

Exchange Rate and External Balances: How Important Are Price Deflators?

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The views expressed in the paper are those of the authors and do not necessarily represent the views of IMF, its Executive Board,
or IMF management.

Motivation

- "The return of elasticity pessimism" - external balance barely responds to price signals, and changing currency values has little effect on capital/trade flows
- Very important issue: optimal exchange rate policy; facilitate external balance adjustment
- Heated debate: link lost, or masked?
 - Local currency pricing?
 - Global value chain?
 - Other offsetting cyclical factors?
 - Nonlinear relationship?

This Paper

- A different view: deflators in real exchange rate
 - Real exchange rate is the "price" in external balance movement, however, there is arbitrary selection of deflators
- Goals: $P \implies \dots? \dots \implies \text{Corr}(\text{REER}, \text{external balance})$
 - Would P matter?
 - How?
 - What can we learn?
- What we did:
 - Systematically construct REER-CPI/-ULC/-GDP deflator
 - Empirically examine $\text{Corr}(\text{REER}, \text{external balance})$
 - Theoretically pin down contributing factors

Main Results

- Choice of price index used in REER matters
 - Negative relationship only between REER-ULC and external balance
 - But not the rest
- Very robust, not driven by
 - Selected country or time
 - Different composition
 - Possible commonly related factors
- Standard model: wage and price rigidity + intermediate goods trade
- Tight link & weak link can be reconciled, link not lost

Existing Literature

- The relationship between real exchange rate and external balance
Chinn and Lee (2006), Mejean et al. (2011), Corsetti et al. (2008), Kim and Roubini (2008), Obstfeld and Rogoff (2005), Leigh et al. (2015)
- Exchange rate pass-through and external balance
Devereux and Yetman (2002), Campa and Goldberg (2005), Choudhri et al. (2005), Gust, Leduc and Sheets (2009), Powers and Riker (2013), Amiti et al. (2014)
- Differences among REERs
Bayoumi et al. (2011), Chinn (2006), Comunale and Hessel (2014)
- New weights in REER
Bayoumi et al. (2013), Bems and Johnson (2015), Patel et al. (2014)

Roadmap

1. Data
2. Empirical analysis
3. Model
4. Conclusion

Data Summary

- Quarterly sample: 2000q1 - 2014q4; annual sample: 1995 - 2014; 35 countries
- Data sources: IFS for CPI, GDP deflator; Haver + WIOD for ULC
- Use the weights from Bayoumi et al. (2005) to construct REERs

$$REER_i = \prod_{j \neq i} \left(\frac{P_i S_{ij}}{P_j} \right)^{\lambda_{ij}}$$

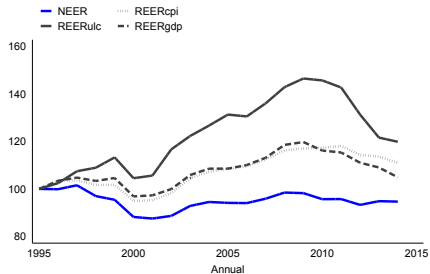
- S_{ij} : nominal exchange rate of country j 's currency per currency i
- $S_{ij} \uparrow$, $REER_i \uparrow$ = country i 's currency appreciates

Deflators Matter

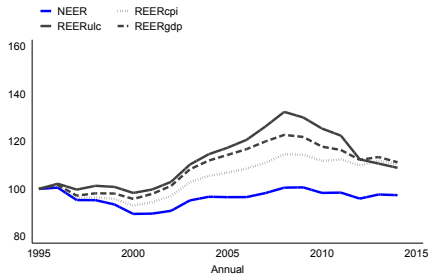
$$\begin{aligned} \text{Var}(\Delta \ln REER) &= \text{Var}(\Delta \ln NEER + \Delta \ln P/P^*) \\ &= \underbrace{\text{Var}(\Delta \ln NEER) + \text{Cov}(\Delta \ln NEER, \Delta \ln P/P^*)}_{\text{contribution from NEER}} \\ &\quad + \underbrace{\text{Var}(\Delta \ln P/P^*) + \text{Cov}(\Delta \ln NEER, \Delta \ln P/P^*)}_{\text{contribution from } P/P^*} \end{aligned}$$

