Monetary Policy and the Predictability of Nominal Exchange Rates

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Introduction

- Two facts about countries with floating exchange rates where monetary policy follows a Taylor-type rule:

  1. *RER* is highly negatively correlated with future changes in *NER* at horizons greater than two years.
     - Correlation is stronger the longer is the horizon.
  2. *RER* is virtually uncorrelated with future inflation rates at all horizons.

- Relative PPP is re-established via changes in the *NER*, not via changes in prices.
  - When a country's consumption basket is relatively expensive, its *NER* eventually depreciates by enough to move the *RER* back to its long-run level

Introduction

- Redo our analysis for
  - China which is on a quasi-fixed exchange rate regime versus the U.S. dollar,
  - Hong Kong which has a fixed exchange rate versus the U.S. dollar,
  - Euro area countries which have fixed exchange rates with each other.
- Current *RER* is highly correlated with future relative inflation rates.
- *RER* adjusts overwhelmingly through prices.

Introduction

- We develop two-country models that can account for our observations about flexible exchange rate regimes.
- Key model features:
  - Taylor rules for monetary policy.
  - Home bias in consumption.

Introduction

- Our results hold whether
  - Prices are flexible or sticky;
  - Markets are complete or incomplete;
  - Internal persistence from habit formation and interest-rate smoothing, or not;
  - Capital is an input to production, or not.

- Results also hold in presence of interest rate spread shocks which invalidate UIP.

- Use sequence of models to develop intuition about key mechanisms underlying our explanation of the facts.

Introduction

- Is our proposed explanation consistent with other features of the data stressed in literature?
  - RER and NER co-move closely in the short run (Mussa (1986)).
  - RERs are highly inertial (Rogoff (1996)).
  - Conventional tests reject UIP.

- We show that a medium-size DSGE version of our model with nominal rigidities is consistent with
  - those features of the data, and
  - the *quantitative* relationship between current *RER* and future changes in inflation and the *NER*.

- Sequel to paper: out-of-sample forecasting properties of our model.

NER regression

- Define the *RER* as:

$$RER_t = \frac{NER_t P_t^*}{P_t}$$

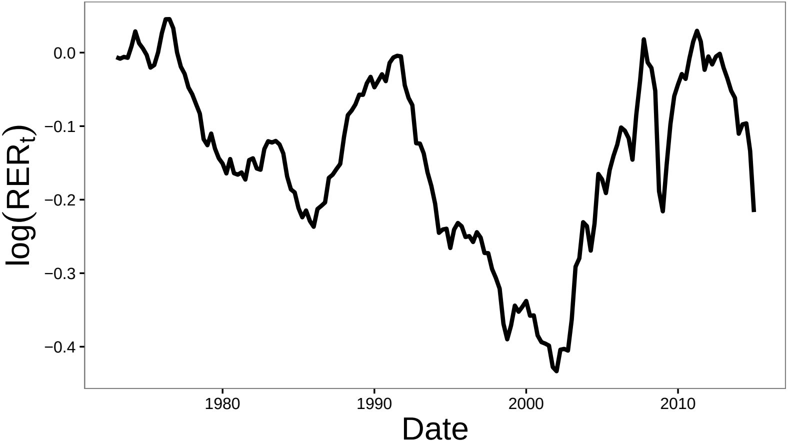
  - P_t = home consumer price index;
  - P_t^* = foreign consumer price index.

- A *rise* in the NER corresponds to a *depreciation* of the $ and an appreciation of the FCU.

- *NER* regression

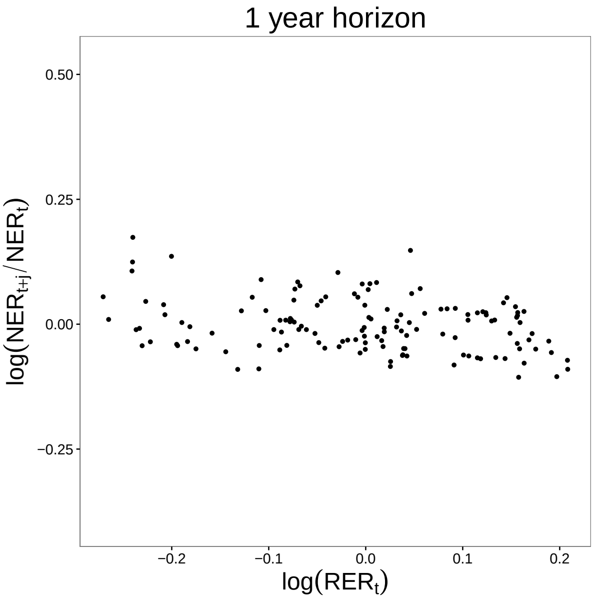
$$\log\left(\frac{NER_{t+j}}{NER_t}\right) = \beta_{0,j}^{NER} + \beta_{1,j}^{NER} \log\left(RER_t\right) + \epsilon_{t,t+j}.$$

