

Modeling & Forecasting
the International Dimensions:
Business cycles, exchange rates, and cross-
border flows capital and trade flows
(Day 2 Morning)

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ISF at Darden School

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Exchange Rates and Fundamentals

A(nother) Horse Race

- Meese & Rogoff (JIE, 1983)
- Chinn & Meese (JIE, 1995)
- Cheung, Chinn, Garcia-Pascual (JIMF, 2005)
- Cheung, Chinn, Garcia-Pascual & Zhang (JIMF, 2019)

Contributions

- Four new models compared against standard models
- Five currencies against USD
- Two specifications
- Three (four) forecast horizons
- Three prediction criteria

Findings

- A random walk can't be beaten often, by MSE criterion
- Structural models do better (DoC)
- “Consistency” results ambiguous
- PPP at long horizon does well
- IRP is useful predictor
- Taylor rule fundamentals mixed

The Models

Uncovered interest rate parity

$$(1) \quad s_{t+k} = s_t + \hat{i}_{t,k_t}$$

Relative purchasing power parity:

$$(2) \quad s_t = \beta_0 + \hat{p}_t ,$$

The Models

Sticky price monetary model.

$$(3) \quad s_t = \beta_0 + \beta_1 \hat{m}_t + \beta_2 \hat{y}_t + \beta_3 \hat{i}_t + \beta_4 \hat{\pi}_t + u_t,$$

where m is log money, y is log real GDP, i and π are the interest and inflation rate

Behavioral equilibrium exchange rate model.

$$(4) \quad s_t = \beta_0 + \hat{p}_t + \beta_5 \hat{\omega}_t + \beta_6 \hat{r}_t + \beta_7 \hat{gdebt}_t + \beta_8 \hat{tot}_t + \beta_9 \hat{nfa}_t + u_t,$$

The (New) Models (or New Variables)

Taylor rule fundamentals.

$$(5) \quad s_{t+k} - s_t = \beta_0 + \beta_1 \hat{y}_t + \beta_2 \hat{\pi}_t + u_t$$

Real interest differential.

$$(6) \quad s_t = \beta_0 + \beta_1 (\hat{i}_t^{shadow} - \hat{\pi}_t) + u_t.$$

The (New) Models (or New Variables)

Sticky price monetary model augmented by risk and liquidity factors.

$$(7) \quad s_t = \beta_0 + \beta_1 \hat{m}_t + \beta_2 \hat{y}_t + \beta_3 \hat{i}_t + \beta_4 \hat{\pi}_t + \beta_5 VIX_t + \beta_6 TED_t + u_t,$$

Yield curve slope.

$$(8) \quad s_{t+k} - s_t = \beta_0 + \beta_1 (\hat{i}_t) + \beta_2 (slope_t) + u_t,$$

Data

- m , IP , i , CPI, PPI from *IFS*
- Output gap is full sample HP filtered IP
- Long term interest rates from Chinn & Meredith, Chinn & Quayyum
- NFA from Lane & Milesi-Ferretti interpolated using CA data
- Gov't debt from *IFS*, BIS, interpolated
- Shadow rates from Wu-Xia, IMF

Estimation

- Rolling regressions
- ECM vs. first differences

$$s_t = X_t \Gamma + u_t$$

$$\Delta s_t = \Delta X_t \Gamma + u_t$$

$$s_t - s_{t-k} = \delta_0 + \delta_1 (s_{t-k} - X_t \Gamma) + u_t$$

- ECT estimated recursively in ECM's

Prediction, not Forecasting

- ECT estimated *recursively* in EC specifications
- ECM are *ex ante* vs. *ex post*
- But not real time
- IRP not estimated, categorized as error correction
- PPP imposed in long run, reversion estimated in ECM

Forecast Comparison

- MSE criterion

$MSE(\text{model } j)/MSE(\text{rw})$

Diebold-Mariano (1995) test [not Clark-West]

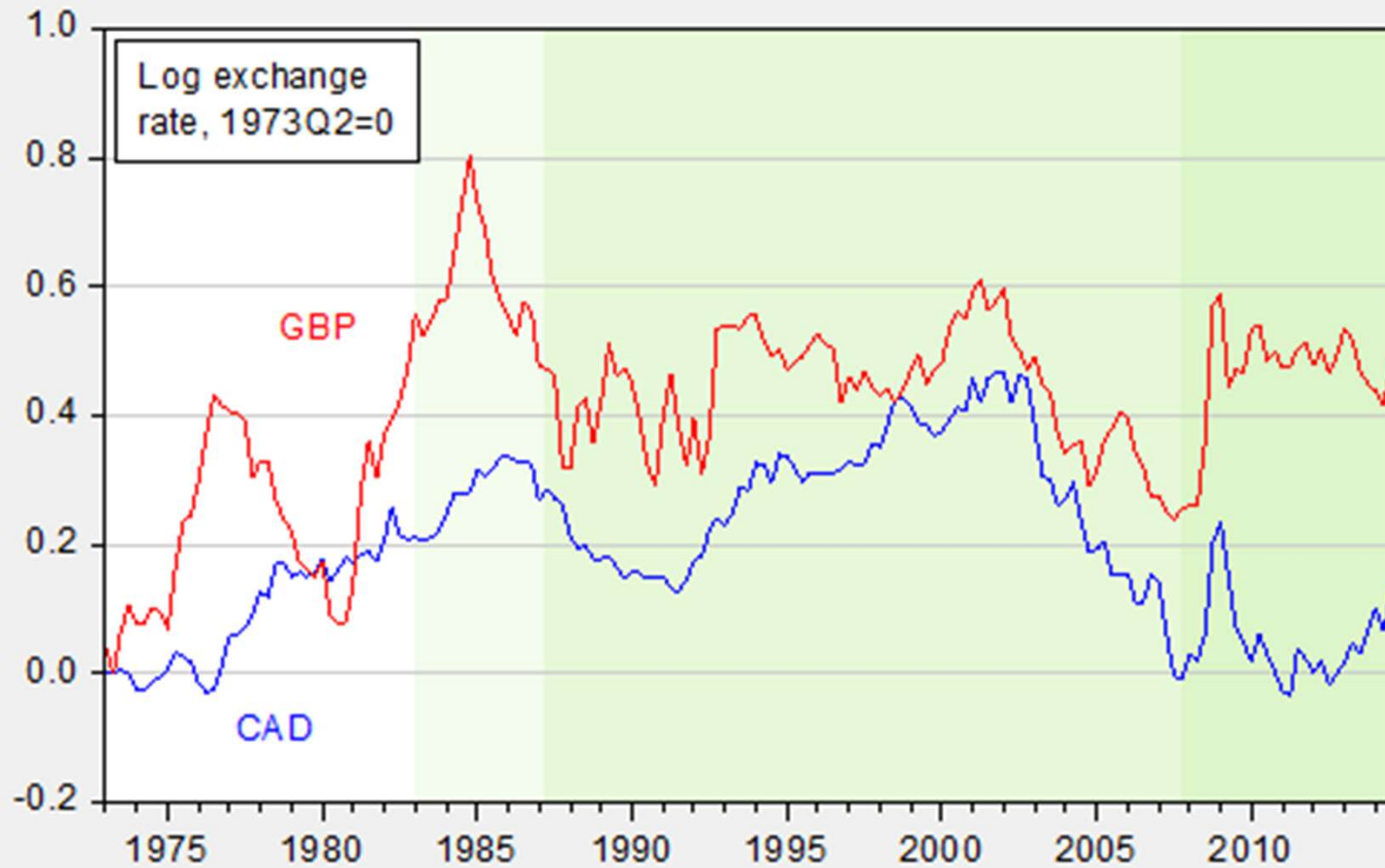
- Direction of Change

Value > 0.5 implies outprediction

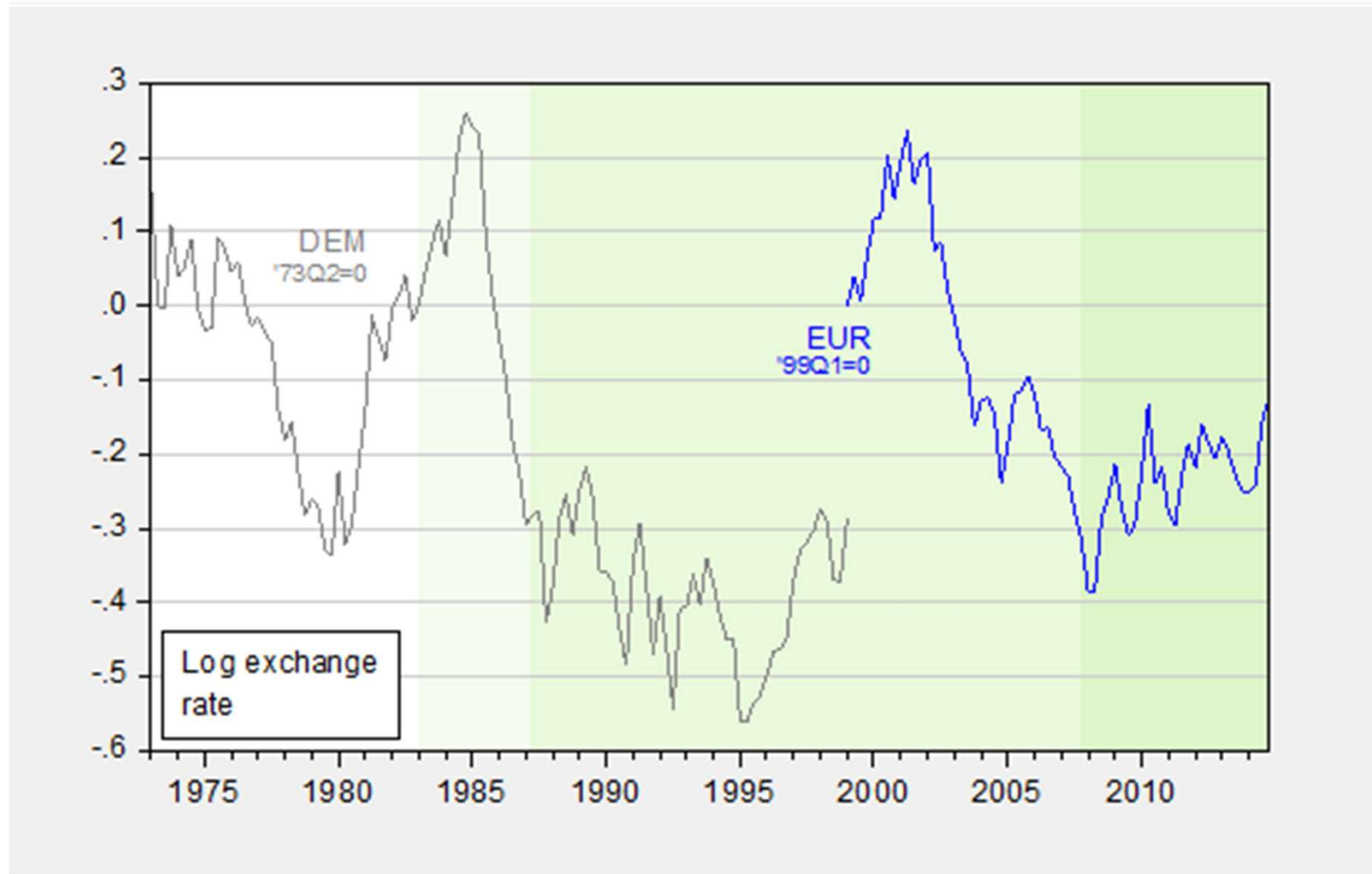
- “Consistency” (Cheung & Chinn, ‘98)

Same $I(d)$, cointegration, unit elasticity

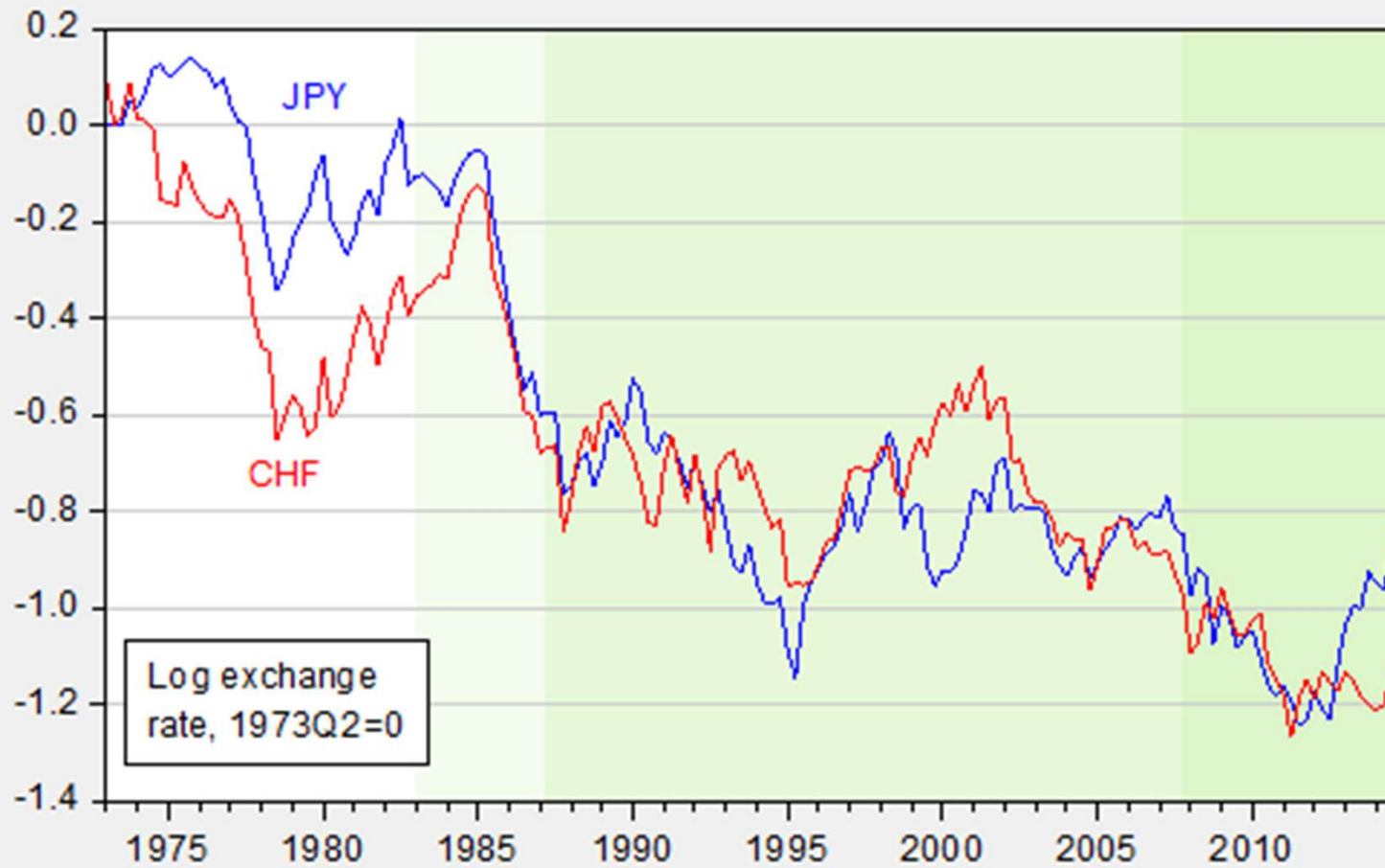
Exchange Rates



Exchange Rates



Exchange Rates



Results: MSE

- Structural model performance is unimpressive
- 69 outperformance RW (16.2%)
- Compare to CCG-P (2005): < 1%
- 27% success in Period I
- 35% of successes are at 5 year horizon
- Best: PPP ECM
- Worst: first difference Yen BEER, Period II (5.7)
- Difficulty in estimating short run dynamics