Quarterly	NEER	P/P*	Annual	NEER	P/P*
REER-ULC	66%	34%	REER-ULC	79%	21%
REER-CPI	93%	7%	REER-CPI	83%	17%
REER-GDP	60%	40%	REER-GDP	87%	13%

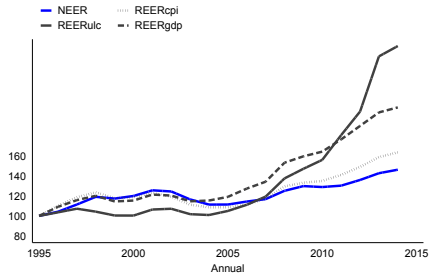
Greece



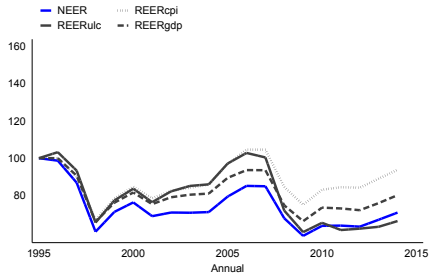
Spain



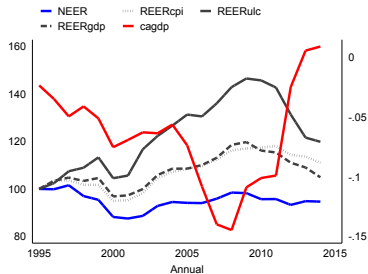
China



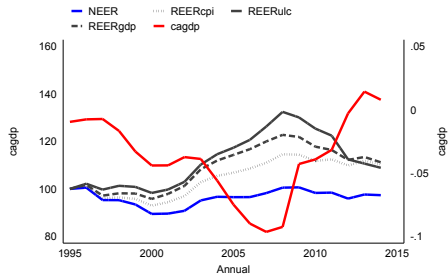
Korea



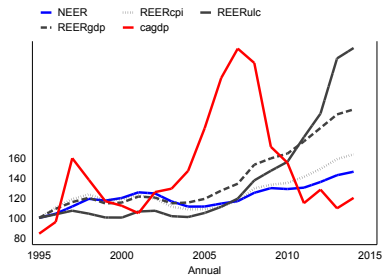
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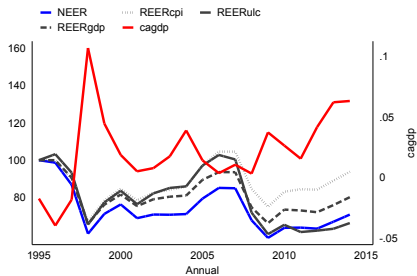
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The Empirical Relationship between REER & CA

Empirical Specification

- Dominant evidences: REERs and external balance are I(1) and cointegrated in our sample
- Error correction model

$$\Delta CA/GDP_{it} = \phi \left(\left[\frac{CA}{GDP} \right] - \beta \ln REER - \beta_1 \ln GDP - \beta_2 \ln GDP^* \right)_{it-1} + \gamma \Delta \ln REER_{it} + \gamma_1 \Delta \ln GDP_{it} + \gamma_2 \Delta \ln GDP_{it}^* + \alpha_i + \epsilon_{it}$$

- Focus on short-run relationship: γ
 - Business cycle dynamics
 - Temporary shock impulse response

Baseline Results (2000q1 - 2014q4)

- REER-ULC is significantly negative correlated with external balance, while REER-CPI and REER-GDP deflator show "disconnection"

	ulc	cpi	gdp
ec			
LR_DD	-0.061 (0.04)	-0.111** (0.05)	-0.078* (0.04)
LR_FD	0.177** (0.08)	0.222** (0.08)	0.200** (0.08)
LR_REER	0.018 (0.06)	0.139 (0.10)	0.047 (0.07)
SR			
SR_ec	-0.149*** (0.02)	-0.152*** (0.02)	-0.148*** (0.02)
SR_DD	0.003 (0.01)	-0.013 (0.02)	-0.022* (0.01)
SR_FD	-0.024 (0.05)	0.000 (0.05)	0.016 (0.05)
SR_REER	-0.048*** (0.01)	-0.005 (0.03)	0.016 (0.01)
obs	2065	2065	2065

