Exchange Rate Uncertainty and Interest Rate Parity

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Motivation

- Recent literature argues that there exists a single world cycle (Rey, 2015; Miranda-Agrippino and Rey, 2022). The demand of Safe Assets from the US economy helps transmit the shocks of its monetary policy
- Being the **USD** the dominant, reserve, and vehicle currency, this cycle is transmitted through **exchange rate fluctuations**, as mentioned in Obstfeld and Zhou (2023)

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- Δ Exchange rate $\rightarrow$ Δ Foreign debt $\rightarrow$ Δ Balance Sheet Risk

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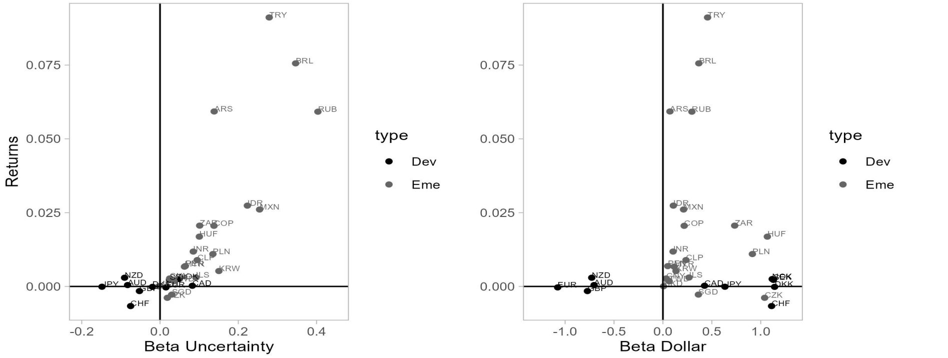
- If **Intermediaries** are exposed to balance Sheet Risks, they will be constrained and forced to charge higher premiums in their assets
- With **high uncertainty**, they will not be able to price the exchange rate and form expectations adequately
- This will create **opportunities for arbitrage** and inefficiencies in trade.
- Implications for domestic prices and investment plans

Motivation

Figure 1: Returns and Betas of Uncertainty and Dollar



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- I propose a daily **Exchange Rate Uncertainty Measure** to explain the **fluctuations of exchange rates**
- This generates persistent deviations of the optimal exchange
- The measure is constructed following the **Factor** uncertainty model of Jurado et al. (2015) and the **group** factor clustering of Ando and Bai (2017).

What I do

- I propose a daily **Exchange Rate Uncertainty Measure** to explain the deviations of the **Covered Interest Rate Parity** for both **LIBOR** and **Government interest rates**
- **High Uncertainty** $\rightarrow$ Deviations of Exchange Rate Parity
- **Uncertainty** does not always reflect changes in the general behavior of the dollar, but also other factors.

What I found...

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What I found...

- As a byproduct of the estimation, I obtain groups of exchange rates that mostly reflect **Trade** and **Geographical Proximity**.
- The cluster of exchange rates changed after 2007, making them less heterogeneous
- Even by controlling for multiple factors, **Exchange Rate Uncertainty** is significant in explaining fluctuations of the exchange rate parity
- Deviations reflect the dominant exchange variation (USD), changes in the international interest rate, and the effect of uncertainty

Contribution

- Clustering Exchange Rates
  Maurer, Tô, and Tran (2019); Greenaway-McGrevy, Mark, Sul, and Wu (2018); Lustig and Richmond (2020); Aloosh and Bekaert (2022)
- Measuring Exchange Rate Uncertainty
  Menkhoff, Sarno, Schmeling, and Schrimpf (2012a); Ismailov and Rossi (2018); Kalemli-Özcan and Varela (2021)
- Effect of Uncertainty on Interest Parity Deviations
  Du, Tepper, and Verdelhan (2018); Du and Schreger (2022); Avdjiev, Du, Koch, and Shin (2019); Kalemli-Özcan and Varela (2021); Della Corte and Krecetovs (2017); Husted, Rogers, and Sun (2018)

Methodology

Uncertainty Estimation

I estimate the uncertainty measures for Exchange Rates based on the Factor model of Jurado et al. (2015) and combine it with the clustering method of Ando and Bai (2017). This procedure has two benefits over the previous methods,

1. **Endogenously** determine clusters of exchange rates to uncover potential hidden structures of the market
2. Estimate the **Uncertainty** with targeted predictors so that the measure can better approximate the actual uncertainty.

