$

- We are agnostic about the exposure of each country to global demand shocks

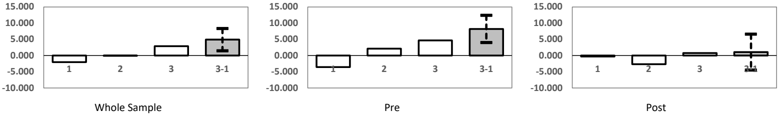
Traditional Carry Robustness

Back

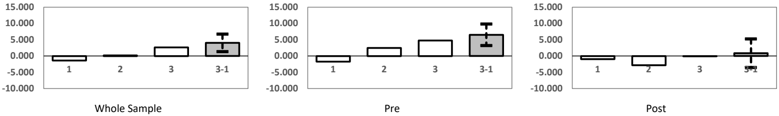
a) Gross returns, 7/2008 breakpoint



b) Gross returns, 1/2008 breakpoint



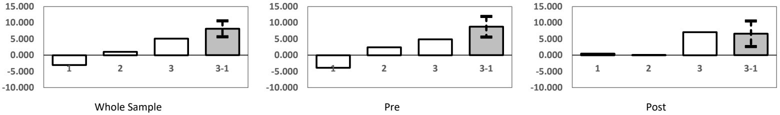
c) Gross returns, equal-weighted portfolios



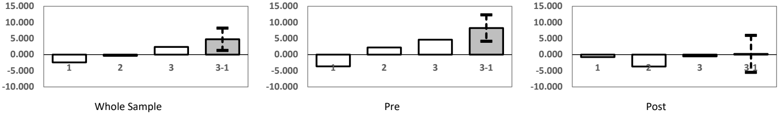
Traditional Carry Robustness

Back

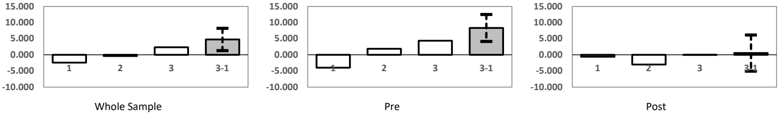
d) Gross returns, 10% winsorization



e) Log returns, 7/2008 breakpoint



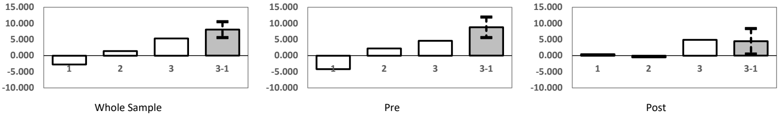
f) Log returns, 1/2008 breakpoint



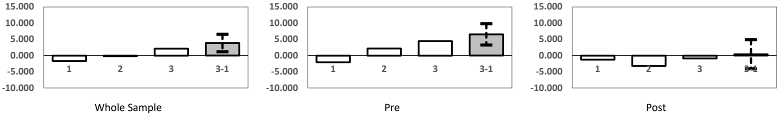
Traditional Carry Robustness

Back

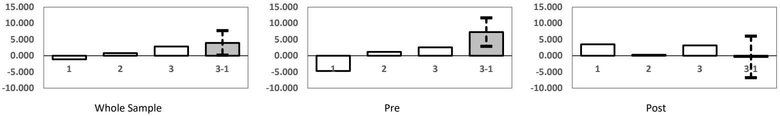
g) Log returns, 10% winsorization



h) Log returns, equal-weighted portfolios



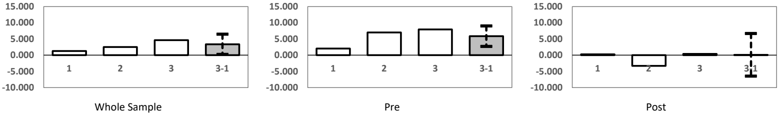
i) Log returns, Euro base currency



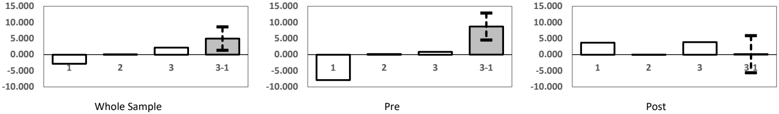
Traditional Carry Robustness

Back

j) Log returns, Japanese yen base currency



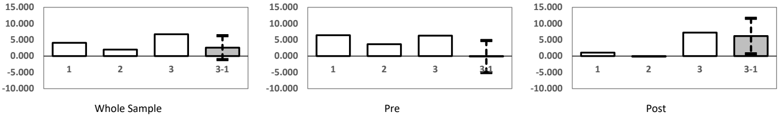
k) Log returns, British pound base currency