Possible Concerns about Baseline Results_____

- Heterogeneity among countries (PMG/MG, EU vs. NonEU)
- Omitted Variable
 - Time effect/Crisis effect
 - Commodity terms of trade
 - Input cost other than labor
- Tradable vs. Non-tradable hypothesis
- Dominant currency vs. currency basket
- Measurement error
 - REERs: cross-check with European Commission Data
 - External balance: Alessandria and Choi (2016) approximation

Robustness Check: Long-run/Short-run Restrictions_____

	Pooling Mean Group			Mean Group		
	ulc	cpi	gdp	ulc	cpi	gdp
ec						
LR_DD	0.020 (0.01)	-0.252*** (0.02)	-0.009 (0.02)	-0.197** (0.08)	-0.205*** (0.05)	-0.218*** (0.05)
LR_FD	0.073** (0.03)	0.495*** (0.04)	0.140*** (0.04)	0.399** (0.13)	0.269*** (0.07)	0.319*** (0.09)
LR_REER	-0.076*** (0.01)	0.239*** (0.03)	-0.056** (0.02)	0.164 (0.11)	0.341*** (0.10)	0.314*** (0.09)
SR						
SR_ec	-0.197*** (0.03)	-0.178*** (0.02)	-0.183*** (0.03)	-0.415*** (0.04)	-0.440*** (0.04)	-0.409*** (0.04)
SR_DD	0.001 (0.02)	-0.040 (0.02)	-0.034* (0.02)	-0.015 (0.02)	-0.040 (0.03)	-0.057** (0.02)
SR_FD	-0.012 (0.07)	0.084 (0.07)	0.035 (0.07)	0.104 (0.07)	0.131* (0.08)	0.134* (0.08)
SR_REER	-0.066** (0.02)	0.037 (0.03)	0.017 (0.03)	-0.053** (0.03)	0.034 (0.03)	0.049 (0.03)
obs	2065	2065	2065	2065	2065	2065
Hausman	1.000	1.000	1.000	1.000	1.000	1.000

- Pooling mean group (PMG): heterogeneous short-run
- Mean group (MG): heterogeneous in both short-run and long-run

Robustness Check: EU vs. Non-EU

	NonEU			EU		
	ulc	cpi	gdp	ulc	cpi	gdp
ec						
LR_DD	-0.035 (0.04)	-0.067 (0.05)	-0.043 (0.04)	-0.173*** (0.05)	-0.287*** (0.05)	-0.244*** (0.06)
LR_FD	0.094 (0.08)	0.126 (0.08)	0.108 (0.08)	0.409*** (0.09)	0.486*** (0.10)	0.497*** (0.09)
LR_REER	0.009 (0.05)	0.083 (0.10)	0.019 (0.06)	-0.077 (0.08)	0.320** (0.13)	0.117 (0.15)
SR						
SR_ec	-0.166*** (0.03)	-0.166*** (0.03)	-0.164*** (0.03)	-0.176*** (0.03)	-0.173*** (0.02)	-0.166*** (0.02)
SR_DD	-0.000 (0.01)	-0.019 (0.02)	-0.029** (0.01)	0.016 (0.03)	0.017 (0.03)	0.005 (0.03)
SR_FD	-0.011 (0.05)	0.014 (0.05)	0.029 (0.05)	-0.031 (0.10)	-0.047 (0.09)	-0.022 (0.10)
SR_REER	-0.047*** (0.01)	-0.001 (0.03)	0.020 (0.02)	-0.069* (0.04)	-0.063 (0.05)	-0.019 (0.04)
obs	1327	1327	1327	738	738	738

