#### **Currency Risk Premia and Macro Fundamentals**

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#### Motivation

- Common perception in the profession that exchange rate fluctuations are more or less random and that macro fundamentals have a hard time explaining and/or predicting exchange rates
- Influential paper by Meese and Rogoff (1983) on the disconnect between macro fundamentals and exchange rates
- Some empirical success at longer horizons, but overall little evidence that exchange rates and fundamentals are linked at horizons below one year

#### This paper:

 $\Rightarrow$  new evidence on the link between macro fundamentals and currency markets ...

#### What we do in a nutshell

- We consider the information content of classical macro fundamentals featuring prominently in the traditional exchange rate literature, e.g.
  - Interest rate differentials, Taylor rule fundamentals
  - Real GDP and money, real exchange rates
- But, moving away from the traditional time-series predictability focus on bilateral exchange rates
- Instead, we consider a multi-currency asset pricing approach
  - Portfolio approach to gauge predictability from an investor's perspective
  - Asset pricing approach / risk premium perspective
- Investigate the drivers of predictability and link of risk premia to the macroeconomy

# Overview of key findings

- Macro fundamentals do have substantial information content for the behavior of currency returns ...
  - Information in fundamentals can serve as the basis for a profitable investment strategy (mean excess returns of up to 6% p.a., Sharpe ratio > 1)
- The drivers of predictability (and risk premia) are mostly cross-sectional, and not temporal ...
  - Helps explaining the dismal predictive power of fundamentals in time-series studies along the lines of Meese and Rogoff
- Predictive content of fundamentals and the corresponding FX returns can best be understood as a compensation for dynamic business cycle risk

#### Outline of the talk

- Data and FX Portfolio Construction
- 2 The Cross-section of Macro Currency Risk Premia
- 3 Dissecting the Drivers of Predictability: Time-series vs Cross-section
- FX Returns and Business Cycle Risk: Asset Pricing Tests



Data and FX portfolios

• Data cover a total of up to 36 currencies (35 currencies v.s. USD):

Argentina, Australia, Austria, Belgium, Brazil, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, India, Indonesia, Ireland, Israel, Italy, Japan, (South) Korea, Mexico, Netherlands, New Zealand, Norway, Portugal, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, the United Kingdom, the United States, and Venezuela

- Sample: 1974Q1-2010Q3, post-BW sample, quarterly data
- Rely on earlier data for constructing conditioning variables
- Global Financial Database (GFD) for exchange rates, interest rates and macro variables (real GDP, CPI inflation, money balances)

Currency excess returns for a U.S. investor who holds a position in country j:

$$rx_{t+1}^{j} = i_t^{j} - i_t - \Delta s_{t+1}^{j}$$

- $i_t^j$  denotes the (log) short-term interest rate of country j
- $i_t$  denotes the (log) U.S. short-term interest rate
- $\Delta s_t^j$ ; log change in the spot exchange rate (FCU per one unit of home currency USD higher S: depreciation of the foreign currency).

► Returns to Currency Speculation

# Portfolio approach

We rely on a **portfolio approach** to study the information content of macro fundamentals for (future) currency returns

- $\Rightarrow$  This has some attractive features, as it ...
  - ... allows to mimick behavior of market participants and is a pure OOS approach (i.e. does not require full sample estimation)
  - ... helps quantifying the economic value of predictability
  - ... accounts for information in the cross-section
  - ... pooled approaches based on a panels of currencies have proved useful and more robust for prediction (Mark and Sul, 2001)

Portfolio approach is common in empirical finance and first applied by Lustig and Verdelhan (2007) in the FX literature

#### Portfolio construction

Data and FX Portfolios

- Build four portfolios that condition lagged currency characteristics
- At the end of each year, we rank all available countries by respective macro fundamental and allocate their currencies into quartile portfolios ...
  - P1: 25% with lowest value of conditioning variable

- P4: 25% with highest value of conditioning variable
- Hold portfolio composition constant for 4 quarters, i.e. annual re-balancing
- All four currency portfolios are long in a basket of foreign currencies and short the US dollar
- ⇒ Long-short portfolio (e.g. P4-P1) quantifies the economic value of predictability by a given macro fundamental. This zero-cost portfolio will be **USD-neutral** by construction

#### Portfolio sorts based on macro fundamentals

We investigate the **information content** of various sets of fundamentals:

- Interest rate differentials (as in the classical carry trade)
- Real GDP and money growth
- Real exchange rates
- Taylor rule fundamentals
- $\Rightarrow$  These will be motivated and outlined in the following ...