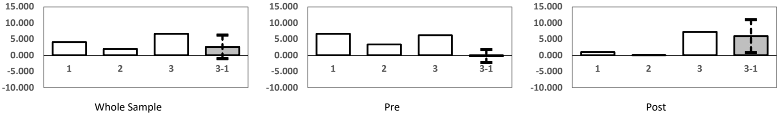
Slope Carry Robustness

Back

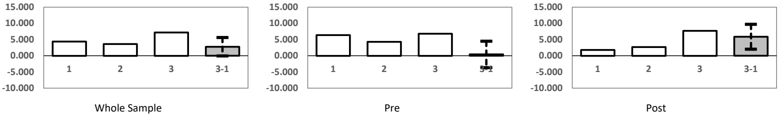
a) Gross returns, 7/2008 breakpoint



b) Gross returns, 1/2008 breakpoint



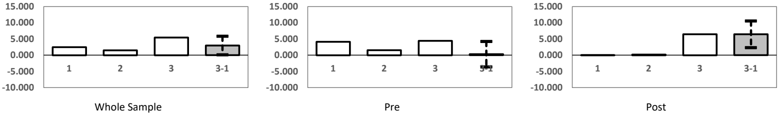
c) Gross returns, equal-weighted portfolios



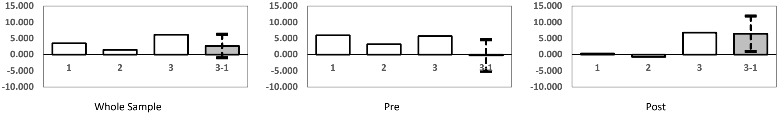
Slope Carry Robustness

Back

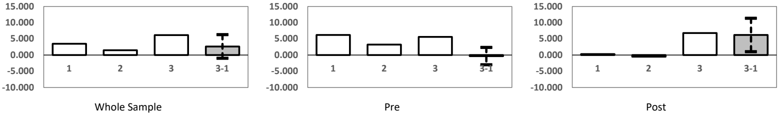
d) Gross returns, 10% winsorization



e) Log returns, 7/2008 breakpoint



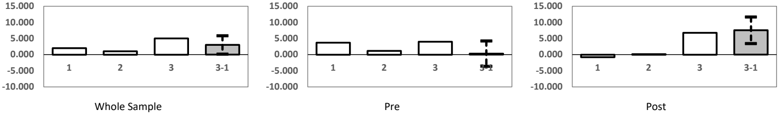
f) Log returns, 1/2008 breakpoint



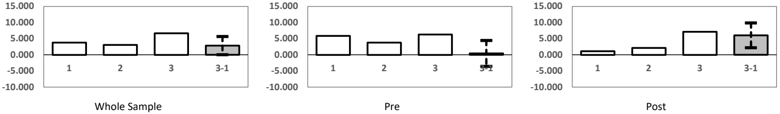
Slope Carry Robustness

▸ Back

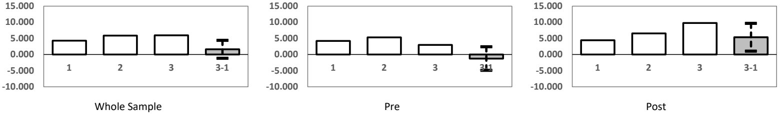
g) Log returns, 10% winsorization



h) Log returns, equal-weighted portfolios



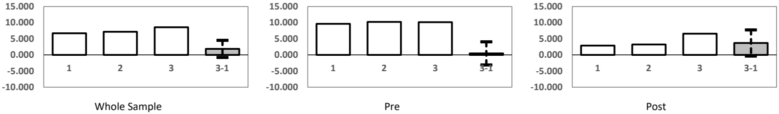
i) Log returns, Euro base currency, equal-weighted portfolios