- Not driven by handful EU countries

Robustness Check: Time Effect and GFC

	+Time FE			Pre-crisis		
	ulc	cpi	gdp	ulc	cpi	gdp
ec						
LR_DD	-0.030 (0.03)	-0.083** (0.03)	-0.046* (0.03)	-0.036 (0.03)	-0.051 (0.04)	-0.055 (0.04)
LR_FD	0.021 (0.17)	0.040 (0.17)	0.016 (0.17)	0.004 (0.09)	0.023 (0.10)	0.030 (0.10)
LR_REER	0.000 (0.02)	0.106** (0.04)	0.023 (0.03)	-0.064** (0.03)	-0.054 (0.04)	-0.043 (0.04)
SR						
SR_ec	-0.158*** (0.01)	-0.157*** (0.01)	-0.155*** (0.01)	-0.254*** (0.02)	-0.243*** (0.02)	-0.242*** (0.02)
SR_DD	0.007 (0.01)	-0.011 (0.02)	-0.024* (0.01)	0.032** (0.02)	0.028 (0.02)	0.009 (0.02)
SR_FD	-0.034 (0.10)	0.004 (0.10)	0.021 (0.10)	0.080 (0.07)	0.087 (0.07)	0.117 (0.07)
SR_REER	-0.047** (0.02)	-0.004 (0.02)	0.020 (0.02)	-0.059** (0.02)	-0.046 (0.03)	0.007 (0.02)
obs	2065	2065	2065	1085	1085	1085

- Not driven by aggregate time effect or crisis

Robustness Check: Commodity Terms of Trade_____

	ulc	cpi	gdp
ec			
LR_DD	-0.042 (0.03)	-0.121** (0.04)	-0.114** (0.05)
LR_FD	0.099* (0.05)	0.170** (0.06)	0.163** (0.06)
LR_REER	-0.037 (0.05)	0.133 (0.10)	0.098 (0.10)
L.commodity	-0.145 (0.14)	-0.313* (0.16)	-0.365* (0.21)
SR			
SR_ec	-0.217*** (0.04)	-0.184*** (0.04)	-0.187*** (0.04)
SR_DD	-0.032 (0.04)	-0.133*** (0.04)	-0.129** (0.04)
SR_FD	0.036 (0.07)	0.164** (0.06)	0.157** (0.07)
SR_REER	-0.058** (0.02)	0.077** (0.03)	0.066* (0.04)
D.commodity	0.489*** (0.09)	0.460*** (0.10)	0.414*** (0.09)
obs	551	551	551

- Commodity ToT affects REER and external balance, but not essential to distinguish REERs

Robustness Check: ULC Represents Overall Cost?_____

- Cobb-Douglas production function: total cost resembles ULC
- Globally declining labor share (Karabarbounis and Neiman (2014))

$$Total\ Cost = ULC + Capital\ Cost = ULC \cdot \underbrace{\frac{labor\ share + capital\ share}{labor\ share}}_{additional\ control}$$

	(1) ulc b/se	(2) ulc[control] b/se
SR		
SR_ec	-0.217*** (0.04)	-0.304*** (0.05)
SR_DD	-0.032 (0.04)	0.064** (0.03)
SR_FD	0.036 (0.07)	-0.113* (0.06)
SR_REER	-0.058** (0.02)	-0.084** (0.03)
D.totalCost/laborCost		-0.272*** (0.07)
obs	551	438

Robustness Check: Tradable vs. Non-tradable_____

- Composition difference: less non-tradable goods in ULC
- Separate tradable and non-tradable REERs

$$p_t = \alpha p_t^N + (1 - \alpha) p_t^T$$

$$p_t^* = \alpha p_t^{N*} + (1 - \alpha) p_t^{T*}$$

$$\Rightarrow \ln REER = (s_t + p_t^T - p_t^{T*}) - \alpha(\hat{p}_t^N - \hat{p}_t^T)$$

where \hat{p} denotes the relative price

	(1) REER-ULC(T)	(2) REER-ULC control for (T-N)	(3) REER-GDP(T)	(4) REER-GDP control for (T-N)
SR				
SR_ec	-0.298*** (0.04)	-0.321*** (0.04)	-0.301*** (0.04)	-0.322*** (0.04)
SR_DD	-0.328*** (0.03)	-0.331*** (0.03)	-0.335*** (0.03)	-0.323*** (0.03)
SR_FD	-0.023 (0.03)	-0.017 (0.03)	-0.024 (0.03)	-0.027 (0.03)
SR_REER	-0.025** (0.01)	-0.026** (0.01)	-0.015 (0.01)	-0.009 (0.02)
obs	490	490	490	490