Table 1: The MSE ratios from the dollar-based exchange rates

Specification	Horizon	Sample 2: 1987q2-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel A: CAN\$/									
ECM	1 quarter	0.963	0.994	0.940	1.018	0.951	0.944		0.818
		0.123	0.911	0.370	0.072	0.435	0.280		0.018
	4 quarter	0.960	1.036	1.071	1.012	1.055	0.777		0.659
		0.611	0.508	0.280	0.168	0.174	0.020		0.003
	20 quarter	0.631	0.898	0.872	0.874	0.996	0.941		0.277
		0.004	0.092	0.062	0.645	0.940	0.484		0.000
FD	1 quarter	1.024	1.055	0.554		1.100			
		0.618	0.467	0.007		0.126			
	4 quarter	1.153	1.152	0.449		1.141			
		0.001	0.141	0.000		0.001			
	20 quarter	1.433	1.204	0.338		1.146			
		0.000	0.000	0.002		0.005			
Panel B: Yen/\$									
ECM	1 quarter	0.939	0.984	0.887	1.021	0.961	0.946		0.881
		0.303	0.926	0.120	0.328	0.427	0.393		0.050
	4 quarter	0.886	1.020	0.917	1.142	0.993	1.041		0.732
		0.172	0.468	0.456	0.016	0.925	0.496		0.004
	20 quarter	0.816	1.363	0.820	1.163	1.449	1.341		1.761
		0.007	0.316	0.041	0.896	0.220	0.377		0.002
FD	1 quarter	1.076	1.149	1.399		1.035			
		0.083	0.020	0.037		0.381			
	4 quarter	1.136	1.259	2.068		1.126			
		0.044	0.002	0.000		0.045			
	20 quarter	1.748	1.538	5.657		1.645			
		0.007	0.154	0.001		0.028			

Panel C: SF/\$						
ECM	1 quarter	0.941	0.991		0.967	0.926
		0.088	0.755		0.300	0.059
	4 quarter	0.813	0.969		0.986	0.940
		0.004	0.278		0.362	0.068
	20 quarter	0.398	1.080		1.024	1.171
		0.000	0.002		0.000	0.048
FD	1 quarter	1.062	1.306		1.074	
		0.088	0.050		0.046	
	4 quarter	1.156	1.656		1.160	
		0.032	0.000		0.041	
	20 quarter	2.309	1.615		1.975	
		0.000	0.185		0.022	

Table 1: The MSE ratios from the dollar-based exchange rates

Specification	Horizon	Sample 1: 1983q1-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel D: BP/\$	1 quarter	0.900	0.943	0.997	1.015	0.952	0.916		0.938
		0.031	0.221	0.941	0.467	0.380	0.048		0.418
	4 quarter	0.733	0.952	1.106	1.022	1.070	0.923		1.062
		0.000	0.432	0.030	0.239	0.244	0.347		0.517
	20 quarter	0.339	1.192	1.496	0.958	1.650	1.273		1.306
		0.000	0.067	0.000	0.182	0.000	0.007		0.042
FD	1 quarter	1.023	1.177	1.006		1.112			
		0.628	0.002	0.971		0.068			
	4 quarter	1.095	1.145	1.056		1.188			
		0.040	0.093	0.758		0.001			
	20 quarter	1.616	1.512	1.389		2.335			
		0.000	0.000	0.008		0.000			

Panel C: SF/\$						
ECM	1 quarter	0.941	0.991		0.967	0.926
		0.088	0.755		0.300	0.059
	4 quarter	0.813	0.969		0.986	0.940
		0.004	0.278		0.362	0.068
	20 quarter	0.398	1.080		1.024	1.171
		0.000	0.002		0.000	0.048
FD	1 quarter	1.062	1.306		1.074	
		0.088	0.050		0.046	
	4 quarter	1.156	1.656		1.160	
		0.032	0.000		0.041	
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		0.031	0.221	0.941	0.467	0.380	0.048		0.418
	4 quarter	0.733	0.952	1.106	1.022	1.070	0.923		1.062
		0.000	0.432	0.030	0.239	0.244	0.347		0.517
	20 quarter	0.339	1.192	1.496	0.958	1.650	1.273		1.306
		0.000	0.067	0.000	0.182	0.000	0.007		0.042
FD	1 quarter	1.023	1.177	1.006		1.112			
		0.628	0.002	0.971		0.068			
	4 quarter	1.095	1.145	1.056		1.188			
		0.040	0.093	0.758		0.001			
	20 quarter	1.616	1.512	1.389		2.335			
		0.000	0.000	0.008		0.000			

Table 1: The MSE ratios from the dollar-based exchange rates

Specification	Horizon	Sample 2: 1987q2-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel A: CAN\$/S									
ECM	1 quarter	0.963	0.994	0.940	1.018	0.951	0.944		0.818
		0.123	0.911	0.370	0.072	0.435	0.280		0.018
	4 quarter	0.960	1.036	1.071	1.012	1.055	0.777		0.659
		0.611	0.508	0.280	0.168	0.174	0.020		0.003
	20 quarter	0.631	0.898	0.872	0.874	0.996	0.941		0.277
		0.004	0.092	0.062	0.645	0.940	0.484		0.000
FD	1 quarter	1.024	1.055	0.554		1.100			
		0.618	0.467	0.007		0.126			
	4 quarter	1.153	1.152	0.449		1.141			
		0.001	0.141	0.000		0.001			
	20 quarter	1.433	1.204	0.338		1.146			
		0.000	0.000	0.002		0.005			
Panel B: Yen/\$									
ECM	1 quarter	0.939	0.984	0.887	1.021	0.961	0.946		0.881
		0.303	0.926	0.120	0.328	0.427	0.393		0.050
	4 quarter	0.886	1.020	0.917	1.142	0.993	1.041		0.732
		0.172	0.468	0.456	0.016	0.925	0.496		0.004
	20 quarter	0.816	1.363	0.820	1.163	1.449	1.341		1.761
		0.007	0.316	0.041	0.896	0.220	0.377		0.002
FD	1 quarter	1.076	1.149	1.399		1.035			
		0.083	0.020	0.037		0.381			
	4 quarter	1.136	1.259	2.068		1.126			
		0.044	0.002	0.000		0.045			
	20 quarter	1.748	1.538	5.657		1.645			
		0.007	0.154	0.001		0.028			

Panel C: SF/\$					
ECM	1 quarter	0.955	0.958	1.002	0.960
		0.271	0.121	0.992	0.218
	4 quarter	0.952	1.090	1.053	1.009
		0.400	0.390	0.665	0.850
	20 quarter	0.512	1.506	1.162	1.290
		0.000	0.112	0.330	0.882
FD	1 quarter	1.077	1.114	1.045	
		0.014	0.073	0.186	
	4 quarter	1.201	1.409	1.164	
		0.002	0.000	0.014	
	20 quarter	1.639	2.476	1.446	
		0.059	0.000	0.244	

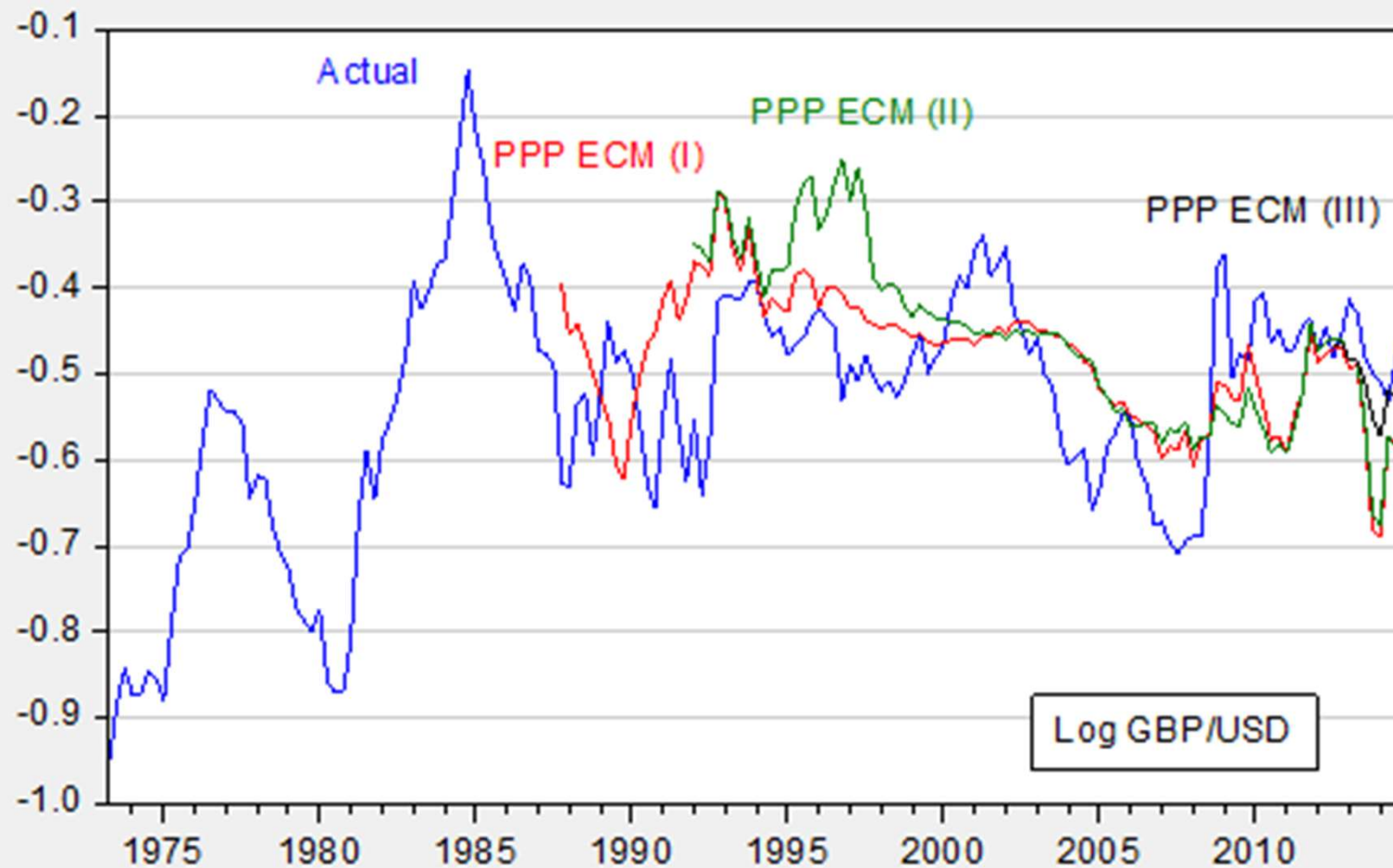
Table 1: The MSE ratios from the dollar-based exchange rates

Specification	Horizon	Sample 2: 1987q2-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel D: BP/\$									
ECM	1 quarter	0.949	0.993	0.940	0.993	0.966	0.956		1.000
		0.301	0.875	0.216	0.985	0.490	0.158		0.957
	4 quarter	0.803	1.000	0.982	0.962	0.992	0.902		1.038
		0.041	0.975	0.666	0.902	0.817	0.250		0.465
	20 quarter	0.512	1.041	1.002	0.959	0.985	0.998		1.146
		0.000	0.719	0.929	0.960	0.744	0.846		0.099
FD	1 quarter	1.010	1.070	0.889		1.045			
		0.851	0.329	0.596		0.411			
	4 quarter	1.087	1.086	0.669		1.070			
		0.017	0.324	0.052		0.055			
	20 quarter	1.279	1.694	1.037		1.783			
		0.000	0.000	0.005		0.000			

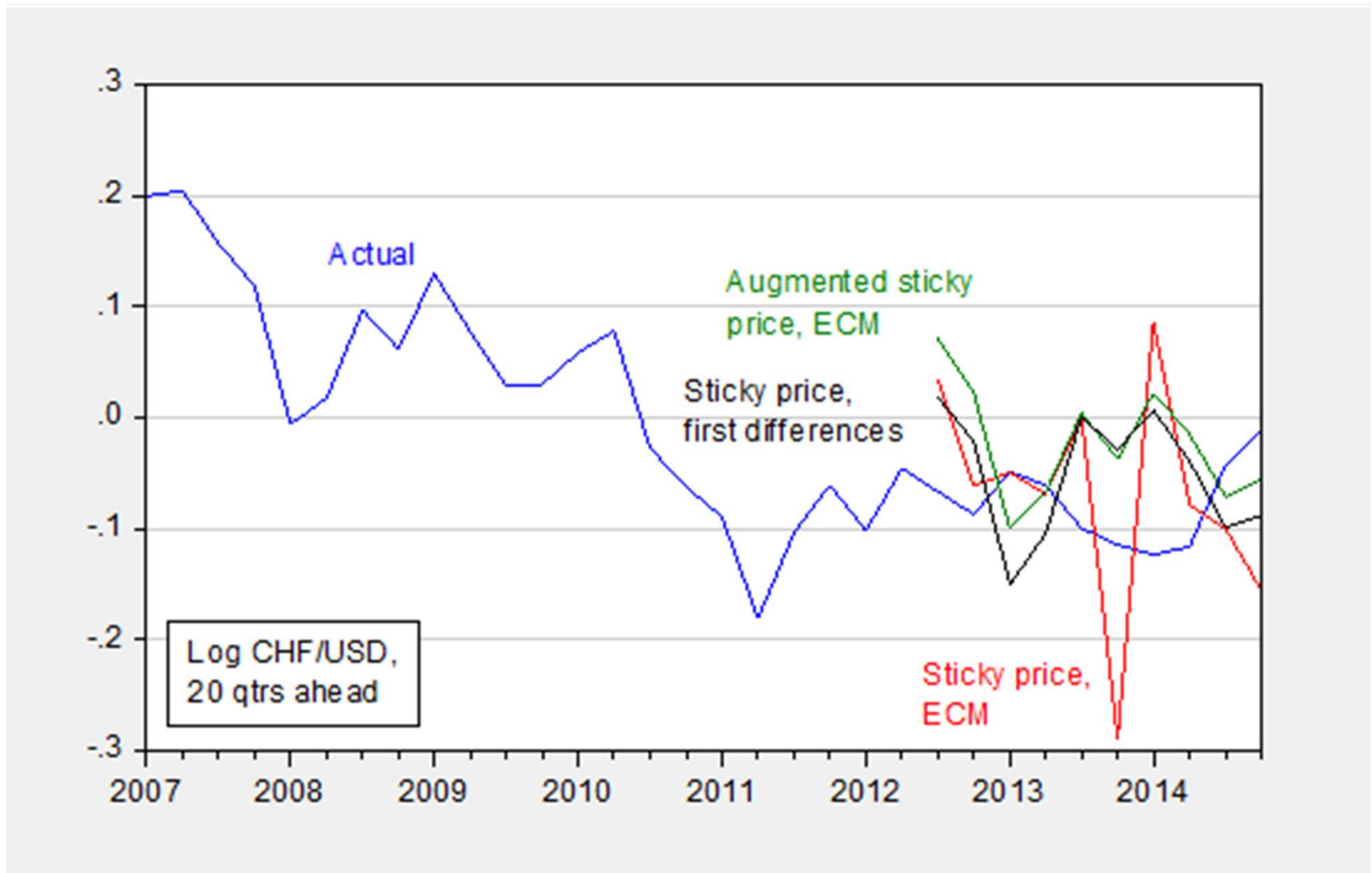
Specification	Horizon	Sample 3: 2007q4-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel A: CAN\$/S									
ECM	1 quarter	0.968	0.973	0.916	0.990	0.951	0.931	0.969	0.978
		0.251	0.300	0.698	0.145	0.338	0.131	0.683	0.662
	4 quarter	0.882	0.976	0.925	0.968	0.993	0.627	0.894	0.975
		0.066	0.430	0.798	0.037	0.683	0.002	0.313	0.575
	20 quarter	0.519	0.952	0.997	0.872	1.040	0.964	0.937	1.146
		0.144	0.866	0.679	0.604	0.770	0.698	0.405	0.115
FD	1 quarter	0.897	1.011	0.447		1.037		0.776	
		0.257	0.721	0.085		0.155		0.230	
	4 quarter	0.947	1.041	0.385		1.038		0.633	
		0.184	0.091	0.019		0.007		0.157	
	20 quarter	1.159	1.207	1.211		1.338		0.919	
		0.086	0.167	0.497		0.083		0.932	
Panel B: Yen/\$									
ECM	1 quarter	0.989	0.946	0.912	0.979	0.971	1.058	0.832	0.943
		0.917	0.421	0.398	0.181	0.864	0.297	0.004	0.518
	4 quarter	0.923	0.966	0.854	0.940	0.933	1.118	0.762	0.885
		0.662	0.737	0.267	0.044	0.876	0.076	0.000	0.102
	20 quarter	0.509	1.019	0.852	0.810	0.869	0.884	0.924	0.918
		0.973	0.381	0.553	0.907	0.603	0.558	0.769	0.379
FD	1 quarter	1.042	1.122	0.650		1.002		1.018	
		0.578	0.137	0.039		0.825		0.872	
	4 quarter	0.889	1.041	0.634		0.954		1.130	
		0.218	0.412	0.000		0.914		0.177	
	20 quarter	0.948	1.338	0.697		1.165		1.643	
		0.480	0.144	0.842		0.253		0.019	
Panel C: SF/\$									
ECM	1 quarter	0.919	1.042	0.971	0.989	1.025	0.973	0.999	1.025
		0.480	0.707	0.554	0.148	0.892	0.652	0.870	0.858
	4 quarter	0.771	0.950	1.019	0.971	1.229	0.943	1.024	1.135
		0.985	0.373	0.909	0.840	0.478	0.308	0.707	0.754
	20 quarter	0.246	2.047	1.489	0.981	1.021	1.491	0.940	1.061
		0.012	0.015	0.145	0.002	0.002	0.007	0.000	0.000
FD	1 quarter	1.048	0.981	1.065		0.989		1.730	
		0.729	0.668	0.725		0.648		0.119	
	4 quarter	1.004	1.016	1.047		0.990		1.621	
		0.630	0.549	0.927		0.601		0.077	
	20 quarter	1.050	1.130	2.327		1.208		3.545	
		0.002	0.002	0.238		0.014		0.002	

