Real Exchange Rate Behavior: New Evidence from Matched Retail Prices

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Motivation

- Classic question: how are tradable goods' prices and exchange rates related?

- A vast literature attempts to characterize the level and behavior of the the Real Exchange Rate

$$q_t^{yz} = \frac{p^y}{p^z} * e^{zy}$$

- Common finding → little co-movement between relative prices in local currencies (RP) and nominal exchange rates (NER), particularly at the retail level

  - The RER co-moves with the NER
  - Passthrough is low (Goldberg and Knetter (97), Burstein and Gopinath (2011))
  - RER shocks are persistent → PPP Puzzle (Rogoff (96))
  - RER for tradeables is just as volatile as for non-tradeables (Engel (99))

Motivation

- No consensus on possible explanations
  - Retail markets are segmented by high transportation and distribution costs (Burstein et al 2003)
  - Retail markups differ over time and space (Atkenson and Burstein 2008)
  - Biases from sectoral aggregation (Imbs et al 2005)
  - Biases from temporal aggregation (Taylor 2001)
  - Biases from disregard of entering and exiting goods (Nakamura and Steinsson 2012)

Motivation

- Huge Empirical Challenge
  - Most papers use CPIs and IPIs
    - Not designed for international comparisons
    - No *levels*, only changes
    - Different index methods and goods across countries
    - No account for entering and exiting varieties
  - Existing micro-datasets are limited in the number of countries (mostly US-Canada or intra-Europe), goods (eg. Big Mac index), and/or degree of product matching (eg. EIU).
  - World Bank's International Comparisons Program (ICP) → relative price levels and PPPs for an identical basket in dozens of countries
    - Extremely low frequency (5 years or more)

Motivation

Taylor (Econometrica 2001, on PPP puzzle)

"To meet the desired standard we would be **hoping that hundreds of price inspectors** would leave a hundred or more capital cities on the final day of each month, **scour every market** in all representative locations**, for all goods**, and come back at the end of a very long day, with a **synchronized set of observations** from Seoul to Santiago, from Vancouver to Vanuatu. **We cannot pretend that this happens**."

What we do

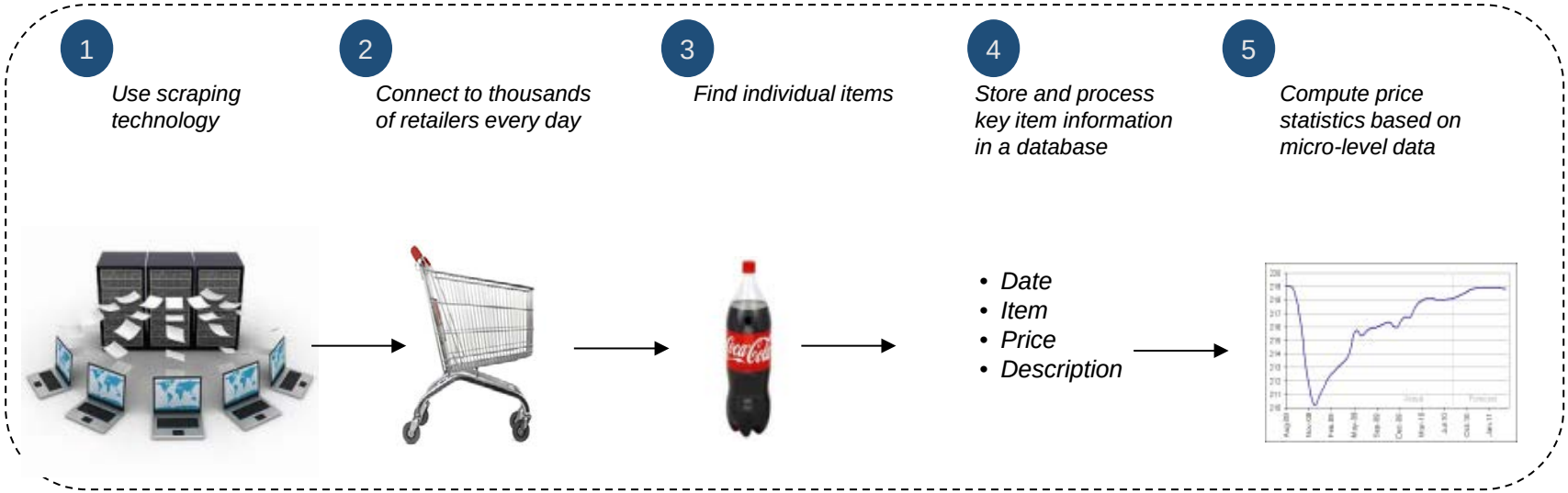
- We use web-scraping methods to substitute for Taylor's "hundreds of price inspectors" and achieve:
  - Better matching of products and methods (relative to CPIs)
  - Higher frequency (relative to ICP)
- Match more than 50,000 individual goods ('varieties') to approx. 350 narrow product definitions ('products') chosen to fully cover the CPI categories of food, fuel, and electronics at the retail level in 9 countries from 2010-2016.
- Compare bilateral real exchange rate behaviors using matched data and CPIs
  - Identify and quantify different measurement biases in CPI-based pass-through estimates