Canada RER_t

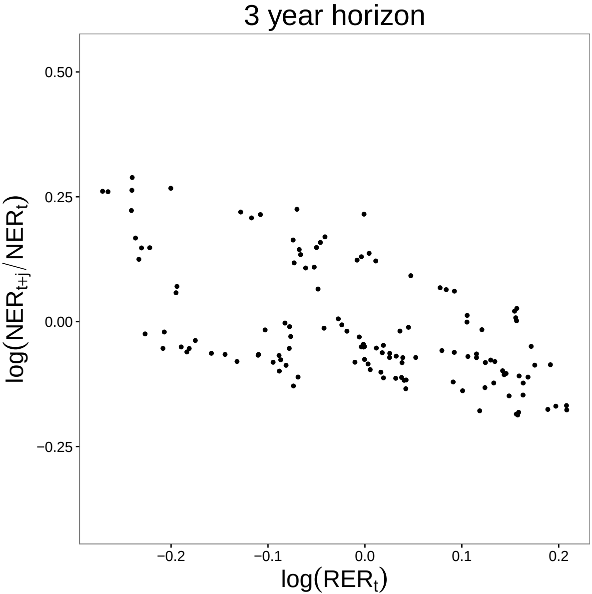


- Rise in *RER* is a rise in price of Canadian consumption basket in units of the U.S. consumption basket.

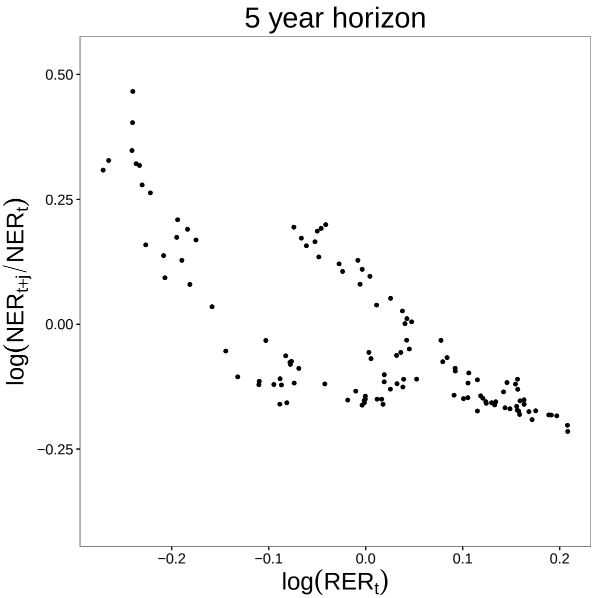
NER regression data: Canada



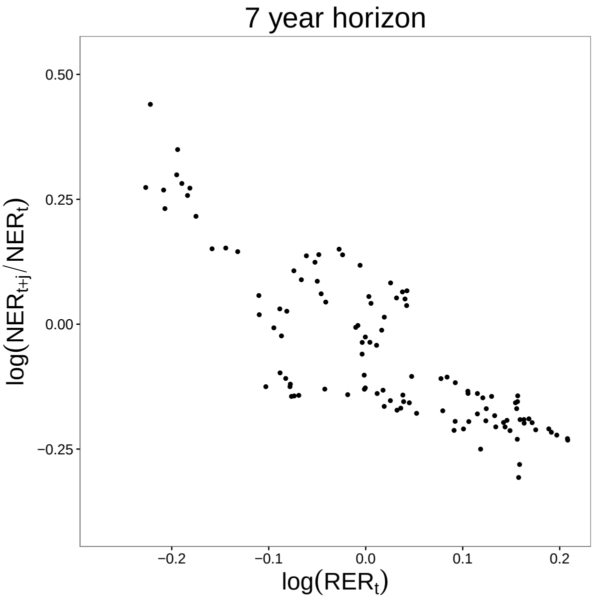
NER regression data: Canada



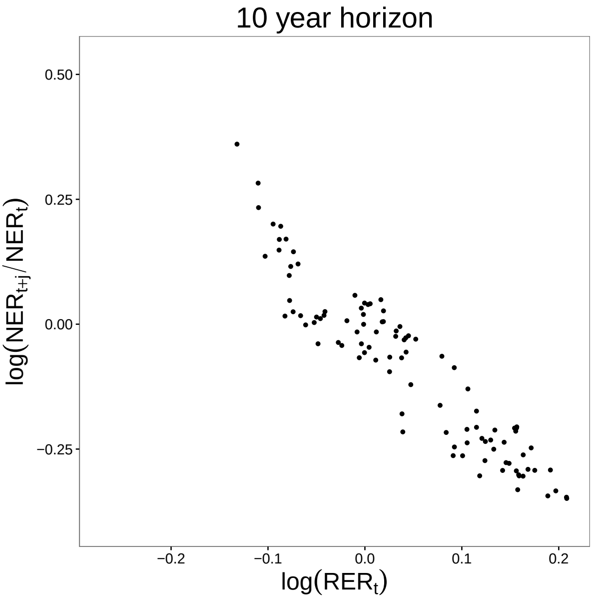
NER regression data: Canada



NER regression data: Canada



NER regression data: Canada



NER regression results: Canada

$$\log\left(\frac{NER_{t+j}}{NER_t}\right) = \beta_{0,j}^{NER} + \beta_{1,j}^{NER}\log\left(RER_t\right) + \epsilon_{t,t+j}.$$