Dominant Currency and REERs

- Casas et al. (2016) show that expenditure switching operates through import substitution depending on how a country's currency fares against the USD (*dominant currency paradigm*)

	ulc	cpi	gdp
ec			
LR_DD	-0.021 (0.02)	-0.054** (0.02)	-0.040** (0.02)
LR_FD	0.114** (0.04)	0.078 (0.05)	0.102** (0.05)
LR_REER	-0.017 (0.04)	0.068 (0.05)	0.019 (0.05)
SR			
SR_ec	-0.280*** (0.04)	-0.271*** (0.03)	-0.276*** (0.03)
SR_DD	-0.035** (0.01)	-0.066** (0.03)	-0.059** (0.02)
SR_FD	0.008 (0.04)	-0.022 (0.05)	-0.021 (0.04)
SR_REER	-0.037** (0.01)	0.030 (0.03)	0.014 (0.03)
obs	665	665	665

Alternative Measure of External Balance_____

$$\frac{X-M}{X+M} \approx \frac{\eta}{2} \left[(2\alpha - 1) \ln \frac{P^*}{P} + \ln \frac{Y^*}{Y} \right], \text{ Alessandria and Choi (2016)}$$

	ulc	cpi	gdp
ec			
LR_DD	-0.022 (0.03)	-0.068 (0.05)	-0.053 (0.04)
LR_FD	0.116* (0.06)	0.126* (0.07)	0.130* (0.07)
LR_REER	-0.032 (0.08)	0.122 (0.11)	0.047 (0.10)
SR			
SR_ec	-0.193*** (0.03)	-0.207*** (0.03)	-0.207*** (0.04)
SR_DD	-0.025* (0.02)	-0.067** (0.03)	-0.062* (0.03)
SR_FD	0.003 (0.04)	0.046 (0.06)	0.042 (0.06)
SR_REER	-0.076*** (0.02)	0.009 (0.05)	0.006 (0.05)
obs	665	665	665

Robustness Check: Other Sources of REER Data_____

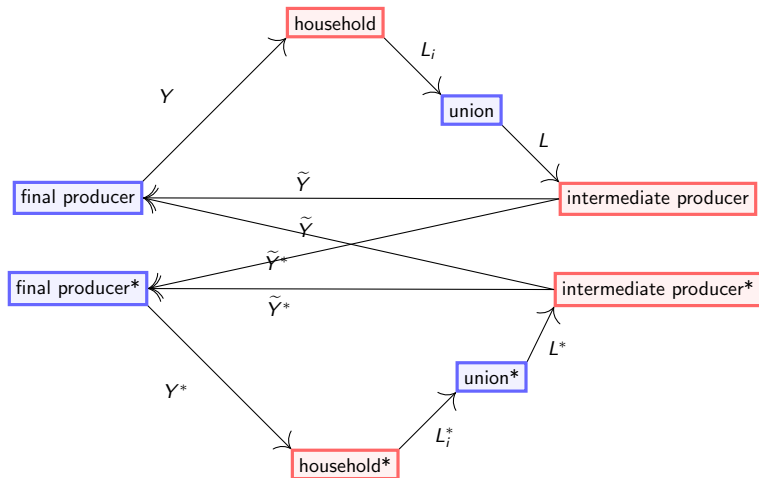
- Self calculation: measurement error?
- Double check with European Commission's data

	(1) ulc[tot] b/se	(2) ulc[mfg] b/se	(3) cpi b/se	(4) gdp b/se
ec				
LR_DD	-0.049 (0.03)	-0.019 (0.04)	-0.083** (0.04)	-0.079** (0.04)
LR_FD	0.023 (0.04)	0.016 (0.04)	0.036 (0.04)	0.036 (0.04)
LR_REER	0.026 (0.03)	-0.021 (0.03)	0.076* (0.04)	0.057* (0.03)
SR				
SR_ec	-0.255*** (0.03)	-0.250*** (0.03)	-0.250*** (0.03)	-0.252*** (0.03)
SR_DD	-0.352*** (0.06)	-0.354*** (0.07)	-0.374*** (0.07)	-0.364*** (0.07)
SR_FD	0.054 (0.07)	0.068 (0.07)	0.062 (0.07)	0.061 (0.07)
SR_REER	-0.053*** (0.01)	-0.055*** (0.01)	-0.013 (0.02)	-0.023 (0.02)
obs	768	768	768	768