What we find

- Strong co-movement of nominal exchange rates and relative prices at the retail level
- Passthrough into relative prices is 75% with matched retail goods and only 34% with CPI data (same countries, sectors, and time period)
- Source of differences
  - 4 percentage points from intra-sectoral differences and multilateral formula
  - 26 percentage points from better product matching
    - Matchable goods are tradable
    - Control for bias in the relative price regression
  - 11 percentage points from product entry/ exit (prices at introduction not captured by CPIs)

Data from The Billion Prices Project

- Academic initiative at MIT (www.thebillionpricesproject.com)
- Use daily data for all goods sold by thousands of large retailers in 50 countries, collected using web-scraping methods by PriceStats (a private company)
- Research focused on inflation measurement, macro and international economics



Main Challenge: Matching Goods across Countries

- "Identical" is not really possible → barcodes, package sizes, flavors, brands, and other details vary by country

- We follow the ICP methodology:
  - Create a list of narrow product definitions → a 'product'.
  - Each individual good/ UPC we find at the store is a 'variety'.
  - Match thousands of varieties to each product.

Methodology

UN's Classification of Individual Consumption According to Purpose

1 Define a "Product"

- Very narrow product definition
- Must be available in multiple countries
- Branded and Unbranded categories

L1 Food and non-alcoholic beverages
L2 Non-alcoholic beverages
L3 Coffee, tea and cocoa
L4 Coffee
L5 Coffee
L6 Illy
L7 Beans (excluding decaf)
L7 Ground (excluding decaf)
L7 Decaf
L7 All Other
L6 All Other
L7 Beans (excluding decaf)
L7 Ground (excluding decaf)
L7 Decaf
L7 All Other

Standard COICOP Levels 1-4

CPI weights only available up to Level 3 (or 1 in some countries)

New Levels

"Product" level

Methodology

1 Define a "Product"

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Some examples of Product Definitions