#### The portfolio sorts - carry

- Carry trade (CT): Long position in high IR currencies ("investment" currencies) funded by borrowing in low IR currencies ("funding" currencies)
  - Strategy builds on the empirical failure of UIP and "forward bias" (Hansen and Hodrick 1980, Fama 1984)
- Implement by ranking currencies according to their IR differential vis a vis the US: P4 contains high IR currencies, P1: low IR currencies
- CT strategy is well-known, heavily used by practitioners, and heavily researched in the academic literature
  - We still include it in our tests for two reasons: First, as it serves as a natural benchmark, and second to revisit the Lustig/Verdelhan (2007) vs Burnside (2011) debate on the fundamental drivers of carry returns

## Results - carry

- Report mean excess returns (p.a.) for different portfolios
- P4-P1: long-short PF, similar to carry factor  $HML_{FX}$  of Lustig et al. (2011)
- Also report returns on the *DOL* factor by Lustig et al. (denoted by Av.)

	P1	P2	P3	P4	Av.	P4-P1
A. Cari	ry Trade (	(CT)				
Mean	-2.11	0.05	0.43	3.99	0.59	6.10
t-stat	[-1.53]	[0.04]	[0.28]	[2.20]	[0.45]	[3.78]

#### The portfolio sorts - real GDP and money

- Rank currencies by differentials in growth rates of real GDP and money
  - Consider long-term 5-yr rolling averages of growth rates
- Depressed growth in real GDP or real money balances in a particular country: Investor demands a higher risk premium for foreign-currency denominated investment
- Based on considerations of risk, one would expect higher excess return on P1 (low growth rate) and lower excess return on P4 (high growth rate)
- We also condition on a combination of real GDP and money growth characteristics (where we add the two growth rates, denoted MIUF)

# Results - real GDP and money

	P1	P2	P3	P4	Av.	P4-P1
B. Real	GDP gi	rowth				
Mean	2.10	1.01	0.51	-1.20	0.60	-3.31
t-stat	[1.46]	[0.63]	[0.34]	[-0.73]	[0.46]	[-1.91]
C. Real	money	growth				
Mean	4.32	-0.02	-0.48	-1.64	0.54	-5.96
t-stat	[2.30]	[-0.01]	[-0.38]	[-1.27]	[0.41]	[-3.59]
D. Real	GDP g	rowth + i	real mone	y growth	(MIUF)	
Mean	4.07	0.15	-0.05	-2.14	0.51	-6.22
t-stat	[2.15]	[0.10]	[-0.04]	[-1.44]	[0.39]	[-3.39]

# The portfolio sorts - Taylor rule fundamentals (TRF)

- Somewhat related to carry strategy, i.e. similar focus on variation of short rates across countries
- But, TRF strategy looks at underlying fundamental macro drivers of short-term IR differentials across countries (inflation and output gap)

	P1	P2	P3	P4	Av.	P4-P1		
E. Taylor rule fundamentals								
Mean	-0.65	1.33	-0.18	2.36	0.72	3.01		
t-stat	[-0.46]	[1.12]	[-0.17]	[1.48]	[0.62]	[1.97]		

# The portfolio sorts - Real exchange rates (RER)

- Strategy is based on deviations of exchange rate from long-run fundamental value as determined by PPP
  - Reversal to fundamental value in the long-run
  - FX value (Pojarliev and Levich 2010)
- "Overvalued" currencies contained in P1 (low RER) low expected return
- "Undervalued" currencies contained in P4 (high RER) high expected return

	P1	P2	P3	P4	Av.	P4-P1
F. Rea	l exchang	e rate (ba	ase year .	1973)		
Mean	-1.30	-0.42	1.40	3.17	0.72	4.47
t-stat	[-0.94]	[-0.29]	[1.08]	[2.21]	[0.63]	[2.82]

# Difference to carry trade strategies

 $\Rightarrow$  Look at carry-adjusted ( $HML_{FX}$ ) mean returns (alphas from simple time series regression)

	P1	P2	P3	P4	Av.	P4-P1
B. Rea	I GDP gr	owth (GD	)P)			
Mean	1.42	0.59	0.47	-2.64	-0.04	-4.06
t-stat	[0.93]	[0.30]	[0.31]	[-1.46]	[-0.03]	[-1.94]
C. Rea	l money g	growth (N	1)			
Mean	2.74	0.36	-0.56	-3.06	-0.13	-5.80
t-stat	[1.44]	[0.20]	[-0.40]	[-2.29]	[-0.10]	[-3.10]
D. Rea	I GDP gr	owth + re	eal money	growth	(MIUF)	
Mean	3.25	0.33	-0.15	-4.09	-0.17	-7.35
t-stat	[1.66]	[0.20]	[-0.11]	[-2.76]	[-0.12]	[-3.69]
E. Tayı	lor rule fu	ndamenta	als (TRF)			
Mean	0.32	1.47	-0.56	-0.66	0.14	-0.98
t-stat	[0.23]	[1.19]	[-0.45]	[-0.46]	[0.12]	[-0.83]
F. Rea	l exchang	e rate (Ri	ER)			
Mean	-0.57	-0.76	-0.02	1.79	0.11	2.36
t-stat	[-0.35]	[-0.47]	[-0.01]	[1.56]	[0.09]	[1.75]

#### Return correlations

⇒ Look at relation between excess returns on the different macro-based FX strategies ...