The Main Model

The Central model of Ando and Bai (2017)'s procedure is the following equation,

$$y_{i,t} = X'_{i,t}\beta_i + \boldsymbol{F'_{g_i,t}}\lambda_{g_i,t} + \boldsymbol{F'_{a,t}}\lambda_{a,t} + \varepsilon_{i,t}$$

where g_i is the **group** i and a are the **common** factors.

Ando and Bai's Model

The estimation of the model consist on minimizing the square errors of the model and a penalty function given as,

$$L(\beta_1, \beta_2, ..., \beta_N, G, F_a, F_{g_1}, F_{g_2}, ...F_{g_S}, \lambda_a, \lambda_{g_1}, \lambda_{g_2}, ...\lambda_{g_S}) = \sum_{i=1}^{N} \|y_{i,t} - X'_{i,t}\beta_i - \boldsymbol{F'_{g_i,t}}\lambda_{g_i,t} - \boldsymbol{F'_{a,t}}\lambda_{a,t}\|^2 + T\sum_{i=1}^{N} \varrho_i(\beta_i) \quad (1)$$

where the penalty function is given by the Smoothly Clipped Absolute Deviation (SCAD) of Fan and Li (2001).

Penalty | Algorithm | Stochastic Volatility

- The uncertainty of the exchange rate is defined as the conditional volatilities $\hat{U}$ of i; $\hat{U}_{i,t}(h_t)$.
- I calculate the wide measure of uncertainty as,

$$\hat{U}_t = \sum_{i=1}^{N} W_i \hat{U}_{i,t}(h_t)) \quad (2)$$

- I use equal weights to each FX, such that $W_i = \frac{1}{N_i}$

Data

Exchange Rates

- Daily data of 31 exchange rates that span from January 1993 to December 2019
- Inflation Targeting System is the common monetary system between the sample. Very few have Pegged FX or Currency Board.
- Most of them are floaters, but not many are free floaters.

Explanatory Variables

Variables used as predictors of the exchange rate:

1. MSCI World Index
2. S&P500 Index
3. Dollar Spot Index (DXY) Index
4. Bloomberg Commodity Index
5. 3-Month Treasury Constant Maturity Rate (T-Bill)
6. 10-Year Treasury Constant Maturity bond
7. Fed Funds 3-month Futures (FF4)
8. WTI 3-month Futures (CL3)
9. The WTI price
10. Chicago Board Options Exchange (CBOE)'s volatility index (VIX).
11. Shadow Short Rates (SSR) of USA, UK, Japan, and Euro of Krippner (2013)

Uncertainty Measure

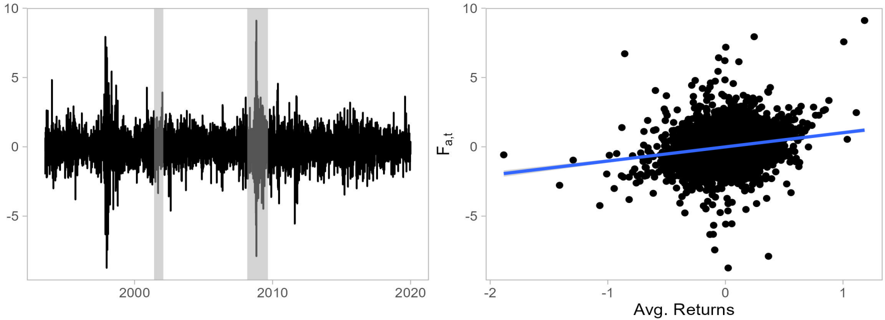
Early Results

- I found that **One factor** (PCA) describes the general exchange rate
- The Factor represents what Menkhoff, Sarno, Schmeling, and Schrimpf (2012b) and Lustig, Roussanov, and Verdelhan (2011) defined as the **"Dollar Factor"**.
- It identifies **Two groups of Exchange Rates**, described by one factor in each
- The existence of a common factor suggests that the **USD** helps spread shocks in the economies.