Food Products	Electronics Products
Basmati White Rice	LG Basic Blu-Ray Player
Jasmine White Rice	LG Specialized Blu-Ray Player
Wheat All-Purpose Flour	Samsung Blu-Ray Player
Barilla Spaguetti (including whole grain)	Samsung Specialized Blu-Ray Player
Non-Barilla Spaguetti (including whole grain)	Sony Blu-Ray Player
Kellogg's Breakfast Cereal (excluding gluten free)	Sony Specialized Blu-Ray Player
Kellogg's Granola Breakfast Cereal	Samsung 32 Inch LED TV (excluding HD, Smart, 3D)
Non-Kellogg's Breakfast Cereal (excluding gluten free)	Philips 32 Inch LED TV (excluding HD, Smart, 3D)
Non-Kellogg's Granola Breakfast Cereal	Panasonic 32 Inch LED TV (excluding HD, Smart, 3D)
Ground Beef	Sony 44-47 Inch LED TV (Full HD, Smart, or 3D)
Chicken Breast (whole)	Toshiba 44-47 Inch LED TV (Full HD, Smart, or 3D)
Honey-Baked Ham Cold Cut	Samsung 61-65 Inch LED TV
Smoked Ham Cold Cut	LG 61-65 Inch LED TV
Low-Sodium Ham Cold Cut	Apple Ipod Shuffle 2GB
Low Fat Hot Dogs	Apple Touch 32GB
Regular Hot Dogs	Sony In-Ear Earphones
Canned Tuna in Oil	Beats In-Ear Earphones
Canned Tuna in Water	Sennheiser Over-Ear Headphones
Philadelphia Regular Cream Cheese	Skullcandy Over-Ear Headphones
Philadelphia Fat Free or Low Fat Cream Cheese	Logitech Basic Webcam
Brown Eggs	Non-Logitech Basic Webcam
White Eggs	Apple 13 Inch Macbook

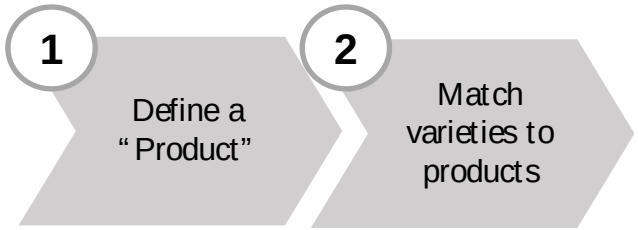
Methodology

1. Define a "Product"
2. Match varieties to products

- Very narrow product definition
- Must be available in multiple countries
- Branded and Unbranded categories

- Dozens of items per product in each country
- Different retailers, brands, and sizes

Methodology



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- *Raw data* : daily prices on all goods sold by the largest retailers in each country

- *Matched data*: Individual goods (varieties) from the raw data are linked to a product:
  - Machine learning algorithm recommends appropriate matches.
    - Naive Bayes Classifier model that trains on hand-categorized items.
  - A manual process to approve the match and enter package sizes

- High product churn (intro and exit), particularly with electronics

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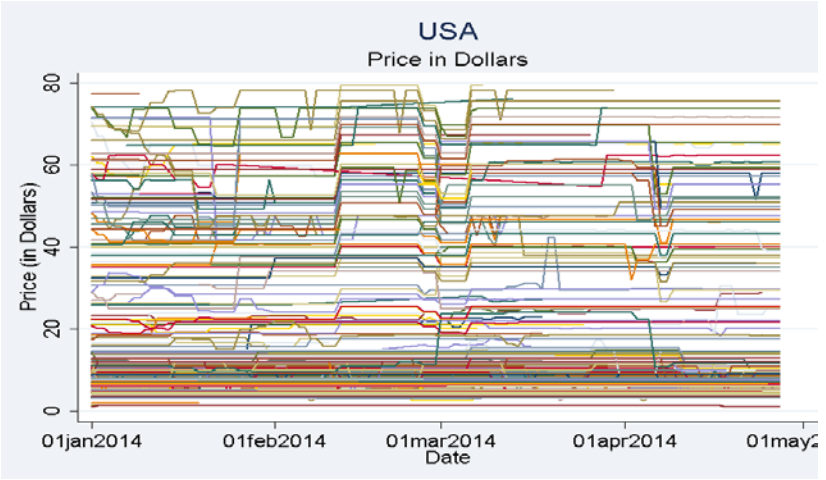
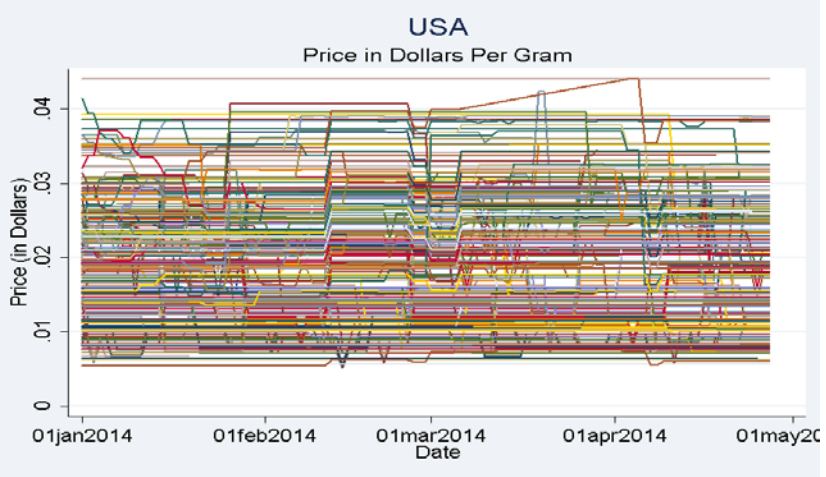
Ground Coffee - Regular