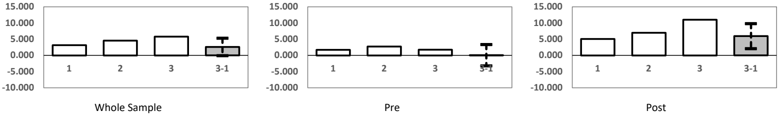
Slope Carry Robustness

Back

j) Log returns, Japanese yen base currency, equal-weighted portfolios

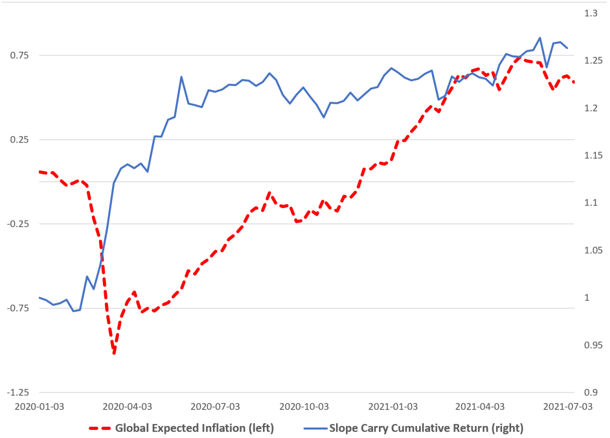


k) Log returns, British pound base currency, equal-weighted portfolios



Slope Carry Robustness (Cumulative Returns)

Back



The decline is not limited to 2008-2009 ▸ Back

	95-07	08-18	09-18	10-18	11-18
Expected GDP (G10)	2.74	1.42	1.57	2.09	2.00
(change relative to 95-07)	–	*(-1.32)*	*(-1.17)*	*(-0.65)*	*(-0.74)*
Expected Inflation (G10)	1.92	1.59	1.43	1.57	1.58
(change relative to 95-07)	–	*(-0.33)*	*(-0.49)*	*(-0.35)*	*(-0.34)*

- Substantial decline even after excluding 2008-2009
- Persistent decline in expected inflation is remarkable, given that most G10 countries have an inflation target of 2%

Alternative Measures of Global News Back

Highly correlated results when we consider:

1. AR model (Core/Headline)
2. Unit-root model (Core/Headline)
3. Phillips curve (Core/Headline): use past unemployment and inflation

as opposed to the OECD forecasts. All models are estimated at the country-level.

Zero Lower Bound

Back

Setup. We assume that the payoff of a one-period bond is

$$FV_{t+1} = 1 \cdot \mathbb{I}_{\{r_t^u \geq \underline{r}\}} + \exp\{-k_t \cdot (m_{t+1} + \alpha_t)\} \cdot \mathbb{I}_{\{r_t^u < \underline{r}\}}$$

where r_t^u is the unconstrained risk-free rate in the absence of a lower bound, $\underline{r}$ denotes the lower bound on the interest rate, and

$$k_t = \frac{\underline{r} - r_t^u}{V_t[m_{t+1}]} \geq 0, \quad \alpha_t = -E_t[m_{t+1}] + \frac{1}{2}\left(\underline{r} - r_t^u\right).$$

It is straightforward to show that:

$$E_t\left[FV_{t+1} | r_t^u < \underline{r}\right] = E_t\left[FV_{t+1} | r_t^u \geq \underline{r}\right] = 1.$$

Price of a one-period bond. The price of the one period bond is

$$P_t^1 = E_t\left[\exp\{m_{t+1}\} FV_{t+1}\right]$$

which depends on the current state of the economy:

$$P_t^1 = \begin{cases} \exp\left\{-r_t^u\right\}, & \text{if } r_t^u \geq \underline{r} \\ \exp\left\{(1-k_t)E_t[m_{t+1}] + \frac{1}{2}(1-k_t)^2 V_t[m_{t+1}] - k_t\alpha_t\right\}, & \text{if } r_t^u < \underline{r}. \end{cases}$$

The log-expected return on the one period bond is

$$r_t^1 = \begin{cases} r_t^u, & \text{if } r_t^u \geq \underline{r} \\ \underline{r}, & \text{if } r_t^u < \underline{r}. \end{cases}$$