A Parsimonious Model

Flow Chart of the Model

- à la Obstfeld (2001)
- Two-country model
- Wage + Price (on final goods) rigidity
- Trade in intermediate goods, flexible price



Household

- Household: consumer of the final goods + monopoly of her own type of labor
- Preset wage \Leftarrow wage rigidity

$$\begin{aligned} \max_{W_t, \{C_{jt}\}, B(\cdot)} \quad & \mathbb{E}_{t-1} \left[\frac{C_t^{1-\rho}}{1-\rho} - \frac{1}{\nu} L_t^\nu \right] \\ \text{s.t.} \quad & C_t = \left(\int_0^1 C_{jt}^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}} \\ & P(\lambda^t) C(\lambda^t) + Q(\lambda^{t+1} | \lambda^t) B(\lambda^{t+1}) \\ & = W(\lambda^t) L(\lambda^t) + B(\lambda^t) + \Pi(\lambda^t), \quad \forall \lambda_t \end{aligned}$$

Labor Union and Intermediate-Goods Producer_____

- Union: $\{L_{it}\} \implies L_t = \left(\int_0^1 L_{it}^{\frac{\zeta-1}{\zeta}} di \right)^{\frac{\zeta}{\zeta-1}}$
- Perfect competitive market for intermediate goods:
 $L_t \implies \tilde{Y}_t = A_t L_t$
- No nominal rigidity: Union charges producer to a markup of $\tilde{W}_t = \frac{\zeta}{\zeta-1} W_t$, and intermediate goods producers sells at marginal cost $\tilde{P}_t = \frac{\tilde{W}_t}{A_t}$

Final-Goods Producer

- Final goods production: $\left(\alpha^{\frac{1}{\eta}} \widetilde{Y}_t^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} \widetilde{Y}_t^{* \frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$
 \Leftarrow intermediate goods trade
- Price is preset \Leftarrow price rigidity

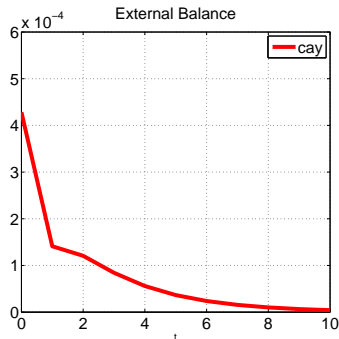
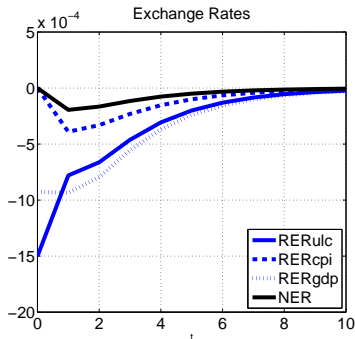
$$\max_{P_{jt}} \mathbb{E}_{t-1} \left[\left((P_{jt} - MC_{jt}) C_{jt} \right) \frac{C_t^{-\rho}}{P_t} \right] \quad \text{for each } j \in [0, 1]$$

$$s.t. \quad C_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\theta} C_t$$

$$MC_{jt} = \left[\alpha \left(\frac{\widetilde{W}_t}{A_t} \right)^{1-\eta} + (1-\alpha) \left(\frac{\widetilde{W}_t^*}{A_t^* S_t} \right)^{1-\eta} \right]^{\frac{1}{1-\eta}}$$

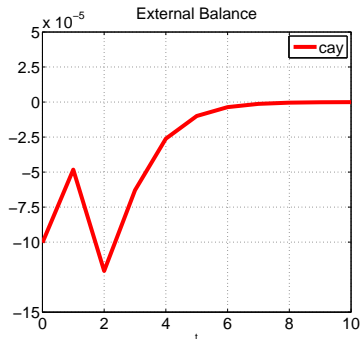
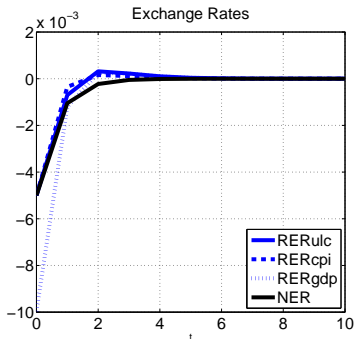
- To close the model, we assume monetary policy as $M_t = P_t Y_t$
- Standard parameterization to quarterly frequency