Adjusting for size



Methodology

1. Define a "Product"
2. Match varieties to products
3. Product RER

- Very narrow product definition
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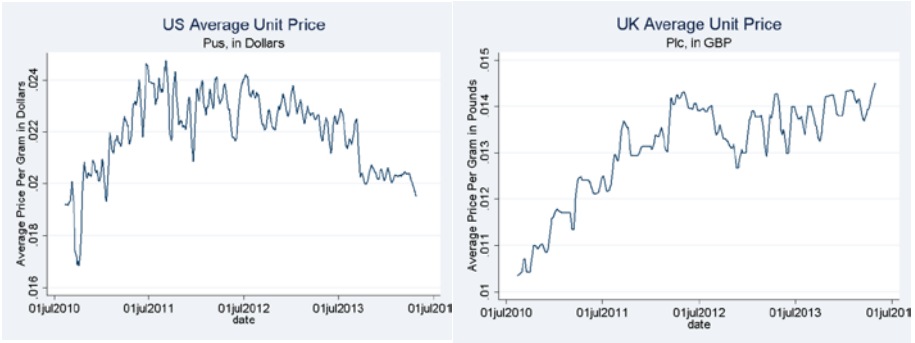
- Dozens of items per product in each country
- Different retailers, brands, and sizes

- Product availability varies across countries and time

Ground Coffee – Regular – 1 gram

Average Price US (dollars) Average Price UK (pounds)



The price for product i, country y, time t is:

$$\ln p_{i,t}^{y} = \frac{1}{N_{i,t}^{y}} \sum_{j \in N_{i,t}^{y}} \ln p_{ij,t}^{y}.$$

where $N_{i,t}^{y}$ is the set of varieties captured by our scraping.

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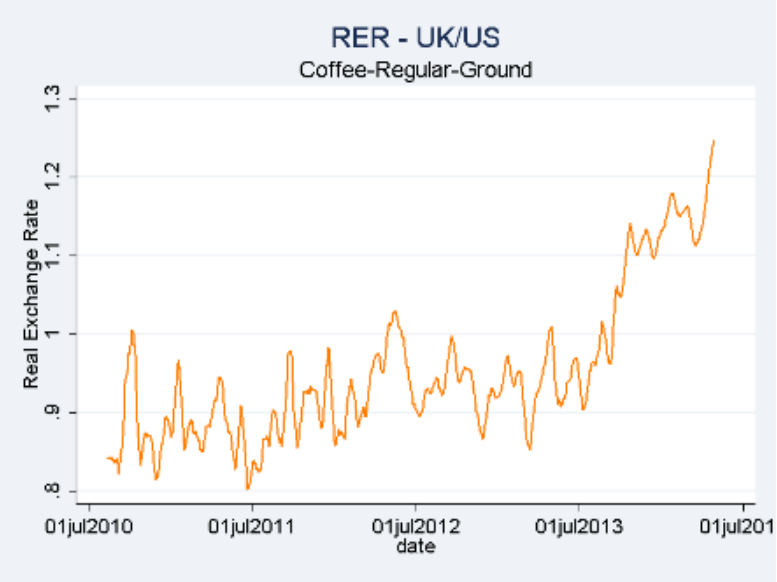
- US is always the base country