	Horizon (in years)				
	1	3	5	7	10
$\hat{\beta}_{1,j}^{NER}$	-0.122	-0.549	-0.944	-1.158	-1.661
	(0.073)	(0.184)	(0.186)	(0.143)	(0.123)
R^2	0.078	0.349	0.590	0.687	0.878

- A high Cdn RER is associated with future depreciations of the Cdn dollar.

Rel.-price regression results: Canada

Quantify *NER* change from relative price changes

$$\log\left(\frac{P^*_{t+j}/P^*_t}{P_{t+j}/P_t}\right) = \beta^\pi_{0,j} + \beta^\pi_{1,j}\log\left(RER_t\right) + \epsilon_{t,t+j}.$$

	Horizon (in years)				
	1	3	5	7	10
$\hat{\beta}^\pi_{1,j}$	0.014	0.033	0.040	0.075	0.258
	(0.015)	(0.044)	(0.064)	(0.106)	(0.183)
R^2	0.011	0.016	0.014	0.024	0.102

- A high Cdn RER is not associated with changes in future relative inflation rates.

Regression results: China and France

Consider our *NER* regression

$$\log\left(\frac{NER_{t+j}}{NER_t}\right) = \beta_{0,j}^{NER} + \beta_{1,j}^{NER}\log\left(RER_t\right) + \epsilon_{t,t+j}.$$

for China vis-à-vis US$ and France vis-à-vis Germany.

	Horizon (in years)		
	1	3	5
China $\hat{\beta}_{1,j}^{NER}$	-0.123	-0.208	-0.261
	(0.035)	(0.060)	(0.096)
France $\hat{\beta}_{1,j}^{NER}$	0.000	0.000	0.000

Regression results: China and France

Relative-price regression

$$\log\left(\frac{P^*_{t+j}/P^*_t}{P_{t+j}/P_t}\right) = \beta^{\pi}_{0,j} + \beta^{\pi}_{1,j}\log\left(RER_t\right) + \epsilon_{t,t+j}.$$

	Horizon (in years)		
	1	3	5
China $\hat{\beta}^{\pi}_{1,j}$	-0.427	-0.926	-1.052
	(0.194)	(0.203)	(0.072)
R^2	0.369	0.667	0.910
France $\hat{\beta}^{\pi}_{1,j}$	-0.245	-1.029	-1.248
	(0.126)	(0.174)	(0.158)
R^2	0.151	0.642	0.795

Regression results: power considerations

- Our results are based on sample sizes that are short relative to horizon of regressions.
  - We use overlapping changes in the NER_t.
- Similar to literature that argues equity premium is predictable at long-run horizons.
- Stambaugh (1999) and Boudoukh, Richardson, and Whitelaw (2006)
  - Regressions based on overlapping samples aren't more informative than corresponding short-horizon regressions.
  - Predictability finding is 'spurious'.
- Use diagnostics suggested by Cochrane (2008) to evaluate whether our correlation findings are 'spurious'.
  - Very unlikely that our results could be generated a RW specification of nominal exchange rates.

Regression results: summary

- For countries with flexible *NER* and a Taylor rule
  - The current *RER* is highly correlated with future changes in the *NER* at horizons greater than two years.
    - Correlation is stronger the longer is the horizon.
  - The current *RER* is virtually uncorrelated with future inflation rates at all horizons.
- For 'other' countries, these results do not hold.

Model

- We build a model to interpret regression results.
  - Model has two symmetric countries, H and F.
- We provide intuition using benchmark model:
  - Complete asset markets;
  - Flexible prices;
  - PPP and UIP hold;
  - No internal persistence from consumption habit and interest rate smoothing;
  - No capital.

Preferences of home country

$$E_t \sum_{j=0}^{\infty} \beta^j \left[\frac{C_{t+j}^{1-\sigma}}{1-\sigma} - \frac{\chi}{1+\phi} L_{t+j}^{1+\phi} + \mu \frac{(M_{t+j}/P_{t+j})^{1-\sigma_M}}{1-\sigma_M} \right],$$

- C_t: consumption,
- L_t: hours worked,
- M_t: nominal money balances,
- P_t: price level.

Home budget constraint

$$B_{H,t} + NER_t B_{F,t} + P_t C_t + M_t - Z_t =$$
$$R_{t-1} B_{H,t-1} + NER_t R^*_{t-1} B_{F,t-1} + W_t L_t + T_t + M_{t-1},$$

- Z_t: net proceeds from contingent claims,
- $B_{H,t}$: nominal bonds from country H,
- $B_{F,t}$: nominal bonds from country F,
- R_t: nominal interest rate paid on H bonds,
- R^*_t: nominal interest rate paid on F bonds,
- W_t: wage rate,
- T_t: lump-sum profits and taxes.