▸ Hierarchical Clustering

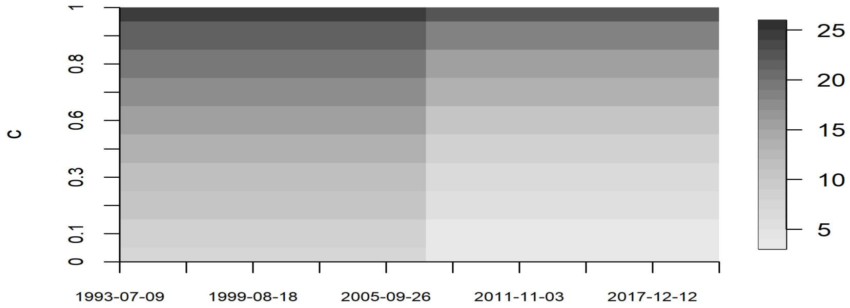
Break in the Factors

Figure 2: Common Factor and the Avg Returns Index



Break in the Factors

I found a **break** in the Factor Structure on July of 2007 using Barigozzi, Cho, and Fryzlewicz (2018)...



Groups with Breaks

For the first period, we get **4 Groups**

Table 1: Estimated groups. Period 1993 - 2007

Group 1 (4)				Group 2 (11)			
EUR	GBP	**NZD**	**NOK**	JPY	**AUD**	**SEK**	DKK
				ZAR	**PLN**	**CZK**	HKD
				INR	**RUB**	**HUF**	
Grup 3 (9)				**Grupo 4 (7)**			
TRY	MXN	BRL	CLP	**CAD**	CHF	SGD	**KRW**
COP	ARS	PEN	CNY	**TWD**	**MYR**	**IDR**	
ILS							

Groups with Breaks

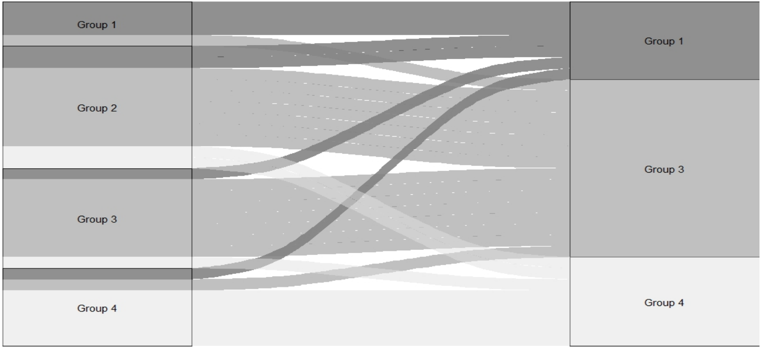
In the second, we get **3 Groups**

Table 2: Estimated groups. Period 2007 - 2020

Group 1 (7)				Group 2 (16)			
EUR	**NZD**	**NOK**	JPY	GBP	**AUD**	**SEK**	**ZAR**
CHF	DKK	ARS		TRY	**PLN**	**CZK**	SGD
				MXN	BRL	CLP	COP
				PEN	**RUB**	**HUF**	
Grupo 3 (8)							
CAD	HKD	**KRW**	**TWD**				
MYR	INR	**IDR**	CNY				