	RGDP	RM	MIUF	TRF	RER
СТ	0.20	-0.03	0.18	0.76	0.55
RGDP		0.53	0.83	0.41	0.41
RM			0.79	0.18	0.12
MIUF				0.41	0.42
TRF					0.67

# Return characteristics of investment strategies

	Carry Trade	MIUF	RER	Combined
Mean excess return (p.a.)	6.10	6.22	4.47	5.60
<i>t</i> -stat	[3.78]	[3.39]	[2.82]	[5.38]
Standard deviation (p.a.)	9.30	9.60	8.69	5.17
Sharpe Ratio	0.66	0.65	0.51	1.08
Skew	-0.55	0.04	-0.53	-0.14
Kurt	3.89	3.08	3.20	3.06
AC(1)	0.08	0.17	0.08	0.21
<i>p</i> -val.	0.61	0.12	0.62	0.04

#### Brief summary of results so far

- Conditioning on macro fundamentals can form basis of a profitable FX investment strategy
- CTs and the strategy conditioning on TRF differentials are related
- In the following, we focus on three strategies (Carry, real GDP/Money and real exchange rate (RER))

#### Key questions:

- What are the drivers of predictability by macro variables?
- What is the role of risk premia in explaining the returns to macro-based FX strategies?

#### Dissecting time-series vs. cross-sectional drivers

- Why do we find predictability by fundamentals in our cross-sectional portfolio approach whereas earlier papers failed to find such a link in the time-series for bilateral exchange rates?
- Where does the predictability unveiled in our multi-currency investment strategy framework come from?
- ⇒ Rely on the analytical framework by Hassan and Mano (2013) to to better understand the source of predictability
  - Hassan and Mano used this technique to dissect the carry trade and forward hias anomalies

#### Covariance decomposition

$$\begin{split} cov(rx_{t+1}^j, F_t^j) &=& E((rx_{t+1}^j - \overline{rx})(F_t^j - \overline{F})) \\ &=& \underbrace{E(rx_t^j[\overline{F}^j - \overline{F}])}_{\text{static}} + \underbrace{E(rx_t^j[F_t^j - \overline{F}_t - (\overline{F}^j - \overline{F})])}_{\text{dynamic}} + \underbrace{E(rx_t^j[\overline{F}_t - \overline{F}])}_{\text{dollar}} + \kappa, \end{split}$$

- $P_{\star}^{j}$ : the macro fundamental for country j at time t
- $\overline{F}$ : uncond. average of the fundamental over time and across countries
- $\overline{F}^{j}$ : average fundamental over time for country j
- $\overline{F}_t$ : denotes the average fundamental across countries at time t

$$\overline{F} = \frac{1}{N \cdot T} \sum_{j=1}^{N} \sum_{t=1}^{T} F_t^j \qquad \overline{F}^j = \frac{1}{T} \sum_{t=1}^{T} F_t^j \qquad \overline{F}_t = \frac{1}{N} \sum_{j=1}^{N} F_t^j$$

#### Covariance decomposition - link to investment strategies

⇒ Decomposition of the covariance between FX returns and lagged characteristics offers interpretation in terms of investment strategies ...

#### **Static trade:** weights given by $\overline{F}^{j} - \overline{F}$

⇒ Go long in currencies with a (permanently) high value of a fundamental vis a vis the rest of countries

## **Dynamic trade:** weights given by $F_t^j - \overline{F}_t - (\overline{F}^j - \overline{F})$

 $\Rightarrow$  Go long in currencies with high value of fundamental in t relative to cross-sectional average in t and relative to their currency-specific average

#### **Dollar trade:** weights given by $\overline{F}_t - \overline{F}$

⇒ Go long in all foreign currencies (and short the USD) when their average fundamental relative to the US in t is higher than the unconditional average

# Covariance decomposition - link to investment strategies (continued)

Sum of static and dynamic component captures the cross-sectional (CS) dimension of predictability

- ullet Go long in currencies with high value of fundamental  $F_{\scriptscriptstyle t}^{j}$  relative to cross-sectional average in t
- $F_t^l \overline{F}_t \to \text{Cross-sectional trading strategy that resembles our portfolio}$ approach

Sum of dynamic and dollar component captures the time-series (TS) dimension of predictability

- Go long in currencies with high value of the fundamental  $\vec{P_t}$  relative to its own time-series mean
- ullet  $P^i_{\cdot \cdot} \overline{P}^j \to \mathsf{Time}$ -series trading strategy akin to predictability tests in the traditional literature

## Results covariance decomposition

			Portfolio				Со	rrelatio	ns	
	Static	Dyn	Dol	CS	TS	Static	Dyn	Dol	CS	TS
Interes	t rate diff	erentials								
Mean t SR	0.65 [3.29] <b>0.66</b>	0.15 [0.73] 0.13	0.27 [1.56] <b>0.34</b>	0.80 [2.83] <b>0.52</b>	0.41 [1.48] <b>0.29</b>	0.37	0.40	0.08	0.52	0.36
MIUF										
Mean t SR	-1.25 [-1.76] - <b>0.31</b>	-0.35 [-0.68] -0.12	0.54 [0.70] 0.15	-1.59 [-2.12] - <b>0.41</b>	0.19 [0.21] 0.04	0.67	-0.08	0.03	0.64	-0.03
Real ex	change r	ate								
Mean t SR	6.03 [2.46] <b>0.39</b>	1.21 [0.61] 0.11	1.73 [0.36] 0.07	7.24 [2.05] <b>0.34</b>	2.94 [0.52] 0.10	0.57	0.43	0.12	0.65	0.25