Complete contingent claims

- Purchases of claims that payoff in state z_{t+1},

$$Q_t^H(z_{t+1})X_t^H(z_{t+1}) + NER_t Q_t^F(z_{t+1})X_t^F(z_{t+1})$$

- $Q_t^H(z_{t+1})$: price of contingent claim that pays 1 unit of HCU in state z_{t+1},
- $X_t^H(z_{t+1})$: quantity of contingent claims in HCU,
- $Q_t^F(z_{t+1})$: price of contingent claim that pays 1 unit of FCU in state z_{t+1}
- $X_t^F(z_{t+1})$: quantity of contingent claims in FCU.
- Payoffs from contingent claims

$$X_{t-1}^H(z_t) + NER_t X_{t-1}^F(z_t)$$

- Standard result about RER with complete markets:

$$\left(\frac{C_t^*}{C_t}\right)^{-\sigma} = RER_t$$

Foreign country

Preferences:

$$E_t \sum_{j=0}^{\infty} \beta^j \left[\frac{(C^*_{t+j})^{1-\sigma}}{1-\sigma} - \frac{\chi}{1+\phi} (L^*_{t+j})^{1+\phi} + \mu \frac{\left(M^*_{t+j}/P^*_{t+j}\right)^{1-\sigma_M}}{1-\sigma_M} \right].$$

Budget constraint:

$$NER_t^{-1} B^*_{H,t} + B^*_{F,t} + P^*_t C^*_t + M^*_t - Z^*_t =$$

$$NER_t^{-1} R_{t-1} B^*_{H,t-1} + R^*_{t-1} B^*_{F,t-1} + W^*_t L^*_t + T^*_t + M^*_{t-1},$$

Final goods producers

- Domestic final goods

$$Y_t = \left[\omega^{1-\rho} \left(X_{H,t}\right)^{\rho} + (1-\omega)^{1-\rho} \left(X_{F,t}\right)^{\rho}\right]^{\frac{1}{\rho}}$$

- Foreign final goods

$$Y_t^* = \left[\omega^{1-\rho} \left(X_{F,t}^*\right)^{\rho} + (1-\omega)^{1-\rho} \left(X_{H,t}^*\right)^{\rho}\right]^{\frac{1}{\rho}}$$

- ω determines home bias in consumption.
- ρ controls elasticity of substitution between home and foreign goods.

Intermediate goods producers

- $X_{H,t}$ and $X_{F,t}$ produced from intermediate inputs:

$$X_{H,t} = \left(\int_0^1 X_{H,t}(j)^{\frac{\nu-1}{\nu}} \, dj \right)^{\frac{\nu}{\nu-1}}$$

$$X_{F,t} = \left(\int_0^1 X_{F,t}(j)^{\frac{\nu-1}{\nu}} \, dj \right)^{\frac{\nu}{\nu-1}}$$

- $X^*_{F,t}$ and $X^*_{H,t}$ produced from intermediate inputs:

$$X^*_{F,t} = \left(\int_0^1 X^*_{F,t}(j)^{\frac{\nu-1}{\nu}} \, dj \right)^{\frac{\nu}{\nu-1}}$$

$$X^*_{H,t} = \left(\int_0^1 X^*_{H,t}(j)^{\frac{\nu-1}{\nu}} \, dj \right)^{\frac{\nu}{\nu-1}}$$

Intermediate inputs

Intermediate inputs produced by monopolists with labor

- Output from H monopolist

$$X_{H,t}(j) + X^*_{H,t}(j) = A_t L_t(j)$$

- Output from F monopolist

$$X_{F,t}(j) + X^*_{F,t}(j) = A^*_t L^*_t(j)$$

Intermediate inputs

- Monopolists in home country choose $\tilde{P}_{H,t}(j)$ and $\tilde{P}^*_{H,t}(j)$ to maximize per-period profits

$$\left(\tilde{P}_{H,t}(j)(1+\tau_X) - W_t/A_t\right) X_{H,t}(j) + \left(NER_t \tilde{P}^*_{H,t}(j)(1+\tau_X) - W_t/A_t\right) X^*_{H,t}(j)$$

  subject to demand curves of final good producers.

- Monopolists in foreign country choose $\tilde{P}_{F,t}(j)$ and $\tilde{P}^*_{F,t}(j)$ to maximize their profits

$$\left(\tilde{P}^*_{F,t}(j)(1+\tau_X) - W^*_t/A^*_t\right) X^*_{F,t}(j) + \left(NER_t^{-1} \tilde{P}_{F,t}(j)(1+\tau_X) - W^*_t/A^*_t\right) X_{F,t}(j).$$

subject to the demand curves of final good producers

Law of one price

- With flexible prices, law of one price holds.
- FONCs for monopolists imply:

$$P_{H,t}(j) = NER_t P^*_{H,t}(j) = \frac{W_t}{A_t}$$

$$NER_t^{-1} P_{F,t}(j) = P^*_{F,t}(j) = \frac{W^*_t}{A^*_t}$$

- Monopolists charge gross markup of one due to subsidy that corrects steady-state level of monopoly distortion.