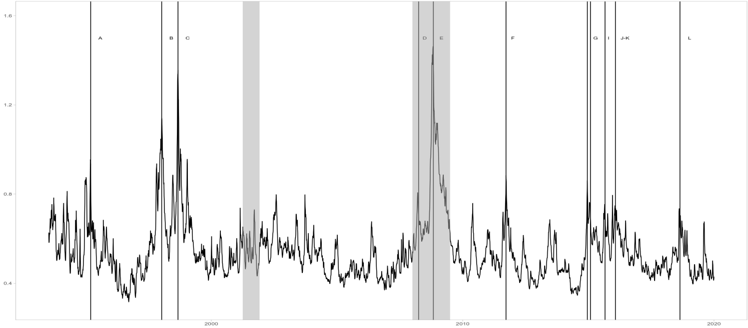
Groups with Breaks

Figure 3: Group Changes Alluvial Chart



Uncertainty

Figure 4: Exchange Rate Uncertainty Index - Breaks



▸ Comparisons ▸ Break vs. No Break

Covered Interest Rate Parity

Covered Interest Rate Parity

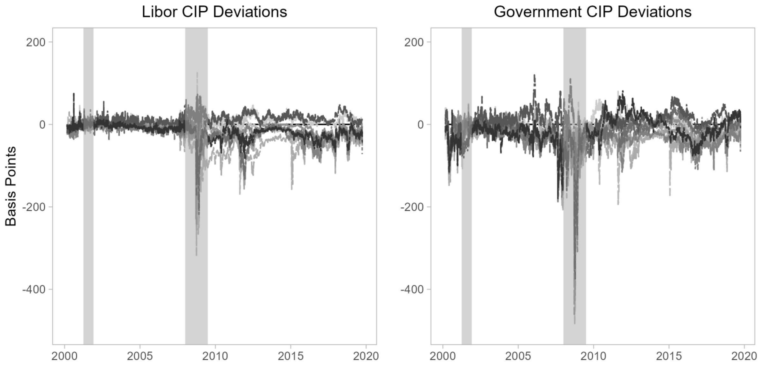
We can define the **Covered Interest Rate Parity** as

$$\lambda_{m,t} = i^*_{t,t+m} - i_{t,t+m} + f_{t+m} - s_t \tag{3}$$

where λ is called the Interest Parity Deviation deviation, expected excess return, or Foreign Risk Premium.

UIRP Deviation

Figure 5: CIP and Government CIP deviations



CIP Regression

I follow Cerutti, Claessens, and Puy (2019) and estimate the following model for each currency:

$$\lambda_t = \alpha_t + \beta_1 \Delta logTWDI_{t-1} + \beta_2 UN_{B,t-1} + \delta_t X_{i,t-1} + \varepsilon_{i,t} \quad (4)$$

where the controls are $X = \{\Delta i_t, \Delta i_t^*, \Delta L^2\}$. L^2 is the He, Kelly, and Manela (2017)' squared intermediary leverage ratio.

CIP Univariate Regression

Table 3: Libor CIP Deviations - Daily Regression

	Libor CIP Deviations - Cerutti, Obstfeld, and Zhou (2021)									
	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
$TWDI_t$	-100.96	**-247.52*****	**-357.38*****	-344.75	**-330.80***	-179.98	**-354.89****	-186.50	24.29	**-289.87****
	(135.03)	(94.44)	(134.70)	(228.35)	(192.50)	(185.28)	(171.02)	(159.25)	(83.60)	(140.33)
Δi_t^*	-4.13	-11.80	**189.79****	**96.39***	**399.91*****	**136.10****	-22.42	**25.60***	-0.79	**103.44*****
	(13.14)	(46.58)	(75.12)	(55.29)	(155.02)	(69.29)	(201.92)	(15.16)	(12.84)	(33.49)
Δi_t	**-135.11*****	**-124.22*****	**-231.23*****	-135.34	**-270.63*****	-147.96	**-312.19*****	**-106.46***	**-38.28****	**-83.07***
	(51.20)	(27.42)	(54.05)	(92.88)	(70.75)	(91.92)	(48.46)	(64.40)	(18.84)	(50.32)
$UN_{B,t-1}$	-5.86	**11.50*****	**-20.23****	**-73.49*****	**-36.44*****	**-57.63*****	**-12.01****	**-46.36*****	**10.13****	**-36.58*****
	(7.58)	(3.85)	(9.15)	(15.32)	(10.29)	(14.15)	(5.94)	(11.23)	(3.97)	(10.48)
ΔL^2	-15.86	8.62	32.55	20.84	12.14	5.45	15.64	16.85	-1.52	8.04
	(12.02)	(12.69)	(24.24)	(21.90)	(18.18)	(19.58)	(13.91)	(16.64)	(7.23)	(21.25)
R^2	0.07	0.09	0.12	0.29	0.19	0.36	0.17	0.20	0.05	0.21
Adj. R^2	0.07	0.09	0.12	0.29	0.19	0.36	0.17	0.20	0.05	0.21
Num. obs.	2708	2708	2708	2708	2708	2708	2708	2708	2708	2708