Bilateral Product RER

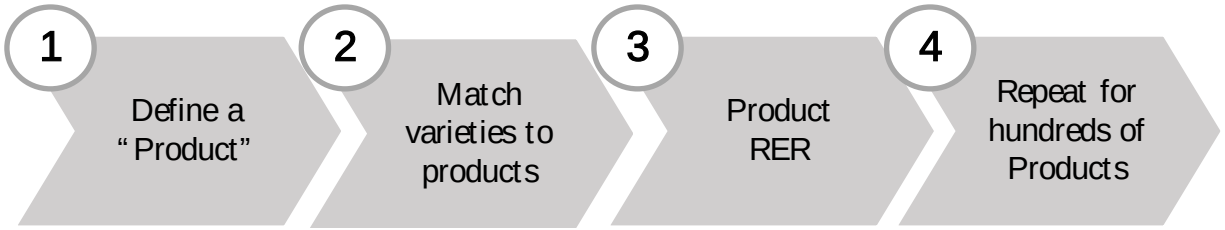
Ground Coffee – Regular – 1 gram



$$\begin{aligned}\ln\left(q_{i,t}^{yz}\right) &= \ln\left(p_{i,t}^{y}\right) - \ln\left(p_{i,t}^{z}\right) + \ln\left(e_{t}^{zy}\right) \\ &= \ln\left(rp_{i,t}^{yz}\right) + \ln\left(e_{t}^{zy}\right),\end{aligned}$$

The nominal exchange rate e_t^{zy} is expressed as units of z per unit of y (increase is appreciation of y)

Methodology



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- CPI weights are not available below Level 3 COICOP.
- Some countries only publish L1 weights
- China does not publish any weights.

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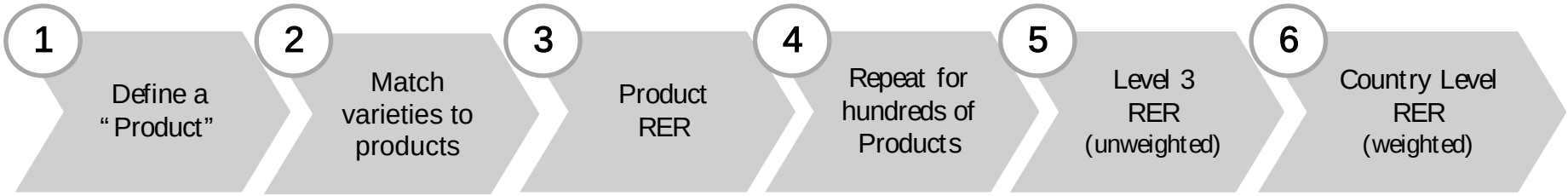