Monetary policy, Taylor rule

- Home country

$$R_t = (R_{t-1})^{\gamma} \left(R\pi_t^{\theta_\pi}\right)^{1-\gamma} \exp\left(\varepsilon_{R,t}\right)$$

- Foreign country

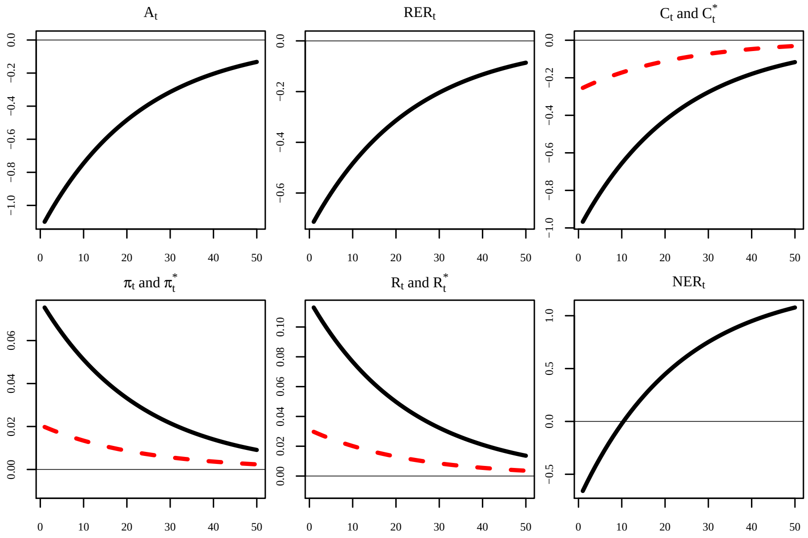
$$R_t^* = \left(R_{t-1}^*\right)^{\gamma} \left(R(\pi_t^*)^{\theta_\pi}\right)^{1-\gamma} \exp\left(\varepsilon_{R,t}^*\right)$$

$R \equiv$ steady state nominal interest rate;
$\pi_t \equiv P_t / P_{t-1}$;
$\pi_t^* \equiv P_t^* / P_{t-1}^*$;
$\varepsilon_{R,t}$ and $\varepsilon_{R,t}^*$ are iid policy shocks

- $\theta_\pi > 1$ so Taylor principle is satisfied.

Technology shock, flex prices, Taylor rule

NER denotes $/FCU



Intuition: the role of home bias

$$RER_t = \frac{C_t}{C_t^*}$$

- Home bias in consumption has three implications.

1. *RER* falls (a unit of foregn C basket buys fewer units of home C basket) since home goods are more costly to produce and home consumption basket places a higher weight on these goods.

2. Domestic consumption falls by more than foreign consumption because domestic agents consume more of good whose relative cost of production has risen.

3. Households' Euler equations imply that domestic real interest rate must rise by more than foreign real interest rate.

Intuition: the role of the monetary policy rule

- Taylor rule and Taylor principle imply that high real interest rates are associated with high nominal interest rates and high inflation rates.
  - So R and π rise by more than R^* and π^*.

- $\pi > \pi^*$
  - Inconsistent with naive intuition that differential inflation rates are key mechanism by which *RER* returns to its pre-shock level.
  - Relative inflation rates are moving in the 'wrong' direction relative to naive PPP intuition.

  - The *only* way for *RER* to revert to its steady state value is via changes in *NER* (a big depreciation).

Overshooting

- Since Taylor rule keeps prices relatively stable, fall in *RER* on *impact* occurs via an *appreciation* of home currency.

$$\hat{RER}_t = \kappa \hat{A}_t \text{ where } \hat{A}_t \text{is an AR(1).}$$

- Inter-temporal Euler eq., complete markets, Taylor rule:

$$-(\hat{C}_t - \hat{C}_t^*) = \hat{R}_t - \hat{R}_t^* + E_t\left[-(\hat{C}_{t+1} - \hat{C}_{t+1}^*) - \left(\hat{\pi}_{t+1} - \hat{\pi}_{t+1}^*\right)\right]$$

$$-\hat{RER}_t = \theta_\pi\left(\hat{\pi}_t - \hat{\pi}_t^*\right) + E_t\left[-\hat{RER}_{t+1} - \left(\hat{\pi}_{t+1} - \hat{\pi}_{t+1}^*\right)\right].$$

- Solve forward

$$\hat{\pi}_t - \hat{\pi}_t^* = \frac{\rho_A - 1}{\theta_\pi - \rho_A}\hat{RER}_t$$

where

$$\left|\frac{\rho_A - 1}{\theta_\pi - \rho_A}\right| < 1.$$

- So relative inflation rates move by less than *RER*.