Specification	Horizon	Sample 3: 2007q4-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel D: BP/\$									
ECM	1 quarter	0.896	0.968	0.935	0.960	0.943	0.962	1.015	1.023
		0.042	0.275	0.254	0.182	0.332	0.194	0.997	0.874
	4 quarter	0.568	0.938	1.011	0.885	1.045	0.961	0.978	1.028
		0.012	0.090	0.539	0.095	0.788	0.512	0.717	0.573
	20 quarter	0.040	0.753	1.019	0.870	1.025	0.665	0.874	1.105
		0.003	0.213	0.310	0.125	0.305	0.027	0.234	0.777
FD	1 quarter	0.848	1.102	0.515		1.114		1.159	
		0.201	0.363	0.329		0.289		0.401	
	4 quarter	0.911	1.392	0.554		1.041		1.078	
		0.071	0.226	0.250		0.697		0.999	
	20 quarter	1.085	1.579	0.141		1.035		0.760	
		0.440	0.306	0.284		0.568		0.891	
Panel E: EU/\$									
ECM	1 quarter	0.876	0.979	0.905	0.986	0.996	0.960	0.985	0.949
		0.188	0.722	0.743	0.401	0.480	0.660	0.680	0.903
	4 quarter	0.558	1.043	1.072	0.946	1.142	1.153	0.849	1.276
		0.008	0.023	0.042	0.157	0.030	0.031	0.288	0.052
	20 quarter	0.310	1.253	1.205	0.945	1.169	1.897	1.308	1.431
		0.008	0.000	0.000	0.050	0.000	0.000	0.000	0.000
FD	1 quarter	0.994	1.197	1.341		1.079		1.589	
		0.669	0.096	0.211		0.283		0.053	
	4 quarter	1.101	1.269	6.023		1.201		1.202	
		0.009	0.017	0.027		0.005		0.200	
	20 quarter	1.476	2.020	11.974		1.582		3.391	
		0.000	0.000	0.001		0.000		0.053	

Best Performance by MSE



Monetary Model augmented/not



Additional Findings

- Real interest differential model does not do particularly well in Period III (best Period I)
- VIX/TED: Helps relative to unaugmented but not necessarily best
- Hard to fit a standard model to euro/dollar
- Taylor rule model does not do particularly well either
- Contrast to conclusion in Rossi (*JEL*, 2013):
“Predictability is most apparent when one or more of the following hold: the predictors are Taylor rule or net foreign assets, the model is linear, and a small number of parameters are estimated.”

Direction of Change

- DoC results more positive, with 128 out of 426 outperformance (30% at 10% MSL)
- Predictability greatest using ECM
- And at long horizons (58 out 128)
- DoC works only for IRP at long horizons

Table 2: Direction of change statistics from the dollar-based exchange rates

Specification	Horizon	Sample 1: 1983q1-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel A: CAN\$/S									
ECM	1 quarter	0.656	0.531	0.523	0.461	0.539	0.594		
		0.000	0.480	0.596	0.377	0.377	0.034		
	4 quarter	0.664	0.680	0.592	0.480	0.568	0.632		
		0.000	0.000	0.040	0.655	0.128	0.003		
	20 quarter	0.624	0.661	0.569	0.578	0.624	0.578		
		0.010	0.001	0.151	0.103	0.010	0.103		
FD	1 quarter	0.547	0.531	0.664		0.453			
		0.289	0.480	0.000		0.289			
	4 quarter	0.504	0.584	0.784		0.496			
		0.929	0.060	0.000		0.929			
	20 quarter	0.294	0.514	0.560		0.431			
		0.000	0.774	0.213		0.151			
Panel B: Yen/\$									
ECM	1 quarter	0.539	0.586		0.516	0.555	0.555		0.656
		0.377	0.052		0.724	0.216	0.216		0.000
	4 quarter	0.576	0.600		0.504	0.672	0.600		0.752
		0.089	0.025		0.929	0.000	0.025		0.000
	20 quarter	0.716	0.670		0.688	0.661	0.550		0.688
		0.000	0.000		0.000	0.001	0.292		0.000
FD	1 quarter	0.492	0.516			0.539			
		0.860	0.724			0.377			
	4 quarter	0.600	0.552			0.608			
		0.025	0.245			0.016			
	20 quarter	0.550	0.596			0.495			
		0.292	0.044			0.924			

Panel C: SF/\$

ECM	1 quarter	0.570	0.578	0.539	0.617
		0.112	0.077	0.377	0.008
	4 quarter	0.608	0.600	0.592	0.560
		0.016	0.025	0.040	0.180
FD	20 quarter	0.817	0.807	0.752	0.661
		0.000	0.000	0.000	0.001
	1 quarter	0.414	0.492	0.453	
		0.052	0.860	0.289	
FD	4 quarter	0.480	0.320	0.480	
		0.655	0.000	0.655	
	20 quarter	0.541	0.578	0.587	
		0.389	0.103	0.069	

Table 2: Direction of change statistics from the dollar-based exchange rates

Specification	Horizon	Sample 1: 1983q1-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel D: BP/\$									
ECM	1 quarter	0.539	0.531	0.492	0.484	0.578	0.555		0.547
		0.377	0.480	0.860	0.724	0.077	0.216		0.289
	4 quarter	0.680	0.600	0.488	0.480	0.536	0.608		0.576
		0.000	0.025	0.788	0.655	0.421	0.016		0.089
FD	20 quarter	0.844	0.532	0.339	0.615	0.349	0.486		0.578
		0.000	0.503	0.001	0.017	0.002	0.774		0.103
	1 quarter	0.445	0.477	0.664		0.492			
		0.216	0.596	0.000		0.860			
FD	4 quarter	0.480	0.488	0.584		0.472			
		0.655	0.788	0.060		0.531			
	20 quarter	0.422	0.495	0.606		0.303			
		0.103	0.924	0.028		0.000			

Table 2: Direction of change statistics from the dollar-based exchange rates

Specification	Horizon	Sample 2: 1987q2-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel A: CAN\$/S									
ECM	1 quarter	0.604	0.450	0.568	0.441	0.505	0.550		0.604
		0.029	0.296	0.155	0.217	0.924	0.296		0.029
	4 quarter	0.500	0.500	0.472	0.463	0.509	0.593		0.750
		1.000	1.000	0.564	0.441	0.847	0.054		0.000
	20 quarter	0.587	0.696	0.728	0.609	0.685	0.728		0.870
		0.095	0.000	0.000	0.037	0.000	0.000		0.000
FD	1 quarter	0.459	0.468	0.676		0.514			
		0.393	0.506	0.000		0.776			
	4 quarter	0.407	0.546	0.731		0.500			
		0.054	0.336	0.000		1.000			
	20 quarter	0.283	0.641	0.554		0.598			
		0.000	0.007	0.297		0.061			
Panel B: Yen/S									
ECM	1 quarter	0.532	0.541	0.631	0.505	0.559	0.532		0.604
		0.506	0.393	0.006	0.924	0.217	0.506		0.029
	4 quarter	0.537	0.546	0.676	0.463	0.602	0.565		0.713
		0.441	0.336	0.000	0.441	0.034	0.178		0.000
	20 quarter	0.663	0.576	0.728	0.630	0.630	0.630		0.522
		0.002	0.144	0.000	0.012	0.012	0.012		0.677
FD	1 quarter	0.450	0.450	0.595		0.514			
		0.296	0.296	0.046		0.776			
	4 quarter	0.528	0.426	0.528		0.500			
		0.564	0.124	0.564		1.000			
	20 quarter	0.598	0.511	0.717		0.554			
		0.061	0.835	0.000		0.297			

Panel C: SF/S					
ECM	1 quarter	0.586	0.550	0.523	0.586
		0.071	0.296	0.635	0.071
	4 quarter	0.611	0.556	0.537	0.528
		0.021	0.248	0.441	0.564
	20 quarter	0.696	0.630	0.739	0.717
		0.000	0.012	0.000	0.000
FD	1 quarter	0.432	0.514	0.477	
		0.155	0.776	0.635	
	4 quarter	0.519	0.389	0.509	
		0.700	0.021	0.847	
	20 quarter	0.685	0.489	0.717	
		0.000	0.835	0.000	

Table 2: Direction of change statistics from the dollar-based exchange rates

Specification	Horizon	Sample 2: 1987q2-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel D: BP/S									
ECM	1 quarter	0.468	0.505	0.586	0.523	0.613	0.523		0.514
		0.506	0.924	0.071	0.635	0.018	0.635		0.776
	4 quarter	0.546	0.556	0.556	0.519	0.528	0.574		0.528
		0.336	0.248	0.248	0.700	0.564	0.124		0.564
	20 quarter	0.772	0.467	0.576	0.652	0.554	0.478		0.457
		0.000	0.532	0.144	0.004	0.297	0.677		0.404
FD	1 quarter	0.505	0.523	0.622		0.495			
		0.924	0.635	0.010		0.924			
	4 quarter	0.454	0.565	0.704		0.454			
		0.336	0.178	0.000		0.336			
	20 quarter	0.435	0.565	0.598		0.272			
		0.211	0.211	0.061		0.000			

Table 2: Direction of change statistics from the dollar-based exchange rates

Specification	Horizon	Sample 3: 2007q4-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel A: CAN\$/									
ECM	1 quarter	0.517	0.448	0.517	0.483	0.414	0.586	0.483	0.586
		0.853	0.577	0.853	0.853	0.353	0.353	0.853	0.353
	4 quarter	0.731	0.423	0.385	0.692	0.308	0.808	0.423	0.423
		0.019	0.433	0.239	0.050	0.050	0.002	0.433	0.433
	20 quarter	0.600	0.500	0.600	0.500	0.500	0.600	0.600	0.600
		0.527	1.000	0.527	1.000	1.000	0.527	0.527	0.527
FD	1 quarter	0.586	0.448	0.759		0.448		0.655	
		0.353	0.577	0.005		0.577		0.095	
	4 quarter	0.462	0.462	0.769		0.231		0.538	
		0.695	0.695	0.006		0.006		0.695	
	20 quarter	0.400	0.400	0.700		0.400		0.600	
		0.527	0.527	0.206		0.527		0.527	
Panel B: Yen/									
ECM	1 quarter	0.655	0.621	0.552	0.586	0.517	0.483	0.655	0.552
		0.095	0.194	0.577	0.353	0.853	0.853	0.095	0.577
	4 quarter	0.731	0.577	0.692	0.615	0.654	0.462	0.923	0.577
		0.019	0.433	0.050	0.239	0.117	0.695	0.000	0.433
	20 quarter	0.500	0.500	0.500	0.500	0.500	0.600	0.600	0.500
		1.000	1.000	1.000	1.000	1.000	0.527	0.527	1.000
FD	1 quarter	0.586	0.379	0.793		0.483		0.448	
		0.353	0.194	0.002		0.853		0.577	
	4 quarter	0.769	0.500	0.846		0.577		0.615	
		0.006	1.000	0.000		0.433		0.239	
	20 quarter	0.500	0.500	0.500		0.500		0.200	
		1.000	1.000	1.000		1.000		0.058	
Panel C: SF/									
ECM	1 quarter	0.483	0.379	0.621	0.586	0.483	0.586	0.586	0.552
		0.853	0.194	0.194	0.353	0.853	0.353	0.353	0.577
	4 quarter	0.423	0.654	0.615	0.462	0.538	0.654	0.577	0.615
		0.433	0.117	0.239	0.695	0.695	0.117	0.433	0.239
	20 quarter	0.200	1.000	1.000	0.800	1.000	1.000	1.000	1.000
		0.058	0.002	0.002	0.058	0.002	0.002	0.002	0.002
FD	1 quarter	0.448	0.517	0.517		0.552		0.448	
		0.577	0.853	0.853		0.577		0.577	
	4 quarter	0.654	0.654	0.615		0.654		0.615	
		0.117	0.117	0.239		0.117		0.239	
	20 quarter	1.000	1.000	1.000		1.000		0.300	
		0.002	0.002	0.002		0.002		0.206	