Traditional Carry with ZLB

$$
\begin{aligned}
\log E_t\left[RX^1_{i\mathrm{l},t+1}\right] - \log E_t\left[RX^1_{i\mathrm{s},t+1}\right] &= \left(\beta^s_c - \beta^l_c\right)\left[k^2_{\varepsilon c}\sigma^2_{xc} + k^2_{\varepsilon\pi}\sigma^2_{x\pi}\right] \\
&+ \left(actual - shadow\right) r^l_t \\
&- \left(actual - shadow\right) r^s_t
\end{aligned}
$$

1. Same FX premium as away from ZLB
2. Additional premium if investment currency is at ZLB (↑)
3. Additional premium if funding currency is at ZLB (↓)

Traditional Carry with ZLB

$$\log E_t \left[RX^1_{i\mathbf{l},t+1} \right] - \log E_t \left[RX^1_{i\mathbf{s},t+1} \right] = \left(\beta^s_c - \beta^l_c \right) \left[k^2_{\varepsilon c} \sigma^2_{xc} + k^2_{\varepsilon \pi} \sigma^2_{x\pi} \right] - \left(actual - shadow \right) r^s_t$$

- Funding currency is usually at ZLB

Traditional Carry with ZLB

$$\log E_t\left[RX^1_{i\mathbf{l},t+1}\right] - \log E_t\left[RX^1_{i\mathbf{s},t+1}\right] = \left(\beta^s_c - \beta^l_c\right)\left[k^2_{\varepsilon c}\sigma^2_{xc} + k^2_{\varepsilon\pi}\sigma^2_{x\pi}\right] - \left(actual - shadow\right) r^s_t$$

- Funding currency is usually at ZLB
- Traditional carry declines

Slope Carry with ZLB

$$E_t \left[RX^{\infty}_{\$k,t+1} \right] = E_t \exp \left\{ -r_{\$,t} + hpr^{\infty,zlb}_{k,t+1} + \left(m^T_{k,t+1} + m^P_{k,t+1} \right) - m_{\$,t+1} \right\}$$

Slope Carry with ZLB

$$E_t\left[RX^{\infty}_{\$k,t+1}\right] = E_t \exp\left\{-r_{\$,t} + hpr^{\infty,zlb}_{k,t+1} + \left(-hpr^{\infty,unc}_{k,t+1} + m^{P}_{k,t+1}\right) - m_{\$,t+1}\right\}$$

Slope Carry with ZLB

$$E_t\left[RX^{\infty}_{\$k,t+1}\right] \quad = \quad E_t \exp\left\{-r_{\$,t} + \left(hpr^{\infty,zlb}_{k,t+1} - hpr^{\infty,unc}_{k,t+1}\right) + m^P_{k,t+1} - m_{\$,t+1}\right\}$$

Slope Carry with ZLB

$$E_t\left[RX^{\infty}_{\$k,t+1}\right] = E_t \exp\left\{-r_{\$,t} + \left(hpr^{\infty,zlb}_{k,t+1} - hpr^{\infty,unc}_{k,t+1}\right) + m^{P}_{k,t+1} - m_{\$,t+1}\right\}$$

Can we make the argument that the two hpr's cancel out?

Why do MPR's only depend on β_c^i? ▸ Back

Why do MPR's only depend on β_c^i? Back

$$\begin{aligned} \Delta c_{i,t+1} &= \mu_{i,c} + \beta_i^c \cdot x_{c,t} + \sigma_c \eta_{i,t+1}^c \\ \pi_{i,t+1} &= \mu_{i,\pi} + \beta_i^\pi \cdot x_{\pi,t} + \sigma_\pi \eta_{i,t+1}^\pi, \end{aligned}$$

where

$$\begin{bmatrix} x_{\pi,t} \\ x_{c,t} \end{bmatrix} = \begin{bmatrix} \rho_\pi & 0 \\ \rho_{c\pi} & \rho_c \end{bmatrix} \cdot \begin{bmatrix} x_{\pi,t-1} \\ x_{c,t-1} \end{bmatrix} + \begin{bmatrix} \sigma_{x,\pi} & 0 \\ 0 & \sigma_{x,c} \end{bmatrix} \begin{bmatrix} \varepsilon_{\pi,t} \\ \varepsilon_{c,t} \end{bmatrix}$$