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

CIP Univariate Regression

Table 4: Government CIP Deviations - Daily Regression

	Government CIP Deviations - Cerutti et al. (2021)									
	AUD	CAD	CHF	DKK	EUR	GBP	JPY	NOK	NZD	SEK
$TWDI_t$	79.42	222.34	75.90	223.84	287.19	288.57	553.90	-16.79	174.25	170.84
	(372.58)	(338.02)	(250.69)	(446.19)	(297.96)	(284.48)	(500.94)	(288.52)	(264.12)	(437.94)
Δi_g^*	-66.20	**-220.95****	**-168.69****	115.82	159.18	-75.04	649.76	-67.08	**-104.42***	-83.84
	(48.87)	(109.06)	(65.67)	(82.33)	(287.00)	(51.22)	(563.13)	(46.53)	(54.89)	(56.14)
Δi_g	117.21	103.21	103.05	131.29	205.93	232.85	265.35	60.94	35.85	92.91
	(182.17)	(194.43)	(116.60)	(213.49)	(201.42)	(168.61)	(226.38)	(195.61)	(90.16)	(242.37)
$UN_{B,t-1}$	**43.12****	**75.29*****	**74.45*****	**113.21*****	**63.92*****	**43.23****	**111.93*****	**94.20*****	**48.98****	**114.68*****
	(21.99)	(28.11)	(15.66)	(31.04)	(24.56)	(20.03)	(37.09)	(35.56)	(23.65)	(37.60)
ΔL^2	5.34	-18.62	-18.09	-16.18	-11.34	-11.57	0.29	-12.70	-12.68	6.45
	(26.68)	(28.48)	(27.65)	(35.01)	(35.38)	(19.01)	(34.44)	(30.10)	(19.59)	(41.04)
R^2	0.10	0.29	0.26	0.33	0.19	0.16	0.35	0.27	0.14	0.29
$Adj.R^2$	0.10	0.29	0.26	0.33	0.19	0.16	0.35	0.27	0.14	0.29
Num. obs.	2708	2708	2708	2708	2708	2708	2708	2708	2708	2708

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

CIP Pool Regression

From the Univariate Regression, we pass to the Panel Regression. Following Avdjiev et al. (2019), I estimate the model

$$\lambda_{i,t} = \alpha_{i,t} + \beta_{1,i}\Delta TWDI_t + \beta_{2,t} UN_{B,t} + \delta_t X_{i,t} + \varepsilon_{i,t} \tag{5}$$

where the controls are $X = \{\Delta ER_{i,t}, \Delta i_t, WTI_{t-1}\}$ and the Uncertainty can be with Breaks, No Breaks, and the VIX.

CIP Panel

Table 5: Libor CIP Deviations - Daily Panel of Currencies

	Models									
	(1)	(2)	(3)	(4)	**(5)**	(6)	(7)	(8)	(9)	**(10)**
$UN_{B,t-1}$	-25.88^{***}	-26.38^{***}	-26.35^{***}	-28.24^{***}	-28.51^{***}					
	(8.66)	(8.85)	(8.84)	(9.74)	(9.66)					
$\Delta UN_{B,t}$	-17.21	-9.00	-12.21	-2.13	5.71					
	(33.00)	(32.26)	(33.21)	(24.88)	(27.23)					
VIX_{t-1}						-15.10^{**}	-16.42^{**}	-16.55^{**}		
						(6.29)	(6.63)	(6.55)		
ΔVIX_t						-6.39	-6.41^{*}	-5.73		
						(4.27)	(3.87)	(3.52)		
VXO_{t-1}									-14.31^{**}	
									(6.21)	
ΔVXO_t									-5.43	
									(3.39)	
$UN_{NB,t-1}$										-30.38^{***}
										(8.69)
$\Delta UN_{NB,t}$										20.76
										(29.00)
$TWDI_t$		-257.80^{**}	-270.15^{**}	-202.76^{**}	-193.29^{*}	-288.62^{**}	-234.19^{**}	-228.23^{*}	-229.31^{**}	-187.82^{*}
		(104.85)	(108.78)	(96.63)	(99.71)	(120.22)	(113.71)	(117.48)	(116.81)	(96.14)
ER_t			0.03	-0.04	-0.14		-0.02	-0.12	-0.13	-0.14
			(0.26)	(0.28)	(0.29)		(0.28)	(0.30)	(0.30)	(0.30)
i_t				-141.55^{***}	-149.14^{***}		-145.78^{***}	-151.77^{***}	-148.70^{***}	-150.34^{***}
				(32.02)	(34.07)		(34.67)	(37.87)	(37.99)	(32.61)
WTI_{t-1}					22.53^{**}			20.26^{*}	21.67^{**}	23.09^{***}
					(8.91)			(10.53)	(10.75)	(8.79)
Adjusted R^2	0.043	0.046	0.047	0.06	**0.063**	0.043	0.058	0.06	0.056	**0.074**
N	32420	32420	32420	32420	32420	32420	32420	32420	32420	32420