- A cross-sectional portfolio approach is key to detecting the link between fundamentals and FX excess returns
- CS component always produces higher mean excess returns and Sharpe ratios than TS component
- A large part of FX returns is due to the static component, that is, persistent differences in fundamentals across countries that give rise to country-specific risk premia
- Helps reconciling results with earlier literature that focuses on bilateral exchange rates in time-series framework

#### Asset pricing tests

Now, shed light on the risk characteristics of the different FX strategies

Is it possible to explain variation in currency risk premia by the exposure to standard business cycle risk factors?

Fierce debate in the literature on carry trades (Lustig/Verdelhan, 2007 v.s. Burnside, 2011)

#### Next steps:

- To investigate this further, we first perform some preliminary tests based on factor loadings
- Then, we turn to some fairly standard GMM-based asset pricing tests

## Preliminary tests

First, look at first-stage time-series regression loadings

Burnside (2011) emphasizes that any risk-based story will have to depend on a sensible and significant **spread in betas** 

#### Risk factors:

- We start by investigating the risk factors originally proposed in Lustig and Verdelhan (2007): consumption of non-durables and services (NDS) and consumption of durables (DUR)
- Then, we move to some other business cycle measures, such as growth in industrial output and real GDP

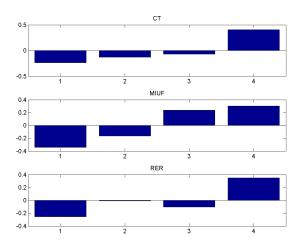
# Factor loadings

		C	Т			MI	UF			RI	ER		Joint H	yp. Tests
	Low	2	3	High	Low	2	3	High	Low	2	3	High	p-val. W1	p-val. W2
IP(q)	-0.31 (0.16)	-0.01 (0.12)	-0.10 (0.17)	0.39 (0.26)	<b>0.01</b> (0.23)	-0.16 (0.15)	-0.03 (0.19)	<b>0.32</b> (0.18)	<b>-0.16</b> (0.17)	-0.05 (0.16)	-0.20 (0.11)	<b>0.37</b> (0.22)	[0.11]	[0.01]
IP(a)	-0.24 (0.17)	-0.12 (0.16)	-0.07 (0.15)	0.39 (0.30)	<b>-0.38</b> (0.24)	-0.15 (0.14)	0.23 (0.19)	<b>0.33</b> (0.17)	- <b>0.24</b> (0.15)	0.00 (0.17)	-0.11 (0.15)	<b>0.33</b> (0.25)	[0.01]	[0.08]
GDP(q)	- <b>0.28</b> (0.15)	-0.20 (0.12)	-0.26 (0.18)	<b>0.71</b> (0.27)	<b>0.19</b> (0.19)	-0.24 (0.13)	-0.13 (0.19)	<b>0.29</b> (0.17)	- <b>0.28</b> (0.18)	-0.17 (0.16)	-0.17 (0.12)	0.40 (0.21)	[0.04]	[0.01]
GDP(a)	- <b>0.22</b> (0.15)	-0.23 (0.14)	-0.20 (0.14)	<b>0.60</b> (0.28)	-0.33 (0.21)	-0.12 (0.14)	0.14 (0.19)	<b>0.33</b> (0.17)	- <b>0.23</b> (0.15)	-0.06 (0.17)	-0.19 (0.14)	0.37 (0.26)	[0.01]	[0.02]
NDS	-0.05 (0.17)	-0.20 (0.14)	-0.04 (0.18)	0.29 (0.26)	-0.20 (0.21)	-0.14 (0.14)	0.05 (0.18)	<b>0.35</b> (0.18)	-0.10 (0.14)	0.11 (0.14)	-0.09 (0.13)	<b>0.10</b> (0.21)	[0.24]	[0.39]
DUR	-0.19 (0.16)	-0.25 (0.15)	0.01 (0.13)	<b>0.44</b> (0.25)	0.02 (0.24)	-0.11 (0.14)	-0.12 (0.16)	0.21 (0.18)	-0.04 (0.15)	-0.10 (0.15)	-0.12 (0.15)	0.02 (0.22)	[0.23]	[0.63]

Wald-test W1: Test null of  $\beta_L = \beta_H$  jointly for a all 3 sets of portfolios