Why is there NER overshooting?

$$RER_t = \frac{NER_t P_t^*}{P_t}$$

- Since RER_t falls by more than P_t^*/P_t, NER_t must initially fall, i.e. the home currency *appreciates* on impact.
- Recall that R_t rises by more than R^*.
- The technology shock is persistent, so there's a persistent gap between R and R^*.
- Since UIP holds, domestic currency must *depreciate* over time to compensate for gap between R and R^*.
- In sum, home currency *appreciates* on impact and then depreciates.

Regression coefficients

$$\log\left(\frac{NER_{t+j}}{NER_t}\right) = \beta_{0,j}^{NER} + \beta_{1,j}^{NER}\log(RER_t) + \epsilon_{t,t+j}.$$

- Calculate plim of $\beta_{1,j}$ implied by simple model assuming that only technology shocks drive economic fluctuations.
- Plim $\beta_{1,j}$ is negative and grows larger in absolute value with horizon.
- In model, a low current value of the *RER* predicts a future depreciation of the domestic currency, so slope of regression is negative.
- Slope increases with the horizon because *cumulative* depreciation of home currency increases over time.

Regression coefficients

- Our model implies plim's of regression coefficients

$$\beta_{1,j}^{NER} = -\frac{1-\rho_A^j}{1-\rho_A/\theta_\pi},$$

- $\beta_{1,j}^{\pi}$ is negative and decreasing in j.
- High θ_π implies small values of $\beta_{1,j}^{NER}$.
  - After a domestic technology shock, $\pi_t > \pi_t^{*}$.
  - The higher is θ_π, the lower is π_t and the less the domestic currency needs to depreciate to bring about the required adjustment in the RER.
  - So, the absolute value of $\beta_{1,j}^{NER}$ is decreasing in θ_π.

Regression coefficients

- We can also solve for plim of $\beta^{\pi}_{1,j}$

$$\beta^{\pi}_{1,j} = \frac{1-\rho_A^j}{\theta_\pi/\rho_A - 1}$$

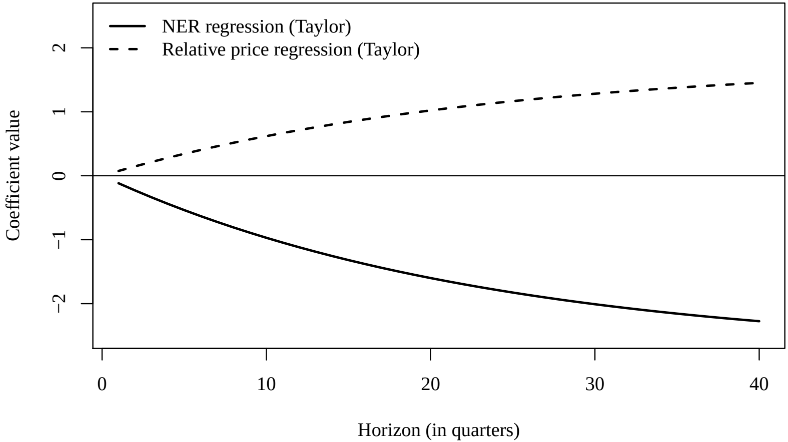
- $\beta^{\pi}_{1,j}$ is positive for all j.

- Higher is θ_π, the lower is $\beta^{\pi}_{1,j}$ for all j

$$\beta^{NER}_{1,j} + \beta^{RP}_{1,j} = -\left(1-\rho_A^j\right) \to -1.$$

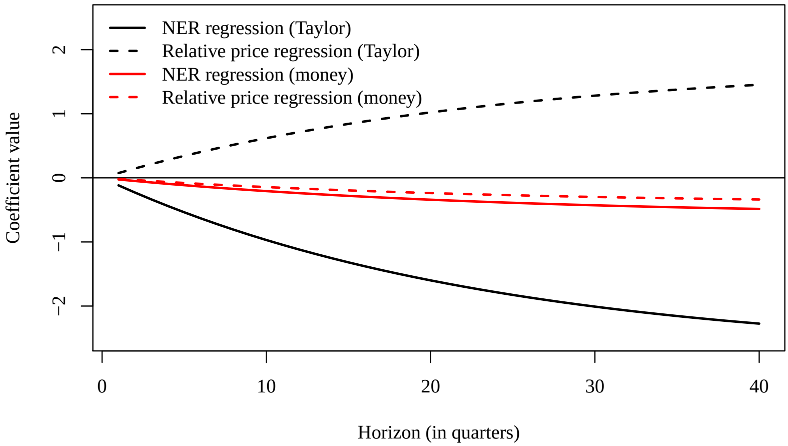
- *RER* converges to its pre-shock steady state level either through changes in inflation or changes in the *NER*.