Driscoll and Kraay(1998) standard errors clustered by currency and time. The number of optimal lags are selected following Newey and West (1994). $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

CIP Panel

Table 6: Government CIP Deviations - Daily Panel of Currencies

	Models									
	(1)	(2)	(3)	(4)	**(5)**	(6)	(7)	(8)	(9)	**(10)**
$UN_{B,t-1}$	74.72***	78.05***	77.85***	79.77***	81.90***					
	(26.37)	(26.71)	(26.47)	(28.67)	(29.29)					
$\Delta UN_{B,t}$	94.62	82.69	81.37	76.48	81.21					
	(112.46)	(109.01)	(107.29)	(93.15)	(94.60)					
VIX_{t-1}						45.25***	46.56***	47.35***		
						(15.75)	(16.83)	(17.16)		
ΔVIX_t						25.14*	25.21**	21.87*		
						(12.98)	(12.57)	(12.07)		
VXO_{t-1}									43.62***	
									(15.89)	
ΔVXO_t									19.22**	
									(9.63)	
$UN_{NB,t-1}$										80.45***
										(28.39)
$\Delta UN_{NB,t}$										75.62
										(96.09)
$TWDI_t$		231.32	215.66	178.92	186.29	308.95	253.77	289.45	295.74	183.45
		(275.88)	(255.57)	(233.66)	(230.38)	(336.35)	(296.19)	(298.07)	(298.87)	(229.63)
ER_t			0.18	0.14	0.45		0.09	0.37	0.38	0.45
			(0.45)	(0.42)	(0.43)		(0.39)	(0.39)	(0.39)	(0.43)
r_t				131.10	158.06		144.64	166.55	164.58	152.28
				(135.82)	(135.65)		(131.81)	(134.81)	(129.31)	(134.15)
WTI_{t-1}					−27.15			−22.58	−23.39	−31.36
					(26.07)			(33.77)	(33.64)	(27.11)
Adjusted R^2	0.168	0.179	0.179	0.185	**0.195**	0.17	0.176	0.182	0.186	**0.199**
N	32420	32420	32420	32420	32420	32420	32420	32420	32420	32420

Driscoll and Kraay(1998) standard errors clustered by currency and time. The number of optimal lags are selected following Newey and West (1994). $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Conclusion

Conclusion

- I estimate a new method to calculate **Exchange rate Uncertainty** using a model that accounts for internal clustering in the groups
- I find that there exists a **break** in July of 2007 that changes the general structure of the model
- After 2007, the exchange rate became more clustered than before. Going from 4 groups to 3 groups.
- EUR, NZD, and NOK follow the same group in every model.

Conclusion

- Following a simple model, the **Uncertainty with breaks and no breaks** have higher fit than other measures of uncertainty
- **Uncertainty** and the **US interest rate** have statistical significance in explaining the CIP deviations
- Accounting by the effect of the dollar, the uncertainty has a **higher fit** than the VIX.
- Uncertainty consistently affects the convenience yield of the US Government Bonds

Thank you!

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Estimation Model

The Penalty function is described by the following equation:

$$\varrho_i(\beta_i) = \begin{cases} \kappa_i|\beta_{i,j}| & |\beta_{i,j}| \leq \kappa_i \\ \frac{\gamma\kappa_i|\beta_{i,j}|-0.5(\beta_{i,j}^2+\kappa^2)}{\gamma-1} & \kappa_i \leq |\beta_{i,j}| \leq \gamma\kappa_i \\ \frac{\kappa_i^2\left(\gamma^2-1\right)}{2\left(\gamma-1\right)} & \gamma\kappa_i < |\beta_{i,j}| \end{cases} \tag{6}$$

where $\kappa_i > 0$ and *gamma* $= 3.7$, as established by Ando and Bai (2017).