Wald-test W2: Test null of  $\beta_1=\beta_2=...=\beta_N=0$ 

# Business cycle sensitivity - example IP(a)



#### Standard AP framework

Basic pricing equation (as laid out in e.g. Cochrane, 2005)

$$\mathbb{E}[\psi_{t+1}rx_{t+1}^i] = 0, \quad (i = 1, ..., N). \tag{1}$$

Our asset pricing tests rely on an SDF linear in the factors  $h_t$ 

$$\psi_t = 1 - b'(h_t - \mu_h) \tag{2}$$

Eq. (1) implies a beta pricing model where expected excess returns depend on factor risk prices  $\lambda$  and risk quantities  $\beta_i$ :

$$\mathbb{E}\left[rx^{i}\right] = \lambda'\beta_{i} \tag{3}$$

#### Results: Asset pricing tests

- Two-factor SDF: DOL factor by Lustig et al (2011) to capture level of returns and indicated business cycle factor
- Estimation via GMM, drawing on the moment conditions implied by the asset pricing restrictions, estimated on the pooled 12 portfolio cross-section
- Report implicit factor risk premia and t-stats based on HAC standard errors

	IP(q)	IP(a)	GDP(q)	GDP(a)	HJ-Dist.	$R^2$
(i)	3.07				0.53	0.69
	(1.77)				[0.00]	
(ii)		8.75			0.43	0.79
		(3.22)			[0.30]	
(iii)		, ,	1.00		0.52	0.56
			(2.03)		[0.01]	
(iv)				3.61	0.47	0.76
				(2.23)	[0.12]	

Consumption-based models in the spirit of Lustig and Verdelhan

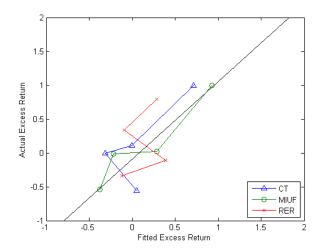
Panel A:	Unc	Unconditional Models							
		$\Delta c_{t+1}$	$\Delta dc_{t+1}$	HJ-Dist.	$R^2$				
	(i)	1.00		0.52	0.59				
		(1.99)		[0.03]					
	(ii)	0.90	0.76	0.52	0.62				
		(1.54)	(1.38)	[0.02]					

- Next, consider conditional CCAPM, allow for SDF parameter time-dependence (e.g. Lettau and Ludvigson 2001)
  - · consumption-wealth ratio, cay
  - output gap (Cooper and Priestley 2009)

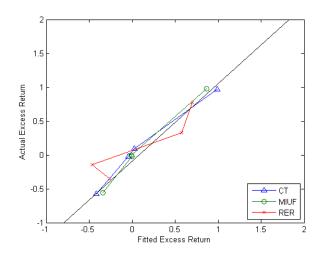
#### Conditional Models

Panel B:	Cond	itional M	1odels			
B.1 cay		$\Delta c_{t+1}$	$z_t \cdot \Delta c_{t+1}$	$z_t$	HJ-Dist.	$R^2$
	(iii)	0.48	1.17	1.99	0.34	0.95
		(1.39)	(2.99)	(1.50)	[0.65]	
	(iv)	0.45	1.11		0.34	0.94
		(1.53)	(2.96)		[0.55]	
	(v)		1.17		0.37	0.92
			(4.96)		[0.20]	
	(vi)			2.99	0.41	0.85
				(3.84)	[0.42]	
B.2 gap		$\Delta c_{t+1}$	$z_t \cdot \Delta c_{t+1}$	$z_t$	HJ-Dist.	$R^2$
	(vii)	0.19	1.07	0.13	0.31	0.92
		(0.69)	(2.18)	(0.12)	[0.72]	
	(viii)	0.16	1.29		0.42	0.88
		(0.70)	(3.15)		[0.24]	
	(ix)		1.53		0.44	0.88
			(4.40)		[0.12]	
	(x)			2.17	0.40	0.84
				(4.67)	[0.51]	

### Pricing errors - CCAPM



# Pricing errors - conditional CCAPM with cay



#### Further tests and robustness

- Consider alternative measures of "value" (different normalization, long-term 5-year changes in nominal and real exchange rates)
- Skip one observation before sorting (to account for publication lags)
- Other ways of constructing portfolios (e.g. signal-weighted approach in the spirit of Asness, Moskowitz and Pedersen 2013)
- Individual cross-sections and expanded cross-section with 24 portfolios
- Monte-Carlo study to assess possible power gains from moving from individual cross-section to larger cross-section



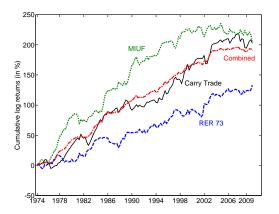




#### Conclusion

- Macro fundamentals do contain valuable information about future EX excess returns
- Information in macro fundamentals can form basis for profitable FX investment strategies
- A multi-currency portfolio approach is key in detecting the link between fundamentals and FX markets
  - Predictability is a cross-sectional rather than time-series phenomenon
  - Implications for theory: Need to move towards a better understanding of cross-country variation in FX risk premia and asymmetries across countries