Table 2: Direction of change statistics from the dollar-based exchange rates

Specification	Horizon	Sample 3: 2007q4-2014q4							
		PPP	SPMM	BEER	IRP	RID	TRF	SPMA	YCS
Panel D: BP/\$									
ECM	1 quarter	0.483	0.621	0.655	0.586	0.586	0.517	0.586	0.586
		0.853	0.194	0.095	0.353	0.353	0.853	0.353	0.353
	4 quarter	0.577	0.692	0.538	0.615	0.538	0.500	0.577	0.615
		0.433	0.050	0.695	0.239	0.695	1.000	0.433	0.239
	20 quarter	0.900	0.400	0.500	0.600	0.500	0.600	0.600	0.600
		0.011	0.527	1.000	0.527	1.000	0.527	0.527	0.527
FD	1 quarter	0.655	0.655	0.793		0.379		0.414	
		0.095	0.095	0.002		0.194		0.353	
	4 quarter	0.654	0.500	0.692		0.500		0.538	
		0.117	1.000	0.050		1.000		0.695	
	20 quarter	0.600	0.600	0.800		0.500		0.700	
		0.527	0.527	0.058		1.000		0.206	
Panel E: EU/\$									
ECM	1 quarter	0.655	0.448	0.517	0.552	0.414	0.483	0.483	0.517
		0.095	0.577	0.853	0.577	0.353	0.853	0.853	0.853
	4 quarter	0.769	0.462	0.577	0.538	0.423	0.538	0.577	0.500
		0.006	0.695	0.433	0.695	0.433	0.695	0.433	1.000
	20 quarter	0.900	0.100	0.100	0.800	0.100	0.100	0.100	0.100
		0.011	0.011	0.011	0.058	0.011	0.011	0.011	0.011
FD	1 quarter	0.414	0.379	0.414		0.379		0.483	
		0.353	0.194	0.353		0.194		0.853	
	4 quarter	0.423	0.462	0.500		0.423		0.500	
		0.433	0.695	1.000		0.433		1.000	
	20 quarter	0.100	0.100	0.100		0.100		0.400	
		0.011	0.011	0.011		0.011		0.527	

“Consistency”

- Many cases of cointegration: 261 (61.3%)
- Very few cases of unit elasticity: 5 (2% of cointegrated cases, 1% of total)
- Consistency criterion holds only in Period III

Conclusions

- Best model/spec./currency combinations do not carry over
- Error correction does best in outperformance at long horizons
- PPP is well represented in this group
- IRP too, although less well than in CCG-P (2005)

Recent Developments

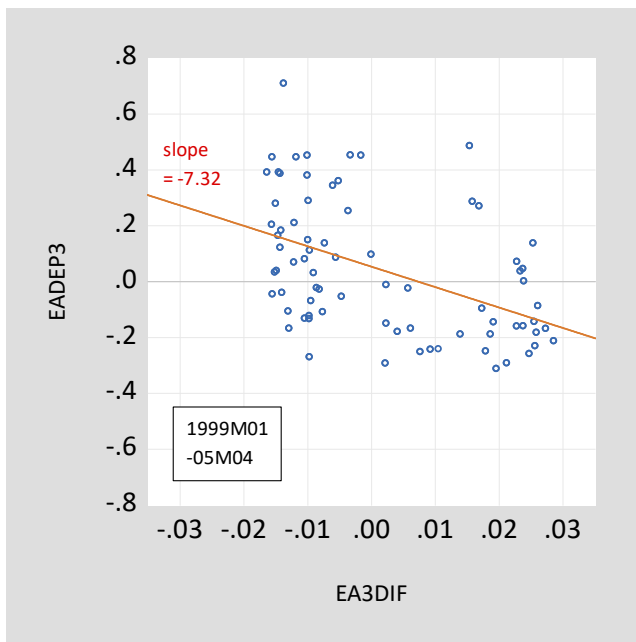
- Various papers focus on global risk variables being important.
- Engel and Wu (JIE, 2022) find exchange rate is persistent so long horizon results (e.g. 5 year changes) might be spurious. Other determinants are persistent (e.g., Treasury premium, SP500, GZ spread, 2s10s, etc.), so implied predictive power might also be spurious.

Uncovered Interest Parity

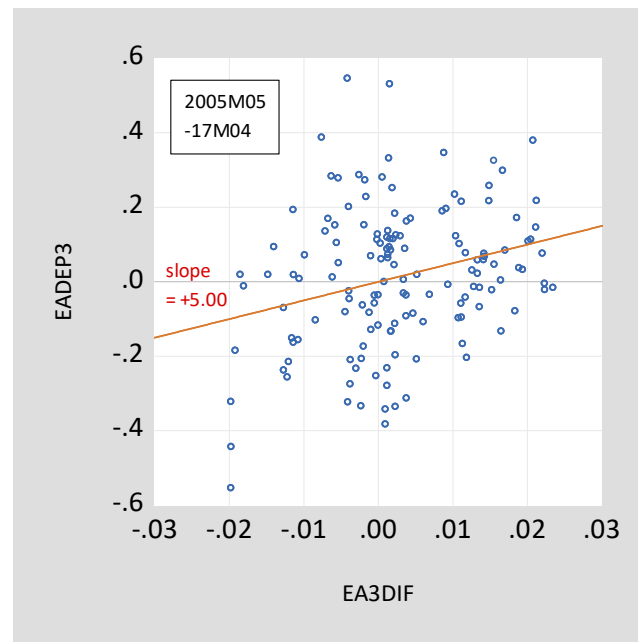
Are Euro Area & US Returns Equalized on Average?

$$S_{t+h} - S_t = (i_{h,t} - i_{h,t}^*) + u_{t+h}$$

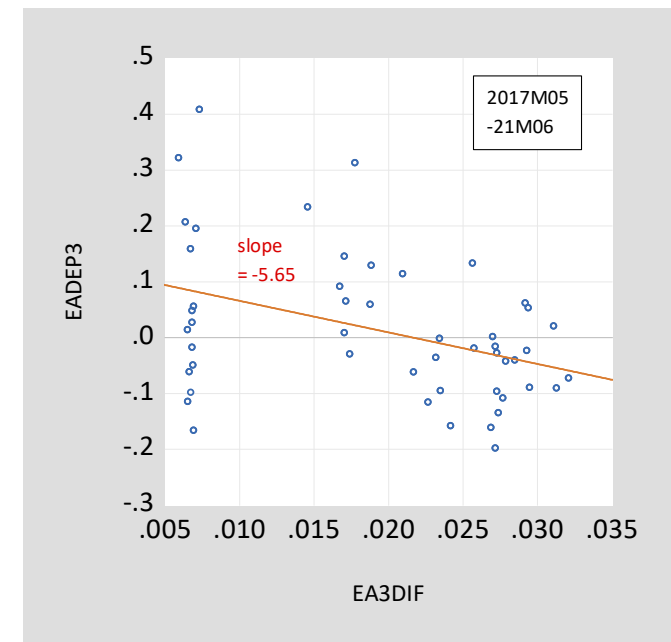
$$S_{t+h} - S_t = \alpha + \beta(i_{h,t} - i_{h,t}^*) + u_{t+h}$$



Early



Middle



Late

3 month ex post depreciation of USD against euro vs corresponding 1-year US-euro area yield differential

Outline

1. Uncovered interest parity (UIP) to Unbiasedness to Fama
2. Data
3. Fama regressions
4. Is It Risk? Is It Covered Interest Differentials?
5. Testing UIP using survey data
6. Reconciling the Results
7. Conclusions

1. UIP to Fama

UIP is a no arbitrage profits condition present in the main macro models accounting for exchange rates:

$$E_t^M [s_{t+h} - s_t] = (i_{h,t} - i_{h,t}^*)$$

- with:
- $s_{t+h} - s_t$ the depreciation of the reference currency with respect to the foreign currency from time t to time $t + h$
 - $i_{h,t}$ the interest rates of horizon h at time t of the reference country
 - $i_{h,t}^*$ the interest rates of horizon h at time t of the foreign country

UIP vs. Unbiasedness Hypothesis

In practice, we test UIP hypothesis through the Fama (1984) regression:

$$s_{t+h} - s_t = \alpha + \beta(i_{h,t} - i_{h,t}^*) + u_{t+h}$$

The OLS regression coefficient β :

$$\hat{\beta} = \frac{\text{Cov}(i_{h,t} - i_{h,t}^*, s_{t+h} - s_t)}{\text{Var}(i_{h,t} - i_{h,t}^*)}$$

Under the null of UIP (and rational expectations), the Fama coefficient is:

$$\beta = 1$$

The Fama Regression

Three key assumptions to go from Fama regression to UIP:

Covered Interest rate Parity : $f_{h,t} - s_t = (i_{h,t} - i_{h,t}^*) - \epsilon_{h,t}^{cip}$

Risk Premium: $f_{h,t} = E_t^M [s_{t+h}] + \epsilon_{h,t}^{rp}$

Rational Expectations:

$$s_{t+h} = E_t^M [s_{t+h}] - \epsilon_{t+h}^f$$

2. Data

- We take the US as domestic country from 1999 to 2021M09 (since we look at up to one year ahead exchange rate changes, interest rate sample is 1999M01-2020M09 for ex post exchange rate changes)
- We consider bilateral nominal exchange rates of 8 advanced economies (Canada, Switzerland, Japan, Denmark, Norway, Sweden, UK and the euro area as a whole)
- We take off-shore 1-year and 3-month interest rates (to reduce political risk)
- We use expectations at 1 year and 3 months of exchange rates drawn from Consensus Forecasts from 2003 to 2021M09

Data: Interest Rates

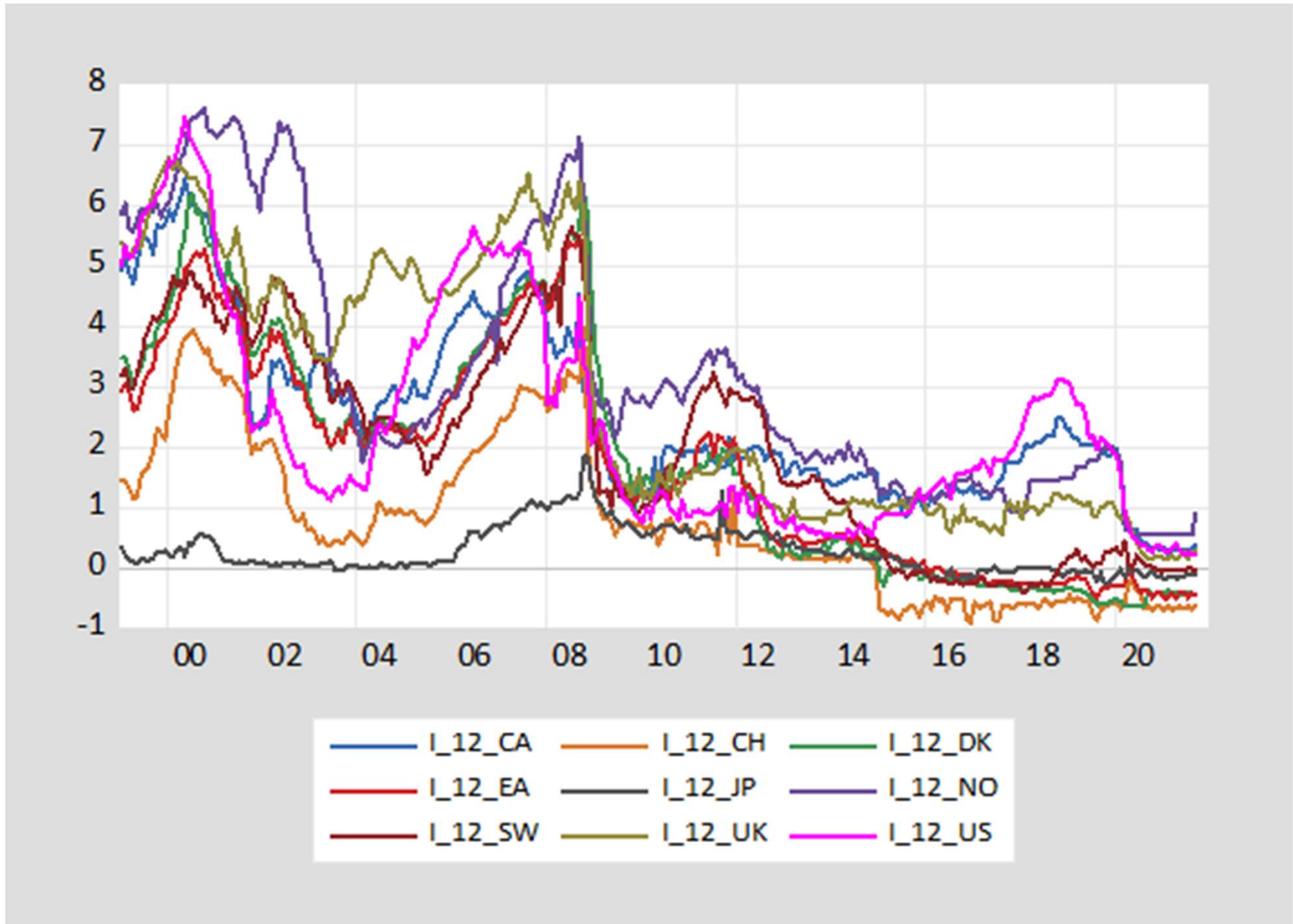


Figure 1: Interest Rates on 1Y-Eurocurrency Deposits

Data: Interest Differentials

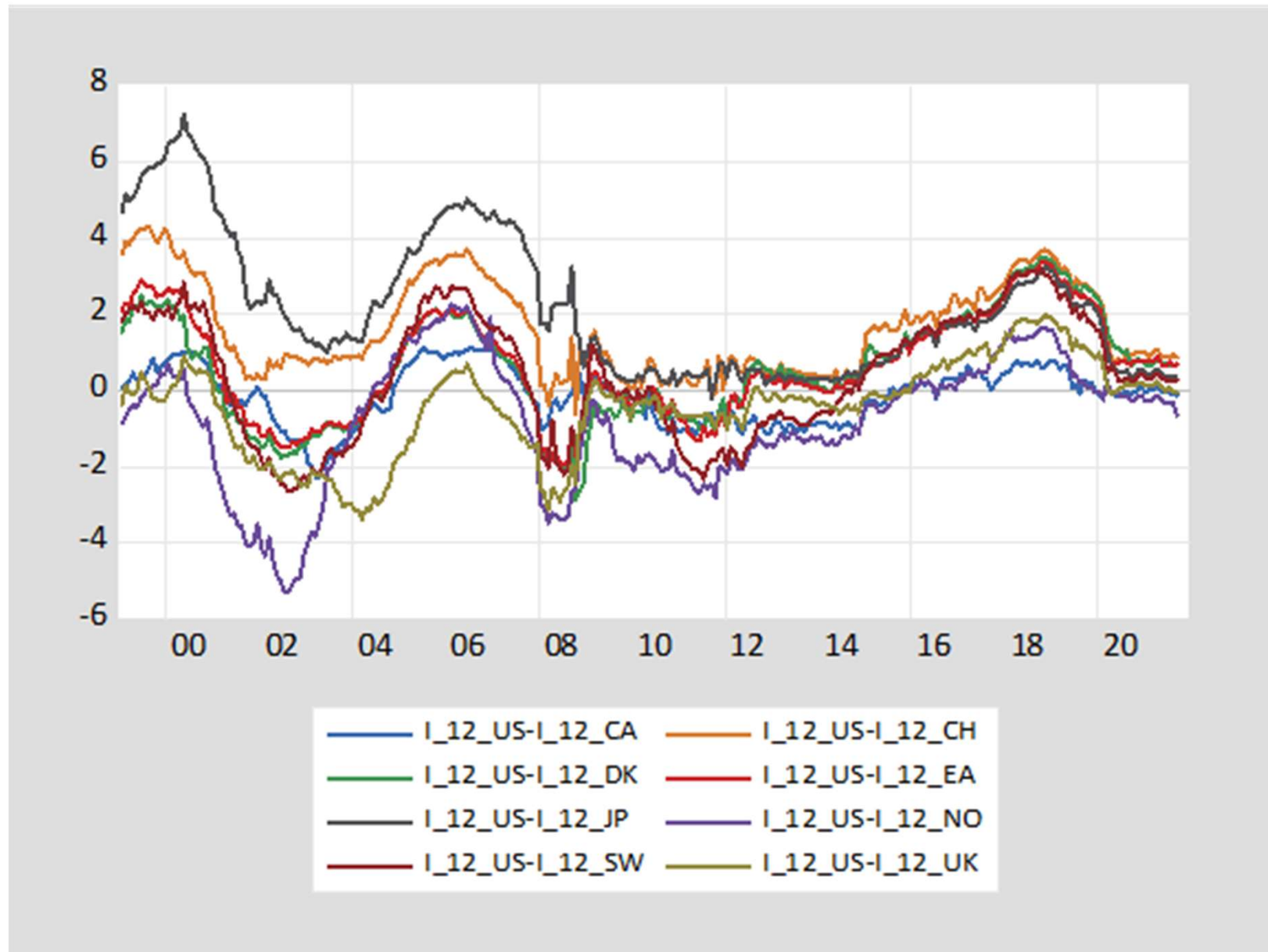


Figure 2: 1Y-Eurocurrency Deposit Rates Differential (US Dollar minus Foreign Currency)