▸ Econometric Model

Objective function

The final model must satisfy that,

$$\tilde{g}_i = argmin_i \left\| y_{i,t} - X'_{i,t}\beta_i - F'_{g_i,t}\lambda_{g_i,t} - F'_{a,t}\lambda_{a,t} \right\|^2 \tag{7}$$

so the number of estimated groups and factors should be the minimizer of the squared errors.

Panel Information Criteria

The Model requires the estimation of different models and compare them by some criteria. They propose the following Panel Information Criteria:

$$
\begin{aligned}
PIC^c = & \frac{1}{NT} \sum_{j=1}^{S} \sum_{g_i=j} \| y_{i,t} - X'_{i,t}\tilde{\beta}_i - \tilde{F}'_{g_i,t}\tilde{\lambda}_{g_i,t} - \tilde{F}'_{a,t}\tilde{\lambda}_{a,t} \|^2 \\
& + C\frac{1}{N}\sum_{i=1}^{N} \tilde{\sigma}^2 log(T)\tilde{p}_i + Ck\tilde{\sigma}^2 \left(\frac{T+N}{TN} \right) log(TN)\tilde{p}_i \\
& + \sum_{j=1}^{G} Ck_j\tilde{\sigma}^2 \left(\frac{T+N_j}{TN_j} \right) log(TN_j)
\end{aligned} \tag{8}
$$

Estimation Algorithm

- Choose the initial optimal values of the $(k_1, k_2, ..., k_S)$, $(\kappa_1, \kappa_2, ..., \kappa_N)$, and the number of groups S (estimated through the Hierarchical Clustering).
- Fix the number of groups S and, determine the number of common and group-specific' factors.
- Given the current values of the parameters S, k, and $k_1, k_2, ..., k_S$, optimize the regularization parameters κ_i using the criteria defined in equation (8).
- Using the previously estimated parameters, re-optimize the value of the common factors k using equation (8).

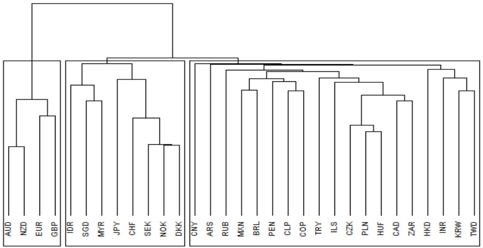
Estimation Algorithm

- with the previous parameters and the estimated k in step 4, estimate the group-specific factors k_g using equation (8).
- Repeat the previous steps until the model achieves convergence.
- Change the value of the number of groups and repeat the previous steps until achieving convergence
- compare the results of each group and select based on the minimizer of the Information Criteria, PIC.