#### Preview of results





#### FX excess returns

The returns to currency speculation can also be written:

$$RX_{t+1}^{j} = (1 + i_{t}^{j}) \frac{S_{t}^{j}}{S_{t+1}^{j}} - (1 + i_{t})$$

- $S_t^j$  is the spot FCU price of one unit USD,  $i_t(i_t^j)$  domestic (foreign) interest rate known at t.
- Borrow one dollar at US interest rate, convert into FCU and invest in the foreign money market; then, convert proceeds back to USD

Taking logs and re-arranging:

$$rx_{t+1}^j = \underbrace{i_t^j - i_t}_{ ext{IRdifferential}} - \underbrace{\Delta s_{t+1}}_{ ext{depreciation FCU}}$$



### Taylor rule fundamentals

Recent exchange rate literature has emphasized the use of Taylor rules to capture the set of fundamentals relevant for understanding exchange rate movements

We employ the following simple calibration

$$\mathsf{TRF}_t = 1.5\pi_t + 0.5\widehat{y}_t$$

for both the home and foreign country where  $\pi$  denotes the inflation rate and  $\hat{y}$  denotes the percent deviation of GDP from a 5-year moving average (as a proxy for the output gap available in real-time).

Calibrated parameters of 1.5 for inflation and 0.5 for the output gap are representative of what is often assumed in the Taylor rule literature.



### RER - Froot/Ramadorai decomposition

- Also make use of log real exchange rates  $\delta_t^j = s_t^j + p_t p_t^j$ , normalized to one in 1973Q1
- $s_t^j$ ; log spot exchange rate (FCU per one unit of home currency USD higher S: depreciation of the foreign currency)
- ullet Home and foreign price levels are denoted as  $p_t\ (p_t^j)$
- High δ weak real exchange rate ("undervaluation"), low δ strong real exchange rate ("overvaluation")

Starting from the expression

$$rx_{t+1}^{j} = (i_{t}^{j} - \pi_{t+1}^{j}) - (i_{t} - \pi_{t+1}) - (\delta_{t+1}^{j} - \delta_{t}^{j})$$



## RER - Froot/Ramadorai decomposition

Rearranging as  $\delta_t = rx_{t+1} - (i_t^j - \pi_{t+1}^j - i_t + \pi_{t+1}) + \delta_{t+1}$ , iterating forward in  $\delta$ , taking conditional expectations and assuming that PPP holds in expectation in the long run  $(\lim_{\ell \to \infty} \mathbb{E}_t \delta_{t+\ell} = 0)$ , one obtains

$$\delta_t = \mathbb{E}_t \left[ \sum_{\ell=1}^{\infty} r x_{t+\ell} - (i_{t+\ell-1}^j - \pi_{t+\ell}^j - i_{t+\ell-1} + \pi_{t+\ell}) \right]$$

 $\Rightarrow$  high  $\delta_t$ , that is, an undervaluation of the currency of country j relative to PPP, coincides with high expected returns going forward and/or lower (real) IR differentials in the future



### Empirical methodology: GMM

• Basic no-arbitrage pricing equation

$$\mathbb{E}[m_{t+1}rx_{t+1}^i]=0, \ \ i=1,\dots,N$$
 with a linear SDF  $m_t=1-b'(h_t-\mu).$ 

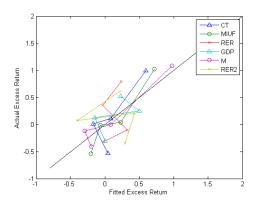
Estimation via GMM

$$g(z_t, \theta) = \begin{bmatrix} [1 - b'(h_t - \mu)] rx_t \\ h_t - \mu \\ (h_t - \mu)(h_t - \mu)' - \Sigma_h \end{bmatrix}$$

• We report b, implied  $\lambda$ s, cross-sectional  $R^2$ s, and HJ-dist with simulated p-values.

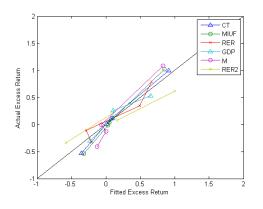


## Pricing errors - 24 portfolios - CCAPM





# Pricing errors - conditional CCAPM with cay



#### Alternative value measures

	P1	P2	P3	P4	Av.	P4-P1					
A. Rea	A. Real exchange rate (base year 2009)										
Mean	-2.37	0.23	0.56	3.79	0.55	6.16					
t-stat	[-1.71]	[0.17]	[0.29]	[2.31]	[0.42]	[3.67]					
B. Rea	B. Real exchange rate (deviation from 5-year average)										
Mean	-1.38	0.84	0.31	2.45	0.56	3.83					
t-stat	[-0.98]	[0.47]	[0.21]	[1.59]	[0.43]	[2.40]					
C. Exchange rate changes (5 years)											
Mean	-0.83	-0.05	-0.28	3.41	0.56	4.25					
t-stat	[-0.56]	[-0.03]	[-0.20]	[1.83]	[0.43]	[2.39]					