Data: Ex post Depreciations

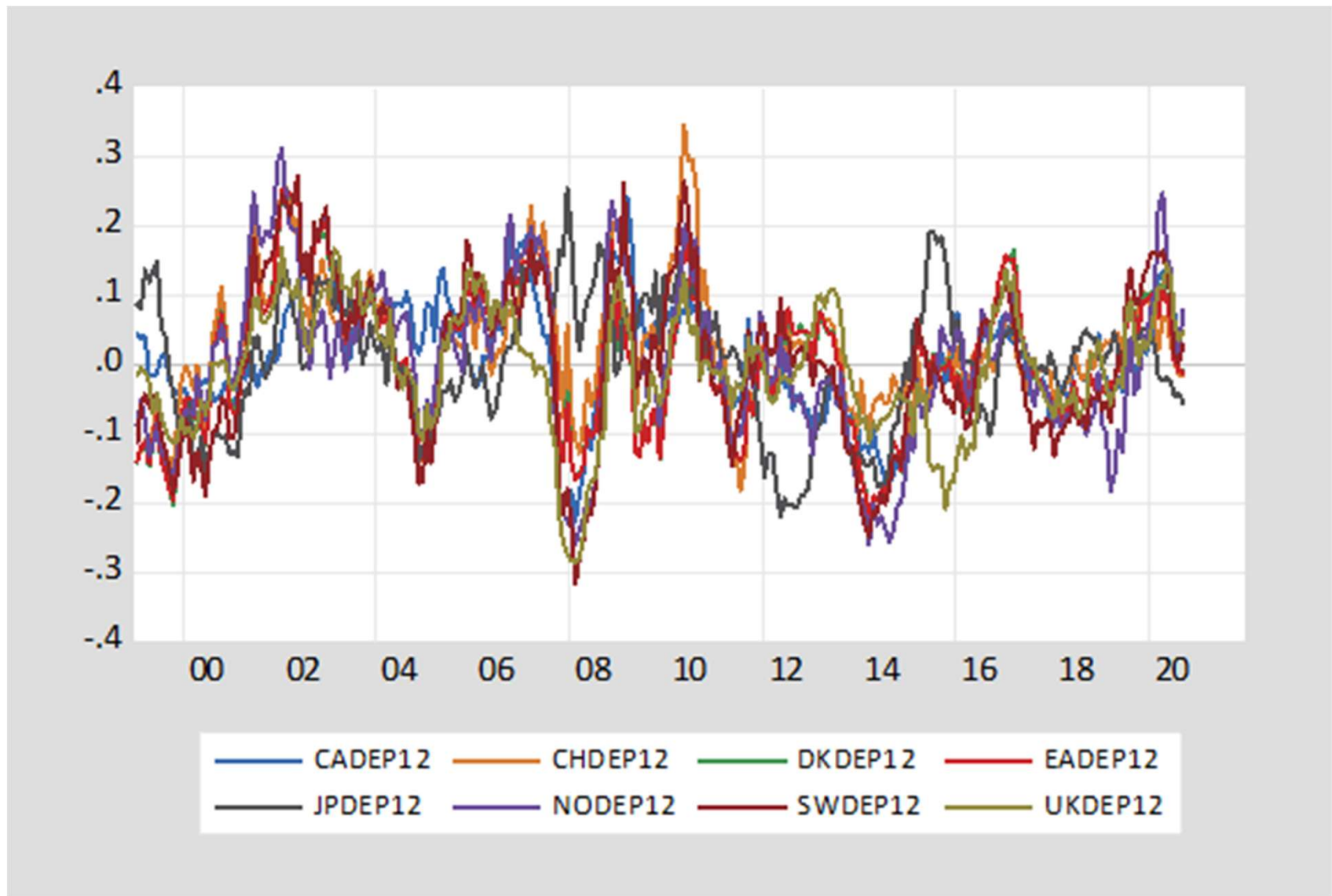
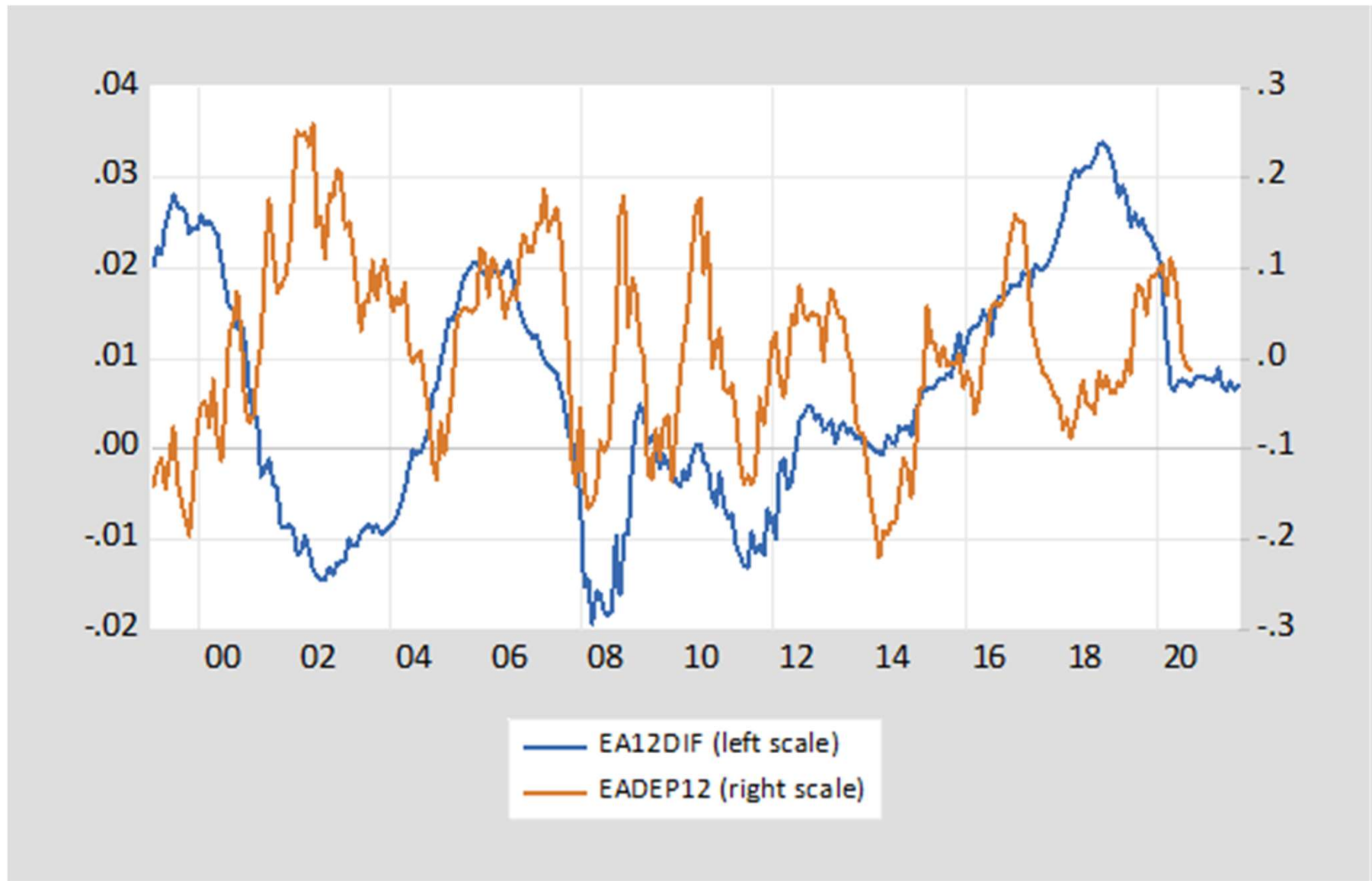


Figure 3: 1Y-Ex-Post Depreciation Rate of the US Dollar w.r.t. Foreign Currency (Positive values indicate depreciations)

Example: EUR/USD



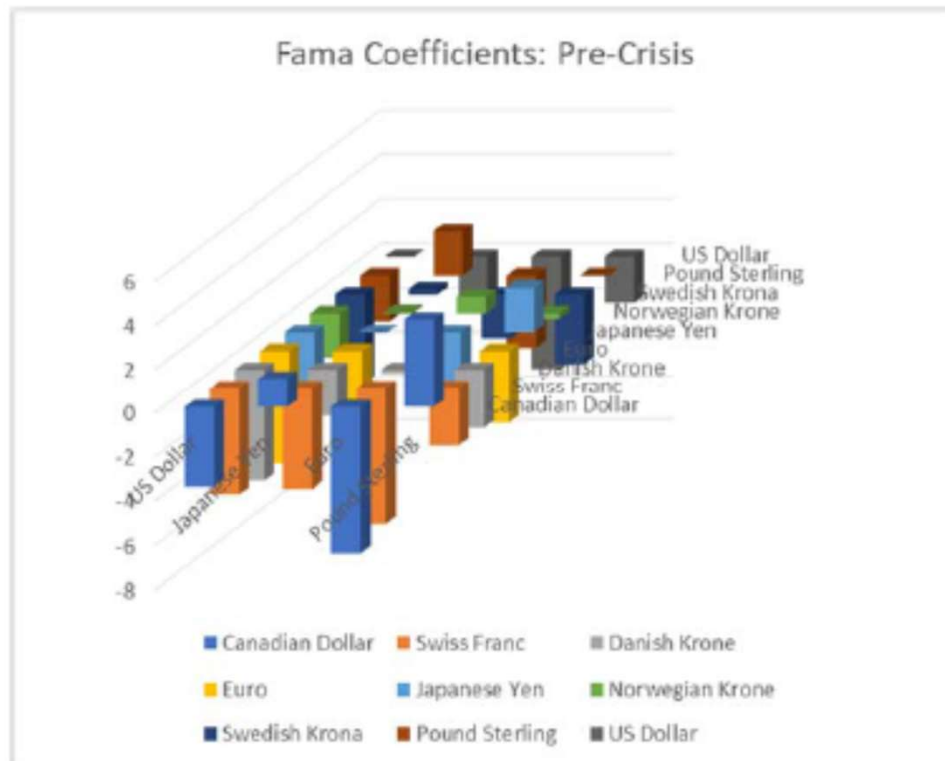
3. Fama Regressions

Table 1: Fama Regression Results

A: Full								
coefficient	CAD	CHE	DKR	EUR	JPY	NKR	SKR	GBP
constant	0.012	0.051	0.017	0.017	0.008	-0.002	0.011	-0.004
	0.010	0.021	0.015	0.016	0.022	0.014	0.017	0.010
beta	1.310	-1.420***	-1.045***	-1.019***	-0.058	-0.583	-1.084***	-0.108
	1.588	0.872	0.909	0.988	0.755	0.944	0.942	1.109
adj.R sq.	0.010	0.036	0.018	0.015	-0.004	0.003	0.018	-0.004
F-statistic	3.606	10.684	5.699	4.947	0.033	1.737	5.815	0.054
N	261	261	261	261	261	261	261	261

Let's break up into subsamples. Previously, used arbitrary break of the beginning of the Global Financial Crisis. This version, use Bai-Perron structural break test

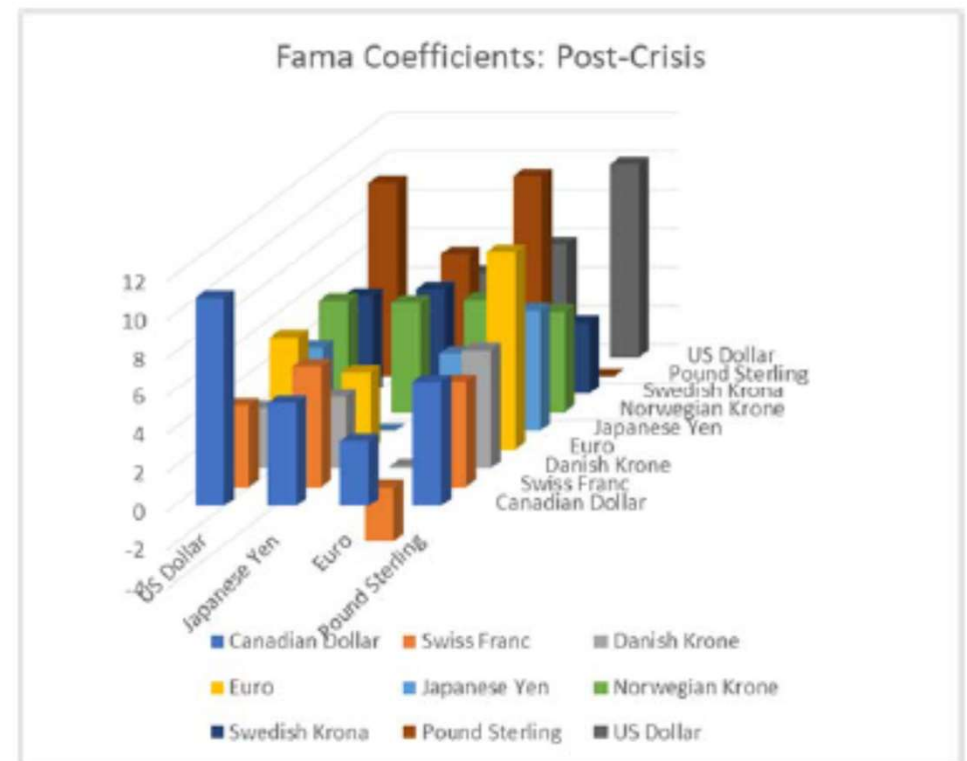
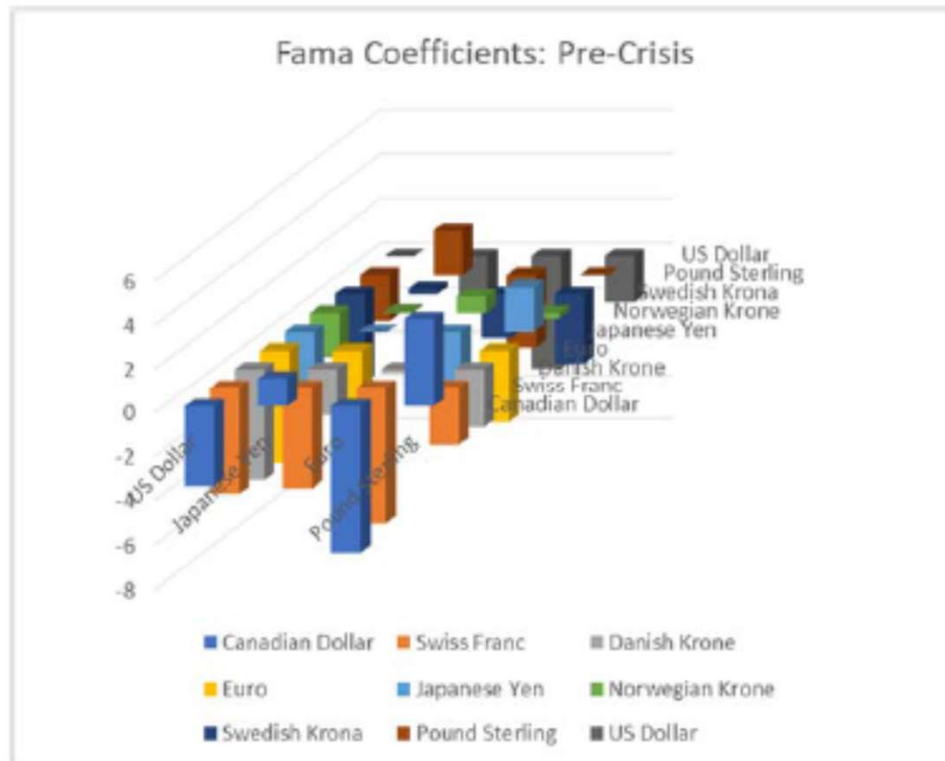
Are the Fama Puzzle and New Fama Puzzle a USD Phenomenon? No