Model-implied NER regression plims



Model-implied NER regression plims

Comparing money growth rate and Taylor rules



Model features

- Technology shocks, in our benchmark model, can produce negative coefficients in our *NER* regression that grow with horizon. But,
  - The intuition relies on *PPP* and *UIP*.
  - The shocks produce counterfactually large price movements.
- Develop a richer version of the model that accounts for our exchange rate facts without violating other key features of the data.
  - Incomplete international asset markets.
  - Shocks to the spread between returns on H and F bonds.
  - Nominal rigidities.
  - Capital (see paper, not in slides today).

Deviations from UIP

To allow for deviations from UIP, we assume

- Markets are internationally incomplete; only nominal bonds can be traded across countries.
- Households derive utility from country H nominal bonds.
  - Easy to generalize this assumption.

Incomplete markets and spread shocks

- Preferences in country H are

$$E_t \sum_{j=0}^{\infty} \beta^j \left[\frac{C_{t+j}^{1-\sigma}}{1-\sigma} - \frac{\chi L_{t+j}^{1+\phi}}{1+\phi} + \mu \frac{\left(\frac{M_t}{P_t}\right)^{1-\sigma_M}}{1-\sigma_M} + \eta_t V\left(\frac{B_{H,t}}{P_t}\right) \right]$$

- Spread shock, η_t is zero in steady state.
- Outside of steady state, there may be shocks that put a premium on home (U.S.) bonds, arising from flights to safety or liquidity.

Incomplete markets

- Preferences in country F are

$$E_t \sum_{j=0}^{\infty} \beta^j \left[\frac{(C^*_{t+j})^{1-\sigma}}{1-\sigma} - \frac{\chi (L^*_{t+j})^{1+\phi}}{1+\phi} + \mu \frac{\left(\frac{M^*_t}{P^*_t}\right)^{1-\sigma_M}}{1-\sigma_M} + \eta_t V\left(\frac{B^*_{H,t}}{NER_t P^*_t}\right) \right]$$

- We add a quadratic cost of holding bonds to budget constraints, as in Schmitt-Grohe and Uribe (2003) to prevent unit root in RER.

Incomplete markets

- With complete markets

$$\left(\frac{C_t^*}{C_t}\right)^{-\sigma} = RER_t$$

  for every state of the world.

- With incomplete markets, this equation doesn't hold.

- Instead we impose clearing in the bond market.

Deviations from UIP

- Ignoring the quadratic costs of bond holdings, household optimality implies

$$E_t \Delta \hat{N}ER_{t+1} = \hat{R}_t - \hat{R}_t^* + \eta_t$$

- Consider the classic Fama (1984) regression

$$\Delta \hat{N}ER_{t+1} = \alpha_0 + \alpha_1(\hat{R}_t - \hat{R}_t^*) + \epsilon_t$$

- UIP implies $\alpha_0 = 0$ and $\alpha_1 = 1$.

- In our model, UIP would be rejected because of a negative covariance between ϵ_t and $(\hat{R}_t - \hat{R}_t^*)$.
  - A rise in η_t is equivalent to a rise in ε_t.
  - Domestic bonds are in zero net supply, yield on domestic bonds must fall leading to a decline in $\hat{R}_t - \hat{R}_t^*$.

Nominal rigidities

- We add Calvo-style sticky prices.
- Local currency pricing and sticky prices break PPP.
- The effect of technology shocks is little changed.
- Spread shocks lead to home currency appreciation and have real effects, e.g. decline in consumption.

Medium-scale model

We add

- Interest rate smoothing ($\gamma = 0.75$).
- Habit persistence (Christiano, Eichenbaum, Evans, 2005).
- Sticky wages (Erceg, Henderson, and Levin, 2000)

We parameterize η_t to be an AR(1), with autocorrelation 0.85.

- If exchange rates are a random walk, this is consistent with typical values of $\hat{R}_t^* - \hat{R}_t = \eta_t$.
  - Also equal to value estimated by Gust et. al. (2016)

Medium-scale model

- We calibrate σ_η, σ_A, and ρ_A so that we match
  - Persistence and volatility of U.S. per-capita real GDP.
  - Coefficient in the Fama (1984) regression of 0.5.

- Nothing significant about the nominal rigidities model changes if we insist that the Fama coefficient is 0.0.

  - Can't match a 0.0 regression coefficient in the model without nominal rigidities.

Model-implied regression results

With nominal rigidities, our calibration exercise yields

$$\rho_A = 0.958$$
$$\sigma_A = 0.011$$
$$\sigma_\eta = 0.004$$

Model-implied probability limit for $\beta_{1,j}$

	Horizon (in years)				
	1	3	5	7	10
NER regression	-0.446	-0.855	-1.061	-1.199	-1.333
Rel.-price reg.	0.074	0.176	0.269	0.340	0.413

Model-implied regression results

Without nominal rigidities, our calibration exercise yields

$$\rho_A = 0.895$$
$$\sigma_A = 0.018$$
$$\sigma_\eta = 0.005$$

Model-implied probability limit for $\beta_{1,j}$

	Horizon (in years)				
	1	3	5	7	10
NER regression	-0.414	-0.975	-1.341	-1.581	-1.797
Rel.-price reg.	0.184	0.476	0.670	0.797	0.912

Key facts for the model

- Real and nominal exchange rates commove closely in the short run (Mussa (1986)).
- *RER*s are highly inertial (Rogoff (1996)).
- Real and nominal exchange rates are very volatile.