# Account for publication lags

P1										
Mean test         -2.04 [-1.45]         0.19 [0.14]         0.53 [0.26]         3.47 [0.24]         0.51 [0.22]         5.51 [0.23]         0.36 [0.26]         [1.92]         0.42 [0.32]         [3.39]           B. Real Test         2.19 [0.22]         0.36 [0.23]         -1.80 [0.24]         0.54 [-2.29]         -3.99 [-2.29]           t-stat [0.32]         [0.22]         [0.99]         [1.20]         [0.42]         [2.29]           C. Real morey swth           Mean [0.38]         0.05         -0.93         -1.24 [0.50]         -5.07           t-stat [2.13]         [0.23]         [-0.71]         [0.94]         [0.39]         [-3.17]           D. Real SDP growth + real money growth           Mean [0.55]         -0.06         0.58 [-2.28]         0.47 [-5.93]         -5.93           t-stat [1.1] [-0.04]         [0.39]         [-1.64]         [0.36]         [-3.46]           E. Taylor with full mean [0.36]         1.10         0.06         2.07         0.68         2.57           t-stat [-0.36]         [0.93]         [0.06]         1.30         [0.60]         [1.64]           F. Real exchange rate (base)           Heal (base)         -0.39         <		P1	P2	P3	P4	Av.	P4-P1			
t-stat         [1.45]         [0.14]         [0.36]         [1.92]         [0.42]         [3.39]           B. Real CDP growth           Mean         2.19         0.36         1.43         -1.80         0.54         -3.99           t-stat         [1.38]         [0.22]         [0.99]         [-1.20]         [0.42]         [-2.29]           C. Real words words           Mean         3.83         0.35         -0.93         -1.24         0.50         -5.07           t-stat         [2.13]         [0.23]         [-0.71]         [-0.94]         [0.39]         [-3.17]           D. Real         GDP growth + real money growth           Mean         3.65         -0.06         0.58         -2.28         0.47         -5.93           t-stat         [2.11]         [-0.04]         [0.39]         [-1.64]         [0.36]         [-3.46]           E. Tulle words           Mean         -0.50         1.10         0.06         2.07         0.68         2.57           t-stat         [-0.36]         [0.93]         [0.5]         [1.38]         [0.60]         [1.64]           F. Real exchange rate (base year 1973) <td colspan="10">A. Carry Trade</td>	A. Carry Trade									
B. Real GDP growth         Mean       2.19       0.36       1.43       -1.80       0.54       -3.99         t-stat       [1.38]       [0.22]       [0.99]       [-1.20]       [0.42]       [-2.29]         C. Real money growth         Mean       3.83       0.35       -0.93       -1.24       0.50       -5.07         t-stat       [2.13]       [0.23]       [-0.71]       [-0.94]       [0.39]       [-3.17]         D. Real GDP growth + real money growth         Mean       3.65       -0.06       0.58       -2.28       0.47       -5.93         t-stat       [2.11]       [-0.04]       [0.39]       [-1.64]       [0.36]       [-3.46]         E. Taylor rule fundamentals         Mean       -0.50       1.10       0.06       2.07       0.68       2.57         t-stat       [-0.36]       [0.93]       [0.55]       [1.33]       [0.60]       [1.68]         F. Real exchange rate (base year 1973)         Mean       -1.26       -0.39       1.32       3.08       0.69       4.34	Mean	-2.04	0.19	0.53	3.47	0.54	5.51			
Mean t-stat         2.19 [0.36]         1.43 [0.99]         -1.80 [0.42]         0.54 [-2.99]           C. Real money growth           Mean and Same testat         0.23 [-0.71]         -1.24 [0.50]         -5.07           D. Real GDP growth + real money growth           Mean and Same testat         0.12 [-0.04]         0.58 [-2.28]         0.47 [-5.93]           t-stat         [2.11]         [-0.04]         [0.39]         [-1.64]         [0.36]         [-3.46]           E. Taylor trule fundamentals           Mean and -0.50 [0.93]         0.05 [0.93]         2.07 [0.68]         2.57 [0.56]           t-stat [-0.36]         0.93]         [0.05]         [1.33]         [0.60]         [1.64]           F. Real exchange rate (base year 1973)           Mean -1.26         -0.39         1.32         3.08         0.69         4.34	t-stat	[-1.45]	[0.14]	[0.36]	[1.92]	[0.42]	[3.39]			