Pre: 1999M01-2006M08

Post: 2006M09-2016M02

Are the Fama Puzzle and New Fama Puzzle a USD Phenomenon? No



Pre: 1999M01-2006M08

Post: 2006M09-2016M02

Are the Fama Puzzle and New Fama Puzzle a USD Phenomenon? No

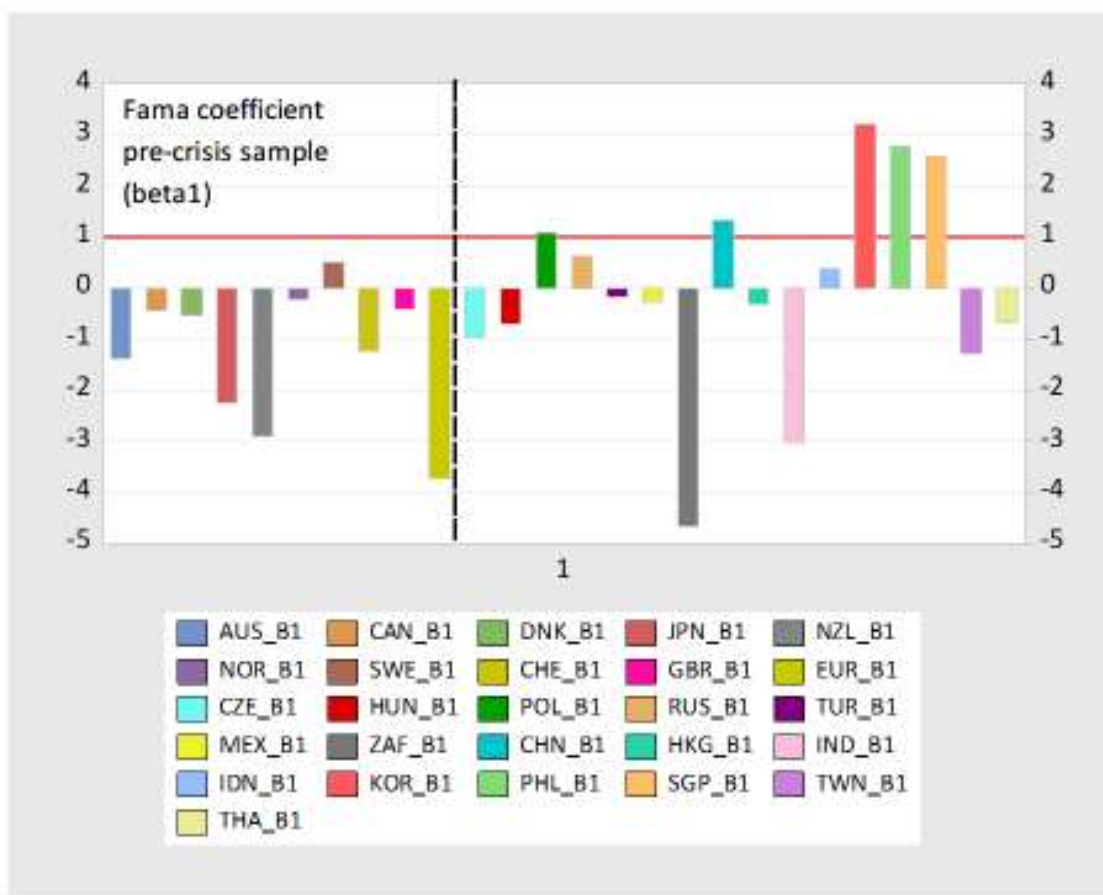
Appendix Table 1: Estimated Fama Coefficients for the Various Sub-samples for Selected Base Currencies (12 month horizon)

A: Full									
	USD	CAD	CHE	DKR	EUR	JPY	NKR	SKR	GBP
USD		1.310	-1.420	-1.045	-1.019	-0.058	-0.583	-1.084	-0.108
JPY	-0.058	-0.065	-0.911	-0.047	-0.160		-0.146	-0.023	0.725
EUR	-1.019	-0.421	-2.294	0.138		-0.160	1.744	-0.572	0.828
GBP	-0.108	3.122	-0.117	0.612	0.828	0.725	0.960	0.123	

B: Early									
	USD	CAD	CHE	DKR	EUR	JPY	NKR	SKR	GBP
USD		-3.793	-4.888	-5.180	-5.213	-2.419	-2.158	-4.141	-2.136
JPY	-2.419	1.404	-4.260	-1.800	-3.086		0.004	0.261	1.921
EUR	-5.213	-6.628	-6.917	-0.141		-3.086	0.772	-1.908	-3.542
GBP	-2.136	4.262	-2.851	-2.908	-3.542	1.921	-0.398	-3.424	

Digression: But They *Are* a Developed Country Phenomenon

Fama Regression: Pre-Crisis

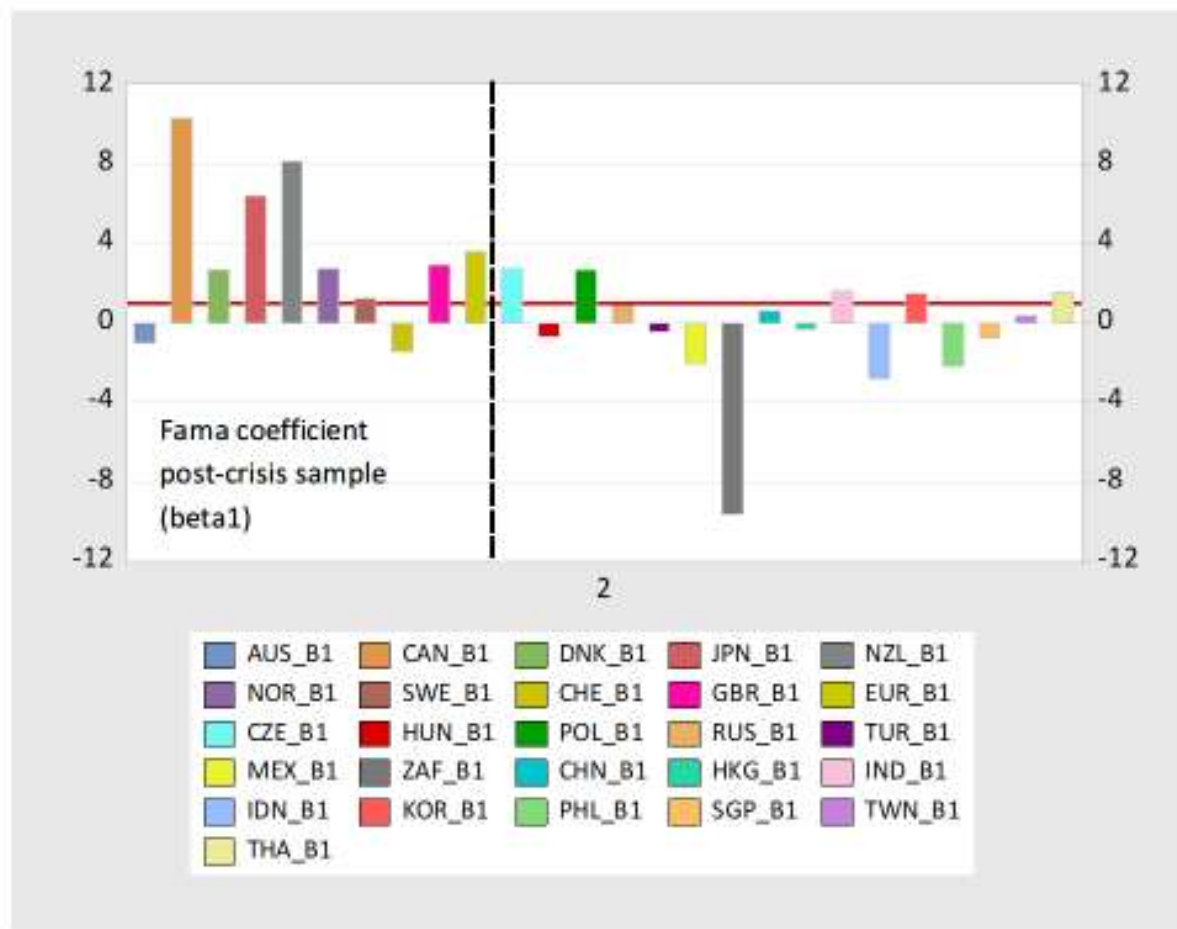


Three month Fama coefficient, 1986M08-2008M05; from Chinn & Frankel (2020)

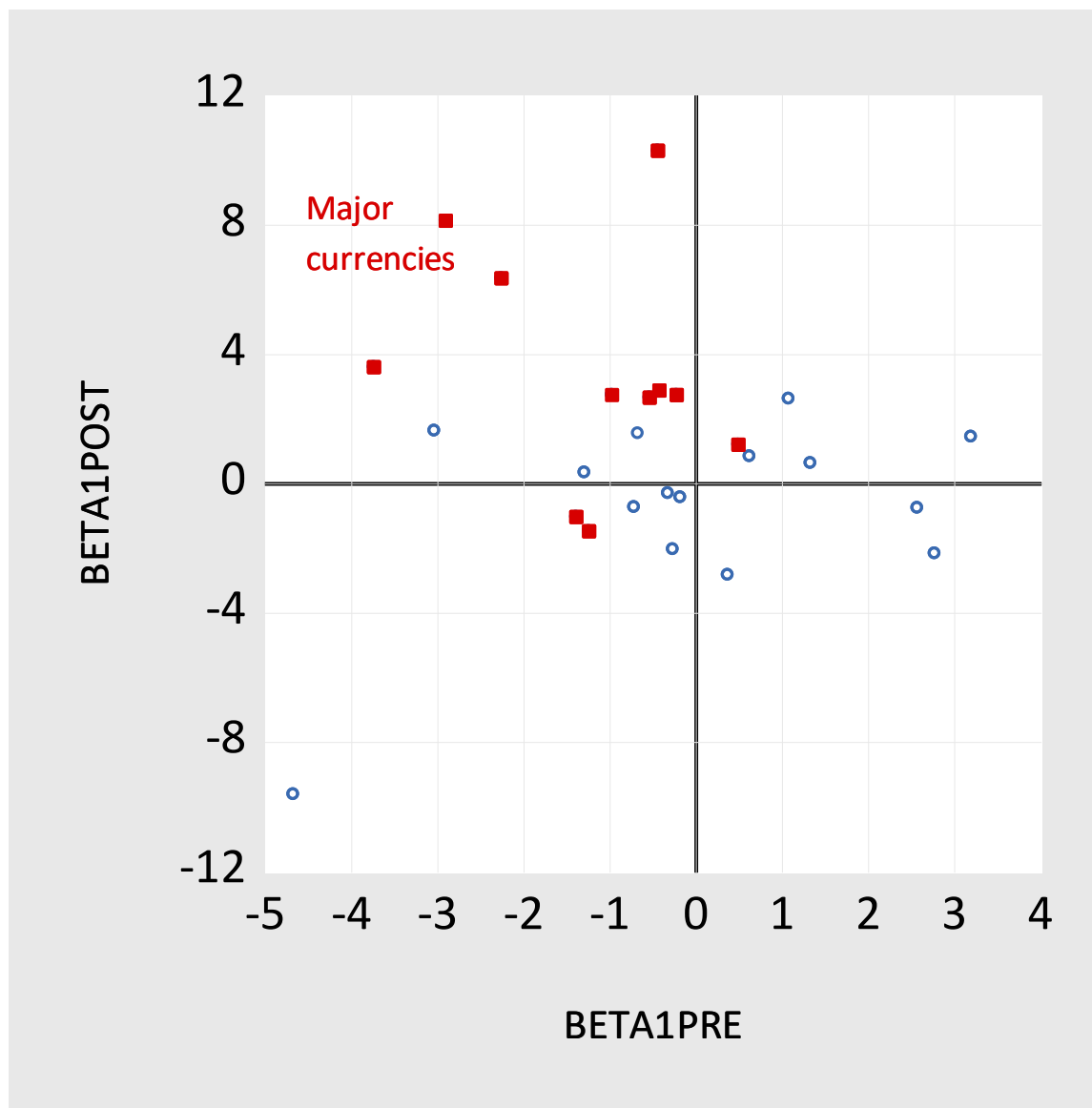
Digression: But They Are a Developed Country Phenomenon

Fama Regression: Post-Crisis

Three month Fama coefficient, 2008M09-2017M05; from Chinn & Frankel (2020)



Pre- & Post- Fama Coefficients

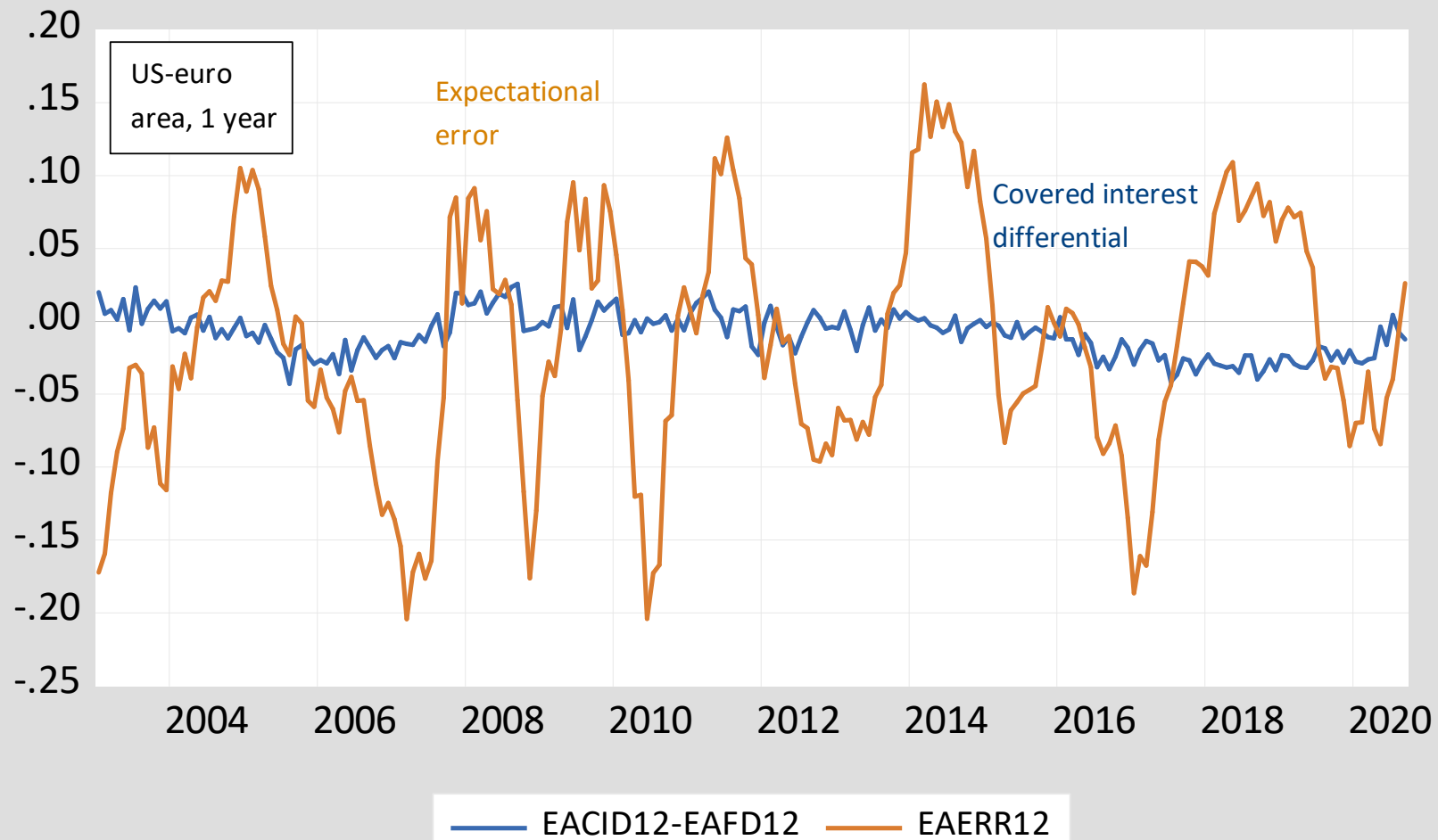


Three month Fama coefficient, Pre=1986M08-2008M05, Post=2008M09-2018M02;
from Chinn & Frankel (2020)