- **Real** SDF depends on shocks to **real** expected growth

Why do MPR's only depend on β_c^i? ▸ Back

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- **Real** SDF depends on shocks to **real** expected growth
- Exposure depends on β_c^i

Why do MPR's only depend on β_c^i? Back

$$
\begin{aligned}
\Delta c_{i,t+1} &= \mu_{i,c} + \beta_i^c \cdot x_{c,t} + \sigma_c \eta_{i,t+1}^c \\
\pi_{i,t+1} &= \mu_{i,\pi} + \beta_i^\pi \cdot x_{\pi,t} + \sigma_\pi \eta_{i,t+1}^\pi,
\end{aligned}
$$

where

$$
\begin{bmatrix} x_{\pi,t} \\ x_{c,t} \end{bmatrix} = \begin{bmatrix} \rho_\pi & 0 \\ \rho_{c\pi} & \rho_c \end{bmatrix} \cdot \begin{bmatrix} x_{\pi,t-1} \\ x_{c,t-1} \end{bmatrix} + \begin{bmatrix} \sigma_{x,\pi} & 0 \\ 0 & \sigma_{x,c} \end{bmatrix} \begin{bmatrix} \varepsilon_{\pi,t} \\ \varepsilon_{c,t} \end{bmatrix}
$$

- **Real** SDF depends on shocks to **real** expected growth
- Exposure depends on β_c^i
- **Nominal** SDF: $m_{i,t+1} = m_{i,t+1}^{real} - \pi_{i,t+1}$
  ↬ MPR does not depend on β_π^i

Why do MPR's only depend on β_c^i? Back

$$
\begin{aligned}
\Delta c_{i,t+1} &= \mu_{i,c} + \beta_i^c \cdot x_{c,t} + \sigma_c \eta_{i,t+1}^c \\
\pi_{i,t+1} &= \mu_{i,\pi} + \beta_i^\pi \cdot x_{\pi,t} + \sigma_\pi \eta_{i,t+1}^\pi,
\end{aligned}
$$

where

$$
\begin{bmatrix} x_{\pi,t} \\ x_{c,t} \end{bmatrix} = \begin{bmatrix} \rho_\pi & 0 \\ \rho_{c\pi} & \rho_c \end{bmatrix} \cdot \begin{bmatrix} x_{\pi,t-1} \\ x_{c,t-1} \end{bmatrix} + \begin{bmatrix} \sigma_{x,\pi} & 0 \\ 0 & \sigma_{x,c} \end{bmatrix} \begin{bmatrix} \varepsilon_{\pi,t} \\ \varepsilon_{c,t} \end{bmatrix}
$$

- **Real** SDF depends on shocks to **real** expected growth
- Exposure depends on β_c^i
- **Nominal** SDF: $m_{i,t+1} = m_{i,t+1}^{real} - \pi_{i,t+1}$
  ↬ MPR does not depend on β_π^i
- Only $E_t[m_{i,t+1}] = \bar{m} - \beta_c^i x_{c,t} - \beta_\pi^i x_{\pi,t}$ depends on both β_π^i and β_c^i

Why does traditional carry only depend on β_c? Back

Why does traditional carry only depend on β_c? ▸ Back

- Complete markets: $\Delta e_{us-j,t+1} = m_{j,t+1} - m_{us,t+1}$
  - ↬ when $m_{j,t+1}$ is high, country j's currency appreciates

Why does traditional carry only depend on β_c? ▸ Back

- Complete markets: $\Delta e_{us-j,t+1} = m_{j,t+1} - m_{us,t+1}$

  ↬ when $m_{j,t+1}$ is high, country j's currency appreciates

- FX return:
  $\log E_t\left[RX^1_{us-j,t+1}\right] = V_t\left[m_{us,t+1}\right] - cov_t\left[m_{us,t+1}, m_{j,t+1}\right]$

  ↬ safe currency: appreciates ($m_{j,t+1} \uparrow$) in bad times ($m_{us,t+1} \uparrow$)

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  ↬ safe currency: appreciates ($m_{j,t+1}\uparrow$) in bad times ($m_{us,t+1}\uparrow$)