t-stat         [1.38]         [0.22]         [0.99]         [-1.20]         [0.42]         [-2.29]           C. Real money growth           Mean         3.83         0.35         -0.93         -1.24         0.50         -5.07           t-stat         [2.13]         [0.23]         [-0.71]         [-0.94]         [0.39]         [-3.17]           D. Real GDP growth + real money growth           Mean         3.65         -0.06         0.58         -2.28         0.47         -5.93           t-stat         [2.11]         [-0.04]         [0.39]         [-1.64]         [0.36]         [-3.46]           E. Taylor rule monetalisment         Mean         -0.50         1.10         0.06         2.07         0.68         2.57           t-stat         [-0.36]         [0.93]         [0.05]         [1.33]         [0.60]         [1.68]           F. Real exchange rate (base year 1973)           Mean         -1.26         -0.39         1.32         3.08         0.69         4.34	B. Real GDP growth									
C.   Real   money   growth	Mean	2.19	0.36	1.43	-1.80	0.54	-3.99			
Mean test         3.83 [0.35] [0.27] [-0.71] [-0.94] [0.39] [-3.17]           D. Real GDP growth + real money growth         Feature (0.36) [-3.46] [0.36] [-3.46]           Mean (0.55) [0.06] [0.07] [0.08] [0.08] [0.36] [-3.46]         [0.36] [0.36] [-3.46]           E. Taylor rule multiplication (0.36) [0.39] [0.05] [0.36] [0.36] [0.56]         2.57 [0.36] [0.36] [0.36] [0.56]           t-stat (0.36) [0.93] [0.05] [0.37] [0.37] [0.58]         [1.32] [0.36] [0.58] [0.58]           F. Real exchange rate (baseyear 1973)           Mean (0.12) [0.39] [0.39] [0.32] [0.38] [0.36] [0.36]	t-stat	[1.38]	[0.22]	[0.99]	[-1.20]	[0.42]	[-2.29]			
t-stat         [2.13]         [0.23]         [-0.71]         [-0.94]         [0.39]         [-3.17]           D. Real GDP growth + real money growth           Mean         3.65         -0.06         0.58         -2.28         0.47         -5.93           t-stat         [2.11]         [-0.04]         [0.39]         [-1.64]         [0.36]         [-3.46]           E. Taylor rule fundamentals           Mean         -0.50         1.10         0.06         2.07         0.68         2.57           t-stat         [-0.36]         [0.93]         [0.05]         [1.33]         [0.60]         [1.68]           F. Real exchange rate (base year 1973)           Mean         -1.26         -0.39         1.32         3.08         0.69         4.34	C. Real money growth									
D. Real GDP growth + real money growth   Mean   3.65   -0.06   0.58   -2.28   0.47   -5.93   t-stat   [2.11]   [-0.04]   [0.39]   [-1.64]   [0.36]   [-3.46]   E. Taylor rule fundamentals   Mean   -0.56   0.93   [0.05]   [1.33]   [0.60]   [1.68]   F. Real exchange rate (base year 1973)   Mean   -1.26   -0.39   1.32   3.08   0.69   4.34     C. S.	Mean	3.83	0.35	-0.93	-1.24	0.50	-5.07			
Mean test         3.65 [-0.06]         0.58 [-2.28]         0.47 [-3.93]         -5.93 [-3.46]           E. Taylor rule fundamentals           Mean [-0.36]         1.10 [0.06]         2.07 [0.68]         2.57 [1.68]           t-stat [-0.36]         [0.93]         [0.5]         [1.33]         [0.60]         [1.68]           F. Real exchange rate (base year 1973)           Mean [-1.26]         -0.39 [1.32]         3.08 [0.69]         4.34	t-stat	[2.13]	[0.23]	[-0.71]	[-0.94]	[0.39]	[-3.17]			
t-stat         [2.11]         [0.04]         [0.39]         [1.64]         [0.36]         [-3.46]           E. Taylor rule fundamentals           Mean         -0.50         1.10         0.06         2.07         0.68         2.57           t-stat         [0.36]         [0.93]         [0.05]         [1.33]         [0.60]         [1.68]           F. Real exchange rate (base year 1973)           Mean         -1.26         -0.39         1.32         3.08         0.69         4.34	D. Real GDP growth + real money growth									
E. Taylor rule fundamentals  Mean	Mean	3.65	-0.06	0.58	-2.28	0.47	-5.93			
Mean t-t-stat         -0.50 [0.93]         1.10 [0.05]         2.07 [1.33]         0.68 [0.65]         2.57 [0.66]         1.68 [1.68]           F. Real exchange rate (base year 1973)           Mean dean rate (base year 1973)         3.08 [0.69]         4.34	t-stat	[2.11]	[-0.04]	[0.39]	[-1.64]	[0.36]	[-3.46]			
t-stat         [0.36]         [0.93]         [0.05]         [1.33]         [0.60]         [1.68]           F. Real exchange rate (base year 1973)         Wean -1.26         -0.39         1.32         3.08         0.69         4.34	E. Taylor rule fundamentals									
F. Real exchange rate (base year 1973) Mean -1.26 -0.39 1.32 3.08 0.69 4.34	Mean	-0.50	1.10	0.06	2.07	0.68	2.57			
Mean -1.26 -0.39 1.32 3.08 0.69 4.34	t-stat	[-0.36]	[0.93]	[0.05]	[1.33]	[0.60]	[1.68]			
	F. Real exchange rate (base year 1973)									
t-stat [-0.98] [-0.27] [1.05] [2.08] [0.60] [2.82]	Mean	-1.26	-0.39	1.32	3.08	0.69	4.34			
	t-stat	[-0.98]	[-0.27]	[1.05]	[2.08]	[0.60]	[2.82]			