Impulse Response: Productivity Shock



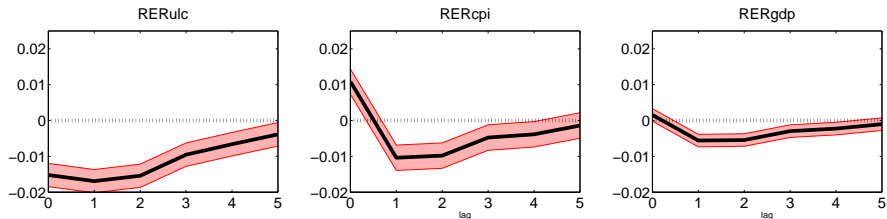
- $A \uparrow + P \text{ preset} \implies C \leftrightarrow \implies S \leftrightarrow$
- $\text{Preset } P \implies \text{REER-CPI} \leftrightarrow$
- $\text{Preset } W \implies \text{ULC} \downarrow \implies \text{REER-ULC} \downarrow$

Impulse Response: Monetary Policy Shock_____



- $M \uparrow + P \text{ preset} \implies C \uparrow \implies \text{external deficit}$
- To facilitate consumption tilting towards home, $S \downarrow \implies \text{REERs} \downarrow$

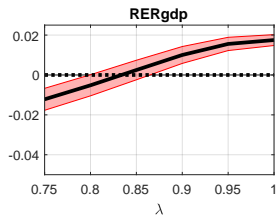
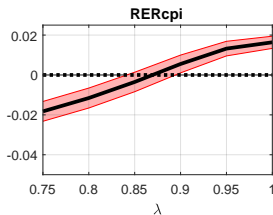
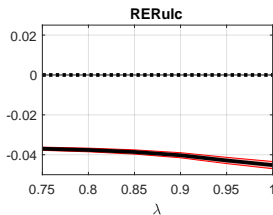
Simulated Correlation



4000 periods simulation \Rightarrow simulated contemporaneous moment and lagged correlation

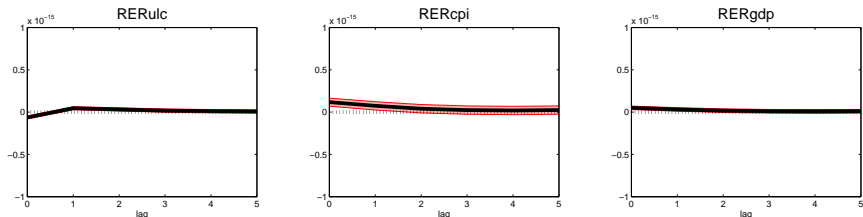
- Contemporaneous negative correlation only in REER-ULC
- Lagged negative relationship in all

The Role of Nominal Rigidity



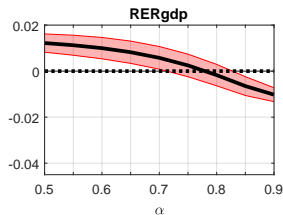
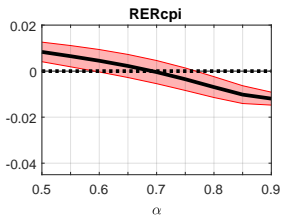
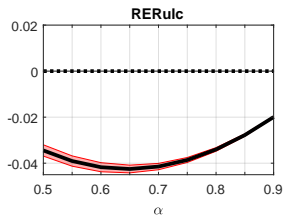
- Final goods price needs to be rigid enough to limit the pass-through of shocks to CPI
- Wage needs to be rigid to maximize the pass-through of shocks to ULC

The Role of Intermediate Goods Trade



- If only final goods are tradable, then preset final goods price mutes the change in external balance
- The emphasis on intermediate goods trade aligns well with the growing importance of intermediate goods trade
 - e.g. Miroudot et al. (2009), "trade in intermediate inputs takes place mostly among developed countries and represents respectively 56% and 73% of overall trade flows in goods and services"