4. Is It Covered Interest Differentials?

- Textbook describes CIP deviations as near zero
- Since the crisis, CIP deviations have grown, initially due to default risk during GFC (Baba & Packer; Coffey, Hrungrung & Sarkar)
- Subsequently due to liquidity issues (Borio, McCauley, McGuire & Sushko; Du, Tepper & Verdelhan)

4. Is It Covered Interest Differentials?



5. Testing of UIP with Survey Data

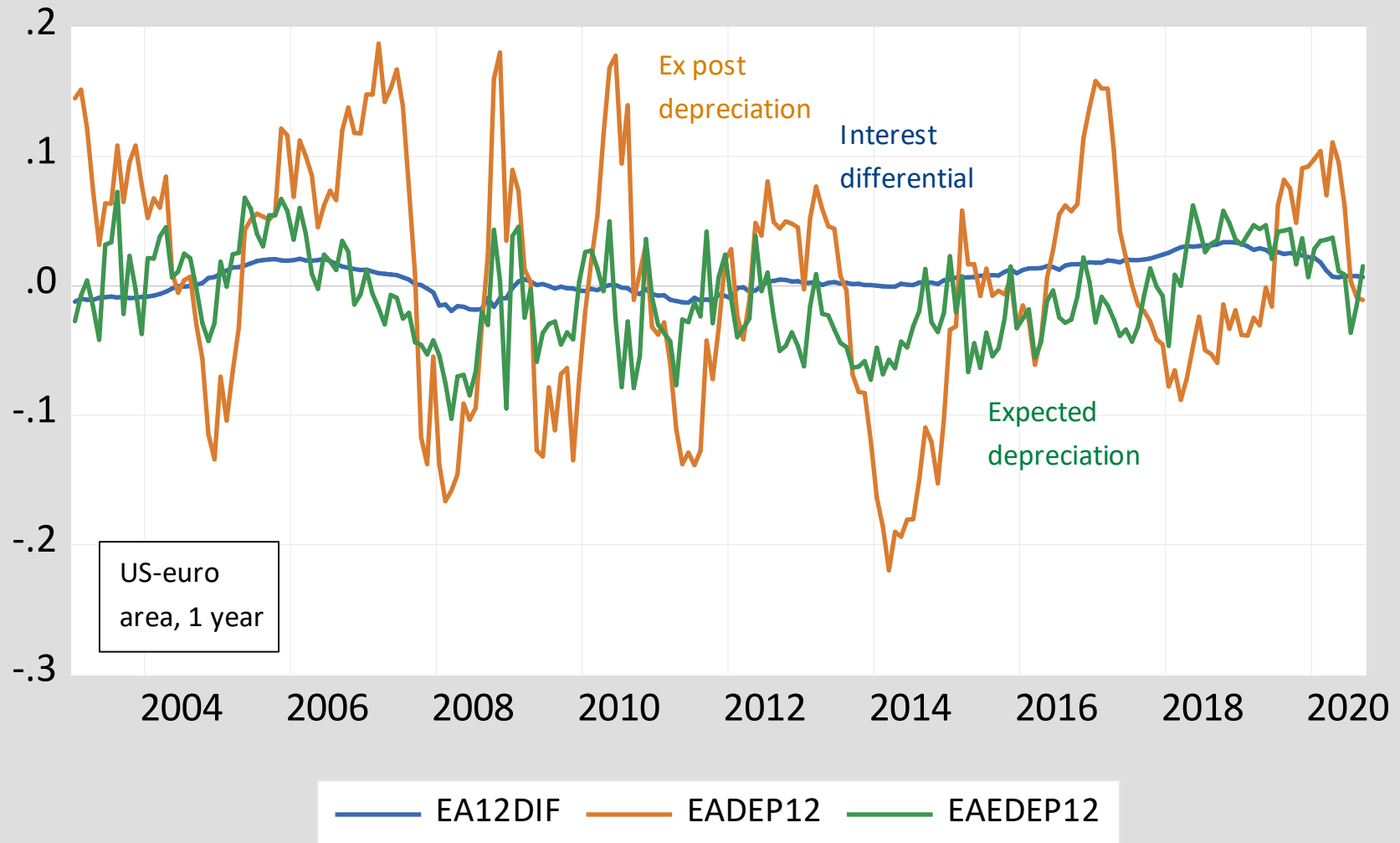
We assume the survey-based measure from Consensus Forecasts equal market's expectations up to an error term:

$$\hat{s}_{t+h}^M = E_t^M [s_{t+h}] - \epsilon_{t+h}^{Mf}$$

This leads to the following regression from 2003M04 to 2018M06:

$$\hat{s}_{t+h}^M - s_t = \alpha' + \beta'(i_{h,t} - i_{h,t}^*) + u'_{t+h}$$

Ex Post vs. Ex Ante Depreciation



Results: Direct Testing of UIP

Table 3: Uncovered Interest Parity Regressions

A: Full

coefficient	CAD	CHE	DKR	EUR	JPY	NKR	SKR	GBP
constant	0.000	-0.054	-0.016	-0.017	-0.057	0.033	0.020	0.000
	0.003	0.007	0.005	0.005	0.007	0.004	0.005	0.004
beta	0.283	2.360***	1.188	1.377	2.987***	1.653***	1.374	0.880
	0.328	0.373	0.290	0.293	0.240	0.258	0.294	0.338
adj.R sq.	0.000	0.349	0.185	0.217	0.597	0.278	0.206	0.088
F-statistic	0.095	114.882	49.056	59.923	314.866	82.706	55.860	21.520
N	213	213	213	213	213	213	213	213

Results: Direct Testing of UIP

2003M01–
2005M04

B: Early

coefficient	CAD	CHE	DKR	EUR	JPY	NKR	SKR	GBP
constant	-0.002 0.005	-0.008 0.014	0.013 0.006	0.012 0.006	-0.019 0.014	0.026 0.006	0.047 0.008	0.005 0.007
beta	-0.394** 0.309	1.845 0.510	1.141 0.383	1.105 0.389	2.374*** 0.347	1.168 0.251	0.724 0.340	0.465 0.316
adj.R sq.	0.012	0.307	0.199	0.183	0.618	0.268	0.087	0.044
F-statistic	10.720	3.691	2.832	2.613	26.769	10.446	19.421	7.264
N	44	44	44	44	44	44	44	44

2005M05 –
20017M04

C: Middle

coefficient	CAD	CHE	DKR	EUR	JPY	NKR	SKR	GBP
constant	-0.004 0.005	-0.062 0.007	-0.027 0.004	-0.027 0.004	-0.062 0.008	0.026 0.005	0.008 0.005	-0.011 0.005
beta	0.119 0.543	2.164*** 0.485	0.386* 0.360	0.673 0.378	2.797*** 0.357	1.352 0.364	0.937 0.318	0.401 0.580
adj.R sq.	-0.007	0.260	0.012	0.042	0.505	0.150	0.082	0.003
F-statistic	1.350	67.941	49.716	40.936	36.395	16.478	1.266	2.304
N	137	137	137	137	137	137	137	137

2017M05 –
2020M09

D: Late

coefficient	CAD	CHE	DKR	EUR	JPY	NKR	SKR	GBP
constant	0.011 0.005	-0.008 0.013	-0.011 0.013	-0.002 0.013	0.006 0.007	0.060 0.012	0.002 0.013	0.020 0.012
beta	2.450* 0.735	0.416 0.441	1.536 0.445	1.293 0.457	0.437* 0.333	1.906 0.984	2.961*** 0.499	1.346 0.817
adj.R sq.	0.191	0.019	0.344	0.311	0.013	0.090	0.579	0.076
F-statistic	33.856	28.892	7.474	2.822	1.641	67.109	109.359	8.058
N	32	32	32	32	32	32	32	32

5. Reconciling the Results

$$s_{t+h} - s_t = \alpha + \beta(i_{h,t} - i_{h,t}^*) + u_{t+h}$$

The limit, as t goes to infinity, of the Fama Coefficient is given by:

$$plim(\hat{\beta})$$

Political / Liquidity
risk: ←

$$= 1 - \frac{Cov(i_{h,t} - i_{h,t}^*, \epsilon_{h,t}^{cip})}{Var(i_{h,t} - i_{h,t}^*)}$$

Risk Premium: ←

$$- \frac{Cov(i_{h,t} - i_{h,t}^*, \epsilon_{h,t}^{rp})}{Var(i_{h,t} - i_{h,t}^*)}$$

Forecasts error: ←

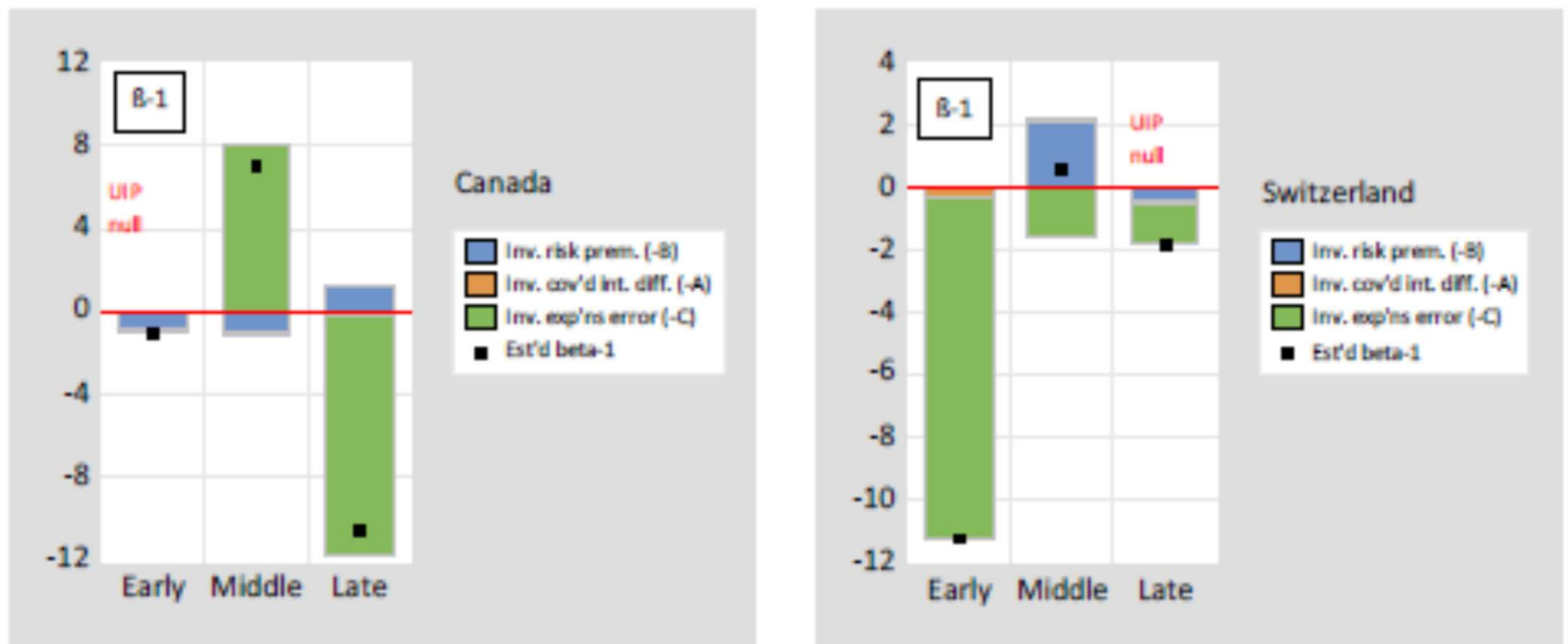
$$- \frac{Cov(i_{h,t} - i_{h,t}^*, \epsilon_{t+h}^f)}{Var(i_{h,t} - i_{h,t}^*)}$$