- Nominal SDFs:

$$\begin{aligned} m_{i,t+1} - E_t\left[m_{i,t+1}\right] &= -k_{\eta c}\sigma_c\eta^c_{i,t+1} - k_{\eta\pi}\sigma_\pi\eta^\pi_{i,t+1} \\ &\quad -\beta^c_i k_{\varepsilon c}\sigma_{xc}\varepsilon_{c,t+1} + \beta^c_i k_{\varepsilon\pi}\sigma_{x\pi}\varepsilon_{\pi,t+1} \end{aligned}$$

↬ global shocks only depend on β^c_i

Why does traditional carry only depend on β_c? ▸ Back

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- Nominal SDFs:

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↬ global shocks only depend on β^c_i

↬ FX return would depend on β^i_π if

(i) country-specific vol of short-run inflation risk

(ii) $\eta^\pi_{i,t+1}$ correlated across country or with global shocks

Why does traditional carry only depend on β_c? Back

- Complete markets: $\Delta e_{us-j,t+1} = m_{j,t+1} - m_{us,t+1}$
  ↬ when $m_{j,t+1}$ is high, country j's currency appreciates
- FX return:
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  ↬ safe currency: appreciates ($m_{j,t+1}\uparrow$) in bad times ($m_{us,t+1}\uparrow$)
- Nominal SDFs:

$$m_{i,t+1} - E_t\left[m_{i,t+1}\right] = -k_{\eta c}\sigma_c\eta^c_{i,t+1} - \beta^i_\pi k_{\eta\pi}\sigma_\pi\eta^\pi_{i,t+1} - \beta^c_i k_{\varepsilon c}\sigma_{xc}\varepsilon_{c,t+1} + \beta^c_i k_{\varepsilon\pi}\sigma_{x\pi}\varepsilon_{\pi,t+1}$$

↬ global shocks only depend on β^c_i

↬ FX return would depend on β^i_π if

(i) country-specific vol of short-run inflation risk

(ii) $\eta^\pi_{i,t+1}$ correlated across country or with global shocks

↬ Effect quantitatively small

Why do β_c and β_π have opposite signs in slope carry?

Back

Why do β_c and β_π have opposite signs in slope carry? Back

Affine term structure model:

$$r_{i,t}^n = \bar{r}_i^n + \beta_i^c \cdot \frac{1-\rho_c^n}{n\left(1-\rho_c\right)} \cdot x_{c,t} + \left(\beta_i^\pi + \beta_i^c \frac{\rho_{c\pi}}{1-\rho_c}\right) \cdot \frac{1-\rho_\pi^n}{n\left(1-\rho_\pi\right)} \cdot x_{\pi,t}$$

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1. Negative real growth shock ($x_{c,t} \downarrow$):

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1. Negative real growth shock ($x_{c,t} \downarrow$): SDF $\uparrow$,

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1. Negative real growth shock ($x_{c,t} \downarrow$): SDF $\uparrow$, yield $\downarrow$, HPR $\uparrow$
   ↬ Investing in high β_i^c currencies is safe

Why do β_c and β_π have opposite signs in slope carry? ▸ Back

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$$r_{i,t}^n = \bar{r}_i^n + \beta_i^c \cdot \frac{1-\rho_c^n}{n\left(1-\rho_c\right)} \cdot x_{c,t} + \left(\beta_i^\pi + \beta_i^c \frac{\rho_{c\pi}}{1-\rho_c}\right) \cdot \frac{1-\rho_\pi^n}{n\left(1-\rho_\pi\right)} \cdot x_{\pi,t}$$

1. Negative real growth shock ($x_{c,t} \downarrow$): SDF $\uparrow$, yield $\downarrow$, HPR $\uparrow$
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Why do β_c and β_π have opposite signs in slope carry? ▸ Back

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   ↬ Investing in high β_i^c currencies is safe
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1. Negative real growth shock ($x_{c,t} \downarrow$): SDF $\uparrow$, yield $\downarrow$, HPR $\uparrow$
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2. Positive inflation shock ($x_{\pi,t} \uparrow$): SDF $\uparrow$
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1. Negative real growth shock ($x_{c,t} \downarrow$): SDF $\uparrow$, yield $\downarrow$, HPR $\uparrow$
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1. Negative real growth shock ($x_{c,t} \downarrow$): SDF ↑, yield ↓, HPR ↑
   ↪ Investing in high β_i^c currencies is safe
2. Positive inflation shock ($x_{\pi,t} \uparrow$): SDF ↑
   2.1 β_i^π: yield ↑, HPR ↓
       ↪ Investing in high β_i^π currencies is risky