Expenditure Switching vs. Intertemporal Adjustment



- RERs affect external balance through both expenditure-switching channel and intertemporal adjustment channel
- The higher the home bias is, the lower the expenditure-switching channel
- Home bias needs to be moderate for foreign export to response to RER changes through expenditure-switching channel

Summary and Conclusion

- Lost link? No, depends on which REER
 - Strong negative correlation for REER-ULC and external balance, but not for REER-CPI/-GDP deflator
- Aligns well with a standard model with wage/price rigidity and intermediate goods trade
- Disconnection between REER-CPI and external balance \neq lost link
- No "best" REER but only "most suitable" REER

Extra Slides

List of Countries

Australia, Austria, Belgium, Bulgaria, Canada, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, United Kingdom, United States

Unit Root Test

- Unit root can not be rejected in most tests for *CA/GDP* and *REERs*.

	cagdp	ln REER ulc	ln REER cp
Quarterly			
<i>H₀ : Unit Root</i>			
Levin-Lin-Chu	0.45	0.04	0.00
Harris-Tzavalis	0.00	0.93	0.24
Breitung	0.02	0.61	0.16
Fisher-type(inverse Chi-square)	0.15	0.95	0.19
Fisher-type(inverse Normal)	0.36	0.88	0.11
Fisher-type(inverse Logit)	0.29	0.88	0.11
Fisher-type(Modified Inverse Chi-Square)	0.15	0.94	0.20
<i>H₀ : Stationary</i>			
Hadri	0.00	0.00	0.00
Annual			
<i>H₀ : Unit Root</i>			
Levin-Lin-Chu	0.77	0.24	0.02
Harris-Tzavalis	0.00	0.58	0.05
Breitung	0.07	0.27	0.23
Fisher-type(inverse Chi-square)	0.20	0.92	0.74
Fisher-type(inverse Normal)	0.61	0.98	0.62

Cointegration Test

- No cointegration can be rejected in most tests.

with cagdp	ln REER ulc	ln REER cpi	ln REER gdp
Quarterly			
Pedroni	0.00	0.04	0.00
West			
Gt	0.00	0.00	0.00
Ga	0.00	0.00	0.00
Pt	0.00	0.00	0.00
Pa	0.00	0.00	0.00
Annual			
Pedroni	0.00	0.00	0.00
West			
Gt	0.00	0.02	0.00
Ga	0.40	0.51	0.45
Pt	0.00	0.00	0.00
Pa	0.00	0.00	0.00

Robustness Check: Annual Data

- Longer (but less frequent) time series give similar results.

	(1) ulc b/se	(2) cpi b/se	(3) gdp b/se
ec			
LR_DD	-0.028 (0.02)	-0.064** (0.02)	-0.047** (0.02)
LR_FD	0.099** (0.04)	0.107** (0.04)	0.108** (0.04)
LR_REER	0.006 (0.06)	0.138* (0.08)	0.059 (0.07)
SR			
SR_ec	-0.272*** (0.03)	-0.268*** (0.03)	-0.271*** (0.03)
SR_DD	-0.033*** (0.01)	-0.072** (0.03)	-0.060** (0.02)
SR_FD	-0.036 (0.04)	0.001 (0.06)	-0.008 (0.05)
SR_REER	-0.048*** (0.01)	0.036 (0.05)	0.011 (0.03)
obs	665	665	665

Parameterization

time discount factor	β	0.99
elasticity of substitution (final goods)	θ	6
elasticity of substitution (labor)	ζ	6
elasticity of substitution (home vs. foreign)	η	1.6
risk aversion	ρ	2
Frisch elasticity	ν	1
home bias in final goods production	α	0.75
persistence in productivity shock	ρ_a	0.65
persistence in monetary policy shock	ρ_m	0.35

$$\epsilon_t^A \sim \mathcal{N}(0, \sigma_A^2), \quad \sigma_A = 0.0015$$
$$\epsilon_t^M \sim \mathcal{N}(0, \sigma_M^2), \quad \sigma_M = 0.0020$$

Impulse Response: Productivity Shock