Deviations from $\beta=1$

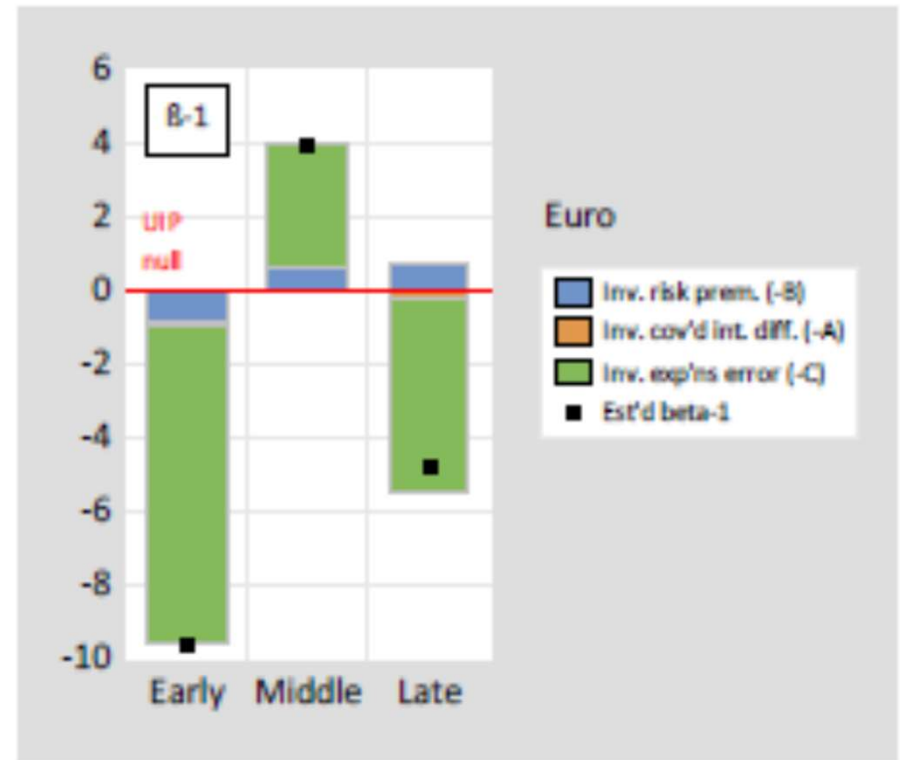
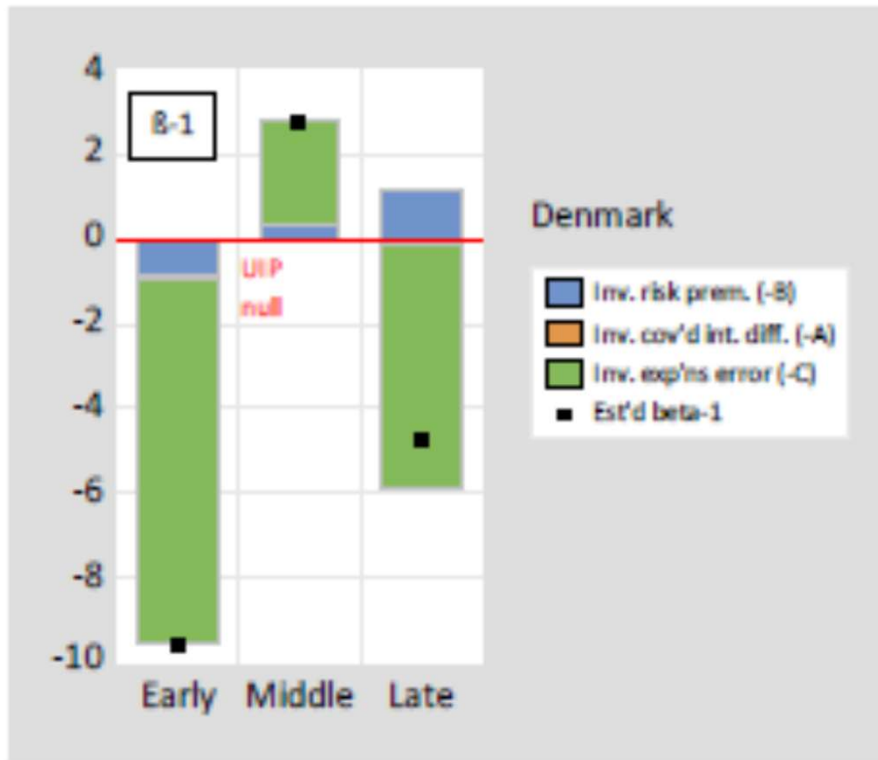
$$plim(\hat{\beta}) = 1 - \underbrace{\frac{Cov(i_{h,t} - i_{h,t}^*, \epsilon_{h,t}^{cip})}{Var(i_{h,t} - i_{h,t}^*)}}_A - \underbrace{\frac{Cov(i_{h,t} - i_{h,t}^*, \epsilon_{h,t}^{rp})}{Var(i_{h,t} - i_{h,t}^*)}}_B - \underbrace{\frac{Cov(i_{h,t} - i_{h,t}^*, \epsilon_{t+h}^f)}{Var(i_{h,t} - i_{h,t}^*)}}_C,$$

Reconciling the Results

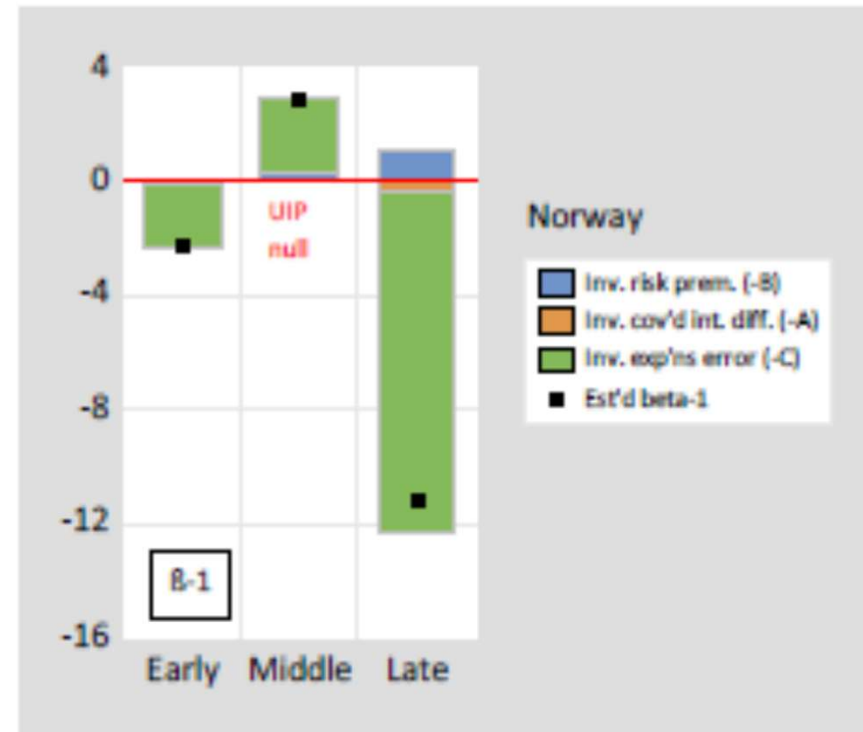
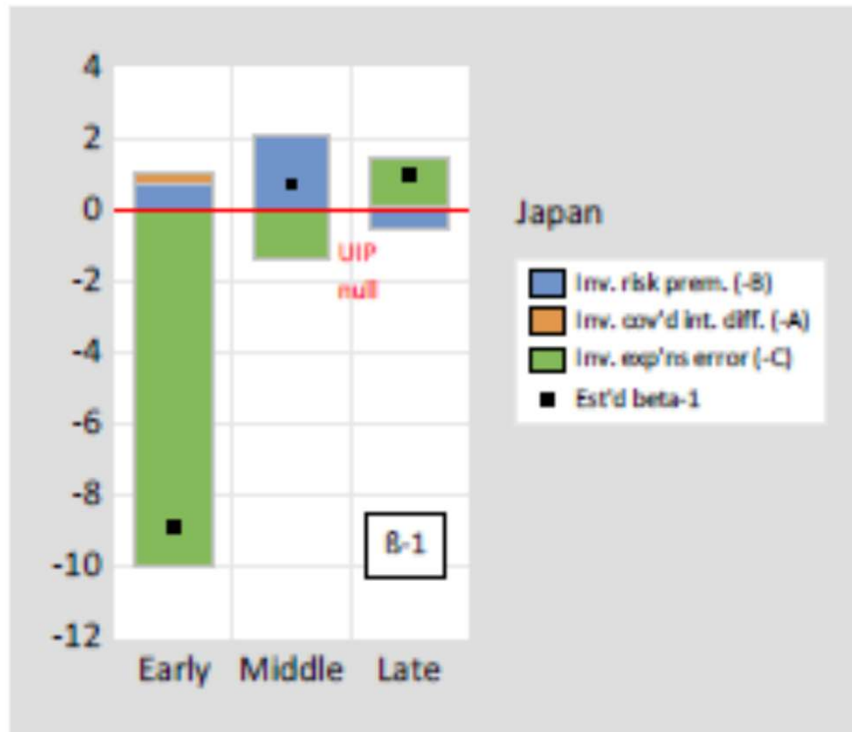
Figure 8: Estimates of Beta from a 1 Year horizon Fama Regression for Early, Middle, and Late Periods



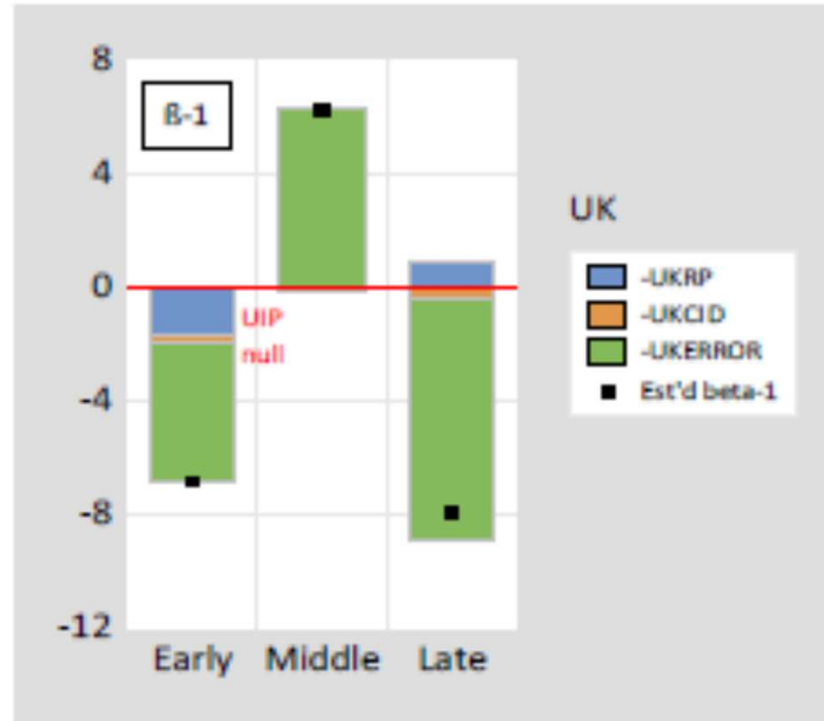
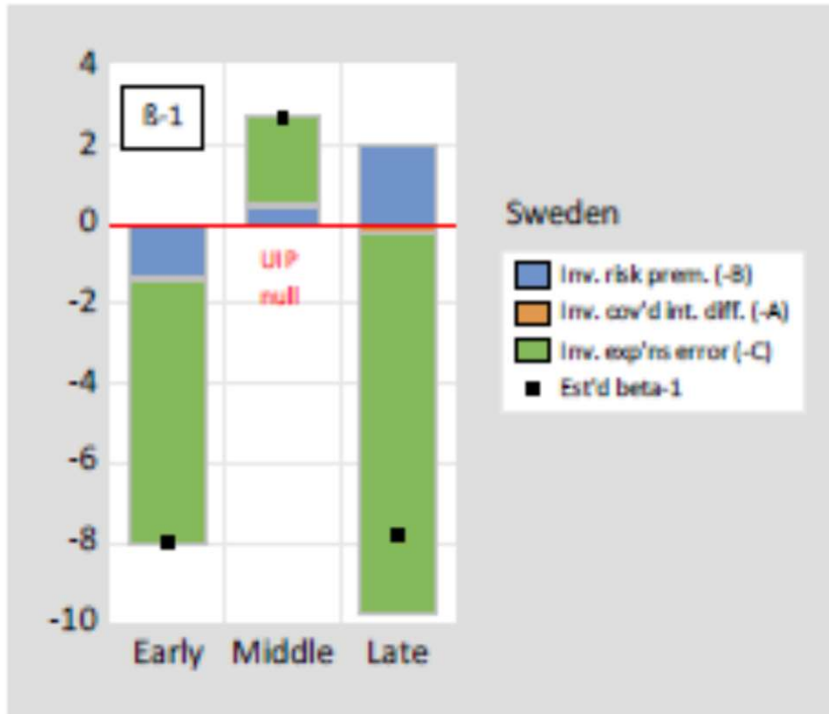
Reconciling the Results



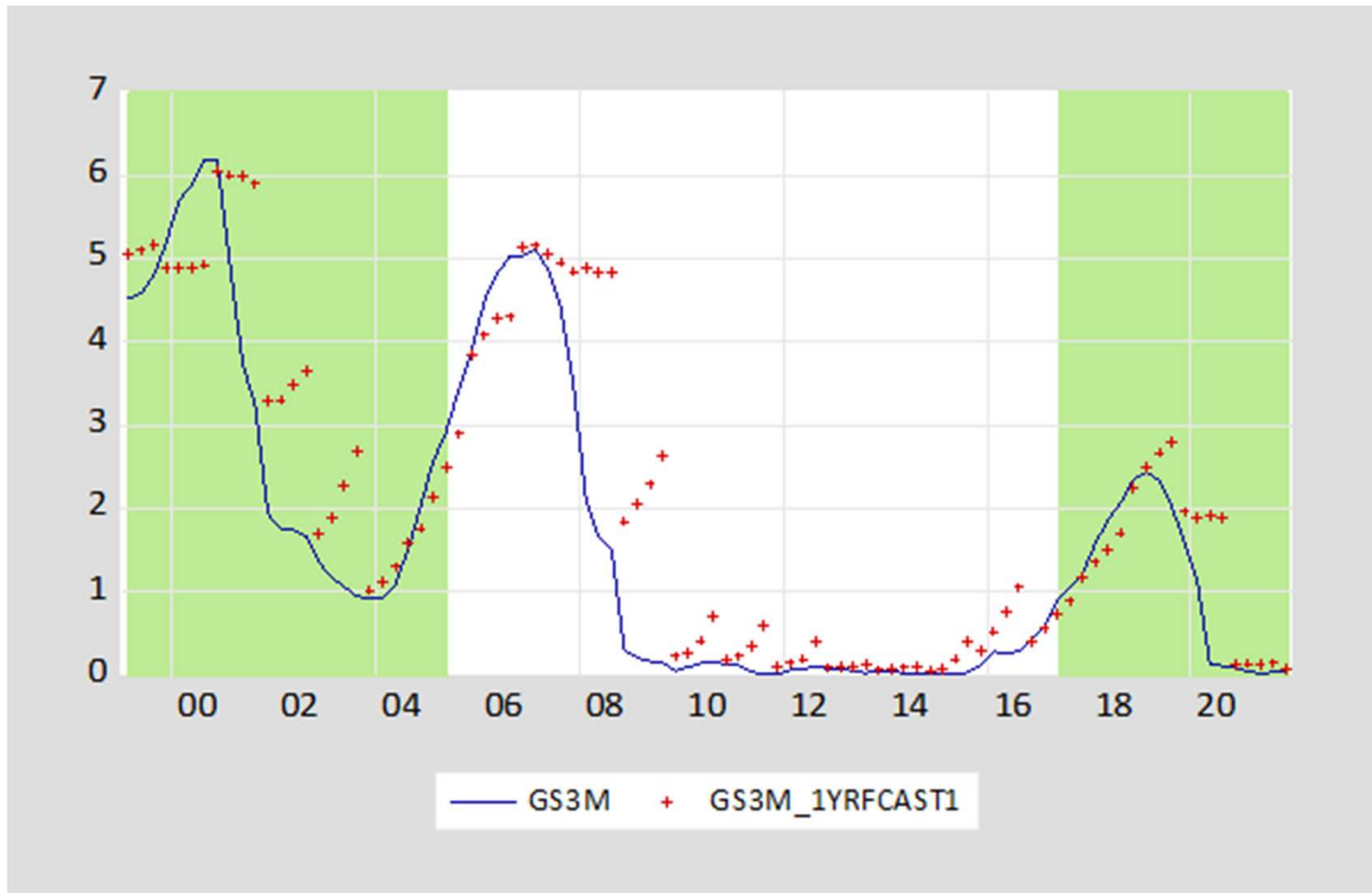
Reconciling the Results



Reconciling the Results



Dollar Turns Out Weaker than Expected, as Interest Rates Rise Less than Expected



6. Conclusions

- We find evidence of breaks in the relationship between ex-post depreciation and interest rate differentials around GFC and post-liftoff: switch from negative to large positive and then negative Fama coefficients = the new Fama puzzle
- Global risk aversion (as measured by VIX) does not help in explaining the Fama puzzle
- UIP seems to hold more generally when using survey data suggesting investors rely on this condition

6. Conclusions

- Presence of forward premium puzzle appears to be driven more by expectational errors than by risk or by covered interest deviations.

Additional Slides

Three Month Results