Why do β_c and β_π have opposite signs in slope carry? ▸ Back

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1. Negative real growth shock ($x_{c,t} \downarrow$): SDF ↑, yield ↓, HPR ↑
   ↬ Investing in high β_i^c currencies is safe
2. Positive inflation shock ($x_{\pi,t} \uparrow$): SDF ↑
   2.1 β_i^π: yield ↑, HPR ↓
      ↬ Investing in high β_i^π currencies is risky
   2.2 β_i^c:

Why do β_c and β_π have opposite signs in slope carry? Back

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1. Negative real growth shock ($x_{c,t} \downarrow$): SDF $\uparrow$, yield $\downarrow$, HPR $\uparrow$
   ↬ Investing in high β_i^c currencies is safe
2. Positive inflation shock ($x_{\pi,t} \uparrow$): SDF $\uparrow$
   - 2.1 β_i^π: yield $\uparrow$, HPR $\downarrow$
     ↬ Investing in high β_i^π currencies is risky
   - 2.2 β_i^c: expect lower growth at $t+1$ ($\rho_{c\pi} < 0$),

Why do β_c and β_π have opposite signs in slope carry? ▸ Back

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$$r^n_{i,t} = \bar{r}^n_i + \beta^c_i \cdot \frac{1-\rho^n_c}{n(1-\rho_c)} \cdot x_{c,t} + \left(\beta^\pi_i + \beta^c_i \frac{\rho_{c\pi}}{1-\rho_c}\right) \cdot \frac{1-\rho^n_\pi}{n(1-\rho_\pi)} \cdot x_{\pi,t}$$

1. Negative real growth shock ($x_{c,t} \downarrow$): SDF $\uparrow$, yield $\downarrow$, HPR $\uparrow$
   ↬ Investing in high β^c_i currencies is safe
2. Positive inflation shock ($x_{\pi,t} \uparrow$): SDF $\uparrow$
   2.1 β^π_i: yield $\uparrow$, HPR $\downarrow$
      ↬ Investing in high β^π_i currencies is risky
   2.2 β^c_i: expect lower growth at $t+1$ ($\rho_{c\pi} < 0$), yield $\downarrow$,

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1. Negative real growth shock ($x_{c,t} \downarrow$): SDF $\uparrow$, yield $\downarrow$, HPR $\uparrow$
   ↬ Investing in high β_i^c currencies is safe
2. Positive inflation shock ($x_{\pi,t} \uparrow$): SDF $\uparrow$
   - 2.1 β_i^π: yield $\uparrow$, HPR $\downarrow$
     ↬ Investing in high β_i^π currencies is risky
   - 2.2 β_i^c: expect lower growth at $t+1$ ($\rho_{c\pi} < 0$), yield $\downarrow$, HPR $\uparrow$

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1. Negative real growth shock ($x_{c,t} \downarrow$): SDF $\uparrow$, yield $\downarrow$, HPR $\uparrow$
   ↬ Investing in high β^c_i currencies is safe
2. Positive inflation shock ($x_{\pi,t} \uparrow$): SDF $\uparrow$
   2.1 β^π_i: yield $\uparrow$, HPR $\downarrow$
   ↬ Investing in high β^π_i currencies is risky
   2.2 β^c_i: expect lower growth at $t+1$ ($\rho_{c\pi} < 0$), yield $\downarrow$, HPR $\uparrow$
   ↬ Investing in high β^c_i currencies is safe

Slopes and Global Expectations

Back

We estimate this equation using the slopes of our 10 countries:

$$y_{i,120,t} - y_{i,3,t} \quad = \quad \Big(\underset{***}{-0.068} + 0.090 \cdot \beta_{i,y}\Big) \cdot E_t\left[\Delta y_{g10,t}\right] + \Big(\underset{***}{-0.267} - \underset{***}{0.100} \cdot \beta_{i,\pi}\Big) \cdot E_t\left[\Delta \pi_{g10,t}\right] + \xi_{i,t},$$

Main results:

1. In the time-series, inflation news are quantitatively dominant
2. In the cross section, heterogenous exposure to inflation news $(\beta_{i,\pi})$ dominates