▸ Econometric Model

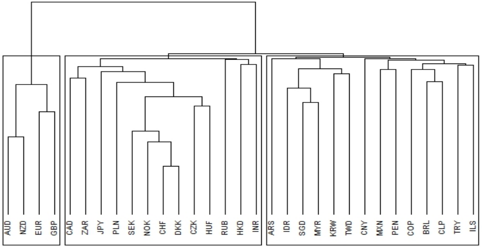
Hierarchical Clustering: Full sample

Figure 6: Dendogram: Full Sample



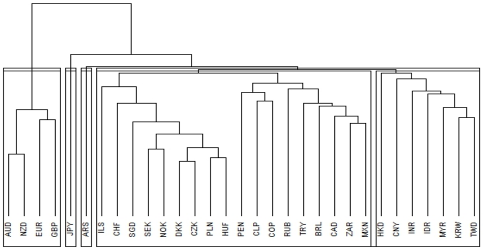
Hierarchical Clustering: 1993-2007

Figure 7: Dendogram: Sample 1993-2007



Hierarchical Clustering: 2007-2019

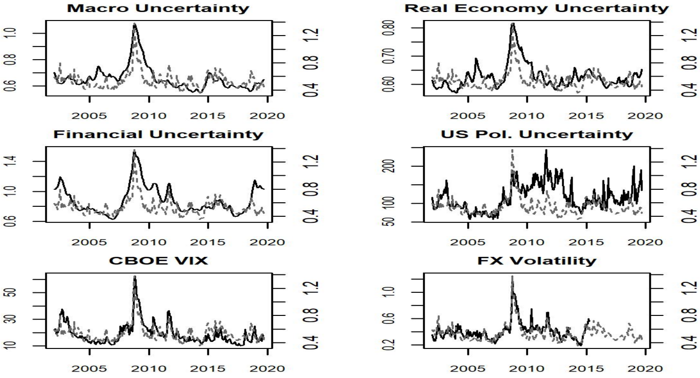
Figure 8: Dendogram: Sample 2007-2019



Results

Uncertainty Comparisons

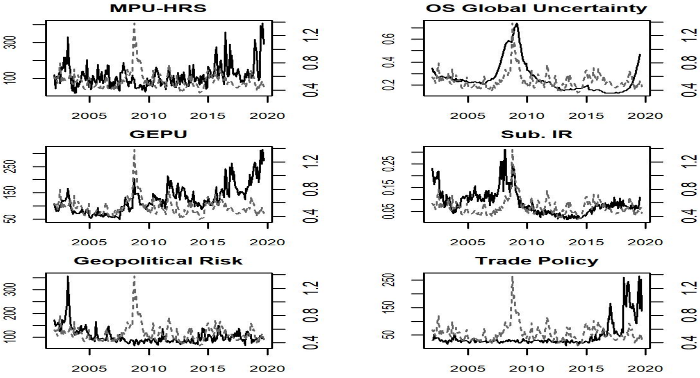
Figure 9: Uncertainty Measure Comparisons



▸ uncertainty

Uncertainty Comparisons

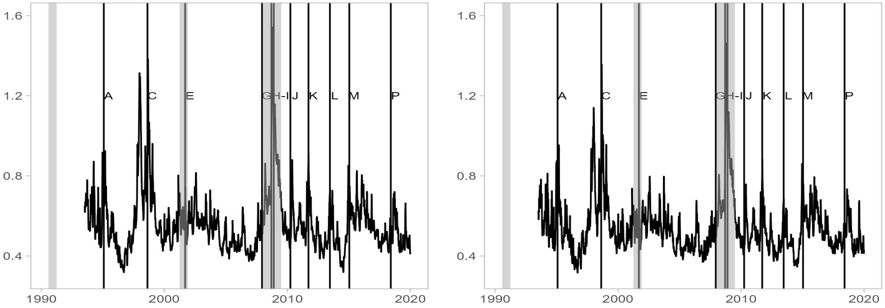
Figure 10: Uncertainty Measure Comparisons



▸ uncertainty

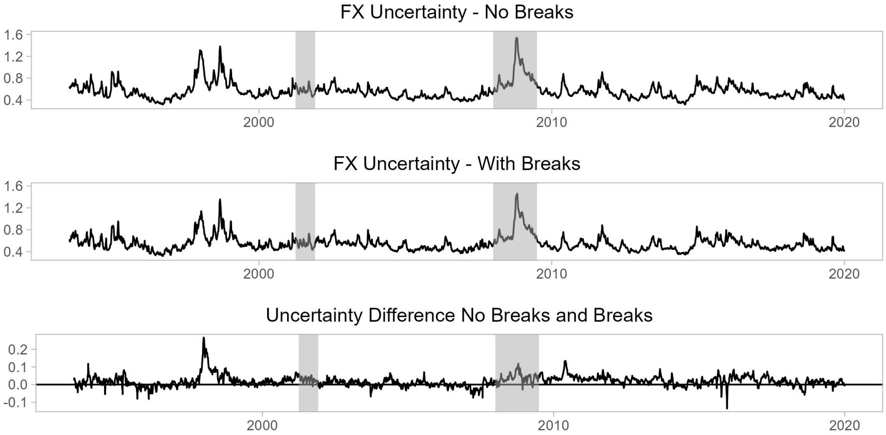
Uncertainty

Figure 11: Exchange Rate Uncertainty Index - No Breaks and Breaks



Uncertainty Differences

Figure 12: ERU Differences; No Break - Break



Stochastic Volatility

The stochastic volatility model described by Kastner and Fruhwirth-Schnatter (2014) estimates the conditional volatility

$$\begin{aligned}
\varepsilon_t &= e^{\frac{h_t}{2}} \epsilon_t \\
h_t &= \mu + \phi(h_{t-1} - \mu) + \sigma v_t \\
h_t &= \phi h_{t-1} + \sigma v_t
\end{aligned} \tag{9}$$

it involves interweaving between the two in the algorithm called the Ancillary-Sufficiency Interweaving Strategy (ASIS) ▸ Back