Exchange Rate Facts

Compare model moments to data.

	ρ_{RER}	$\sigma_{\Delta RER}$
Canada	0.986	0.022
	(0.872, 0.997)	(0.002)
With nominal rigidities	0.890	0.023
Without nominal rigidities	0.928	0.024

- For some countries, we hit the volatility of the ΔNER and ΔRER fairly well.
- For a number of countries in our sample, models somewhat understate volatility of ΔNER and ΔRER
  - Example, for Australia, the $\sigma_{\sigma NER} = \sigma_{\Delta RER} = 0.040$

Exchange Rate Facts

- Correlation of ΔRER and ΔNER is very high in the data: approximately 0.98 (Mussa, 1986).
- With nominal rigidities, model generates corr. of 0.96.
- Without nominal rigidities, model generates corr. of 0.65.

What about capital?

- Add capital as in CEE
- Households only own home country capital
- Results robust

Out of sample forecasting (ongoing work)

- Our baseline *NER* regression has correlated errors, even at the 1 quarter horizon.
- For forecasting, we use

$$\log\left(\frac{NER^i_{t+j}}{NER^i_t}\right) = \beta^i_{0,j} + \beta^i_{1,j}\log\left(RER_t\right) + \beta^i_{2,j}\log\left(RER_{t-1}\right)$$

  where i is for each country.
- Use same time period as our regression results.
- Training sample of 40 quarters.
- Use ratio of mean-squared prediction error relative to random walk without drift for forecasting performance.

Out of sample forecasting (ongoing work)

RMSPE relative to a random walk:

	Horizon	
	1 Month	5 Years
Canada	0.95	1.19
Denmark	0.96	0.85
euro area	0.98	1.28
Japan	0.99	1.19
Norway	0.96	0.80
South Korea	0.91	0.56
Sweden	0.95	0.71
Switzerland	0.99	0.74
U.K.	0.98	0.89

Out of sample forecasting (ongoing work)

- Engel, Mark, West (2007) use panel regressions.
- We estimate

$$\log\left(\frac{NER^i_{t+j}}{NER^i_t}\right) = \beta^i_{0,j} + \beta_{1,j}\log\left(RER_t\right) + \beta_{2,j}\log\left(RER_{t-1}\right)$$

- Only countries where we have the entire sample period.
- Training sample of 40 quarters.
- Use ratio of mean-squared prediction error relative to a random walk without drift for forecasting performance.

Out of sample forecasting (ongoing work)

RMSPE relative to a random walk:

	Horizon	
	1 Month	5 Years
Canada	0.95	0.89
Denmark	0.95	0.79
euro area	0.97	0.84
Japan	0.97	1.09
Norway	0.96	0.76
South Korea	0.95	0.34
Sweden	0.95	0.74
Switzerland	0.99	0.73
U.K.	0.97	0.75

Performance is better with panel structure.

Out of sample forecasting (ongoing work)

- Extend sample from 1973 through 2016
- Add Chile and Mexico.

RMSPE relative to a random walk:

	Horizon	
	1 Month	5 Years
Canada	0.96	0.97
Denmark	0.95	1.22
euro area	0.98	1.28
Japan	0.96	1.01
Norway	0.95	1.10
South Korea	0.93	0.76
Sweden	0.93	1.93
Switzerland	0.97	0.86
U.K.	0.96	1.00
Chile	1.19	1.86
Mexico	0.89	1.14

Substantially worse performance at long horizons.

Model implied RMSPE relative to a random walk

Table 13: Model-implied RMSPE relative to a random walk

	Forecast horizon								
	1Q	2Q	1Y	2Y	3Y	4Y	5Y	6Y	7Y
All Countries	0.98	1.01	1.00	0.95	0.92	0.87	0.81	0.78	0.74
Model (Taylor Rule)	0.99	0.98	0.96	0.94	0.92	0.89	0.85	0.79	0.74
	(0.01)	(0.02)	(0.03)	(0.05)	(0.06)	(0.07)	(0.08)	(0.09)	(0.09)
Model (Money Rule)	1.01	1.02	1.04	1.08	1.11	1.13	1.14	1.13	1.12
	(0.01)	(0.01)	(0.02)	(0.03)	(0.05)	(0.07)	(0.09)	(0.11)	(0.13)

Conclusions

- *RER*s are very useful for predicting changes in *NER*s at medium-to-long horizons.
- The *RER* has virtually no forecasting power for future inflation.
- Home bias and Taylor rules can explain these results.
- Under a Taylor-rule regime, relative PPP is re-established via changes in the *NER*, not prices.
- Medium size DSGE model is consistent with our exchange findings and classic stylized facts about exchange rates emphasized in literature.