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- Food
- Fuel
- Electronics

- 3 Sectors
- Ex-Fuel

Matched Dataset

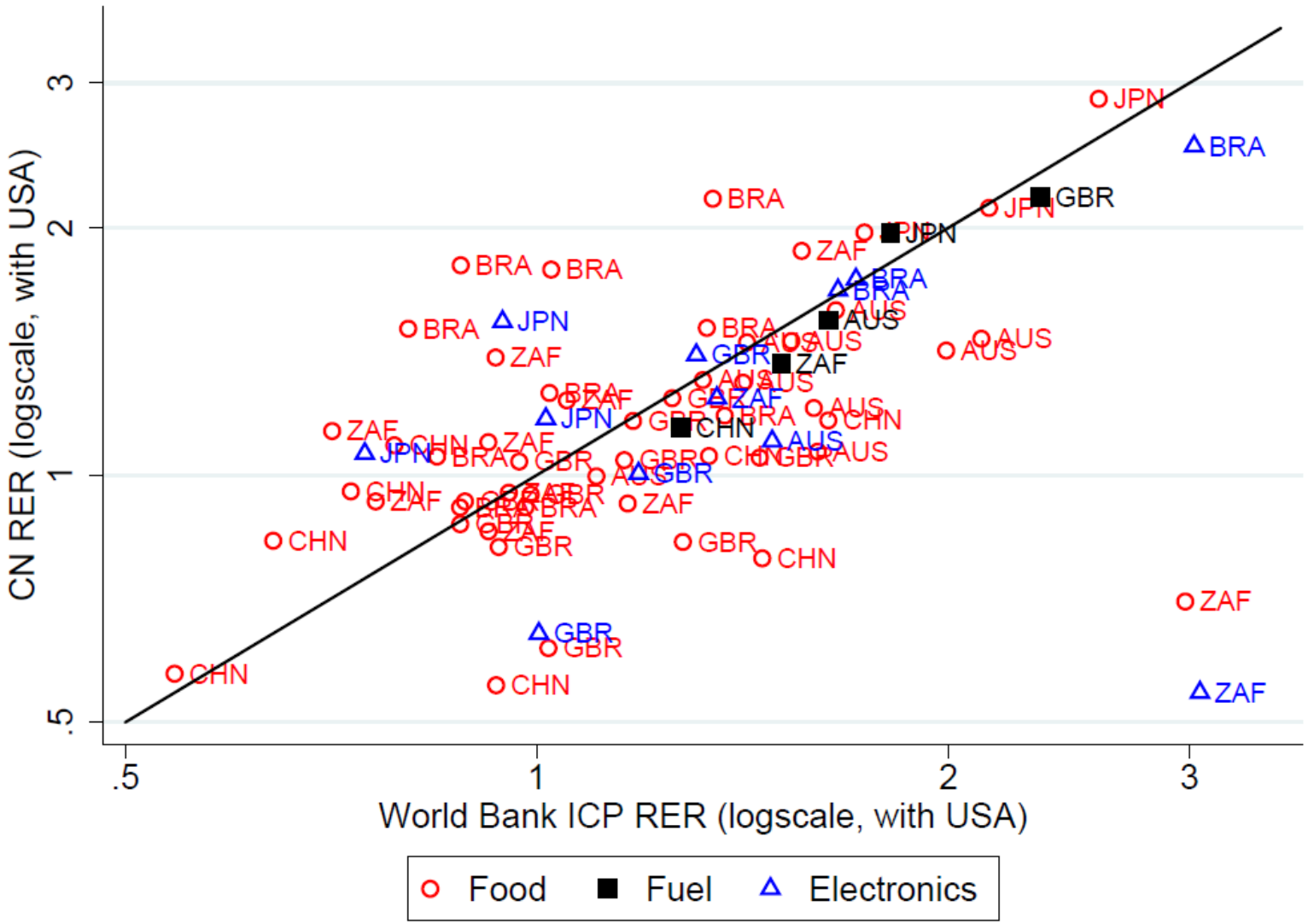
Country	Sector	Start Date	Products	Median Varieties per Product
Argentina (ARG)	Food and non-alcoholic beverages	2008:Q1	112	28
	Fuels and lubricants	2008:Q1	3	1
	Recreation and culture	2011:Q2	79	5
Australia (AUS)	Food and non-alcoholic beverages	2008:Q4	123	17
	Fuels and lubricants	2008:Q3	4	1
	Recreation and culture	2011:Q4	85	4
Brazil (BRZ)	Food and non-alcoholic beverages	2008:Q1	123	22
	Fuels and lubricants	2012:Q1	2	1
	Recreation and culture	2011:Q4	88	6
China (CHN)	Food and non-alcoholic beverages	2008:Q4	112	18
	Fuels and lubricants	2010:Q3	4	26
	Recreation and culture	2013:Q1	104	33
Germany (DEU)	Food and non-alcoholic beverages	2008:Q4	95	9
	Fuels and lubricants	2008:Q1	2	1
	Recreation and culture	2012:Q4	43	2
Japan (JPN)	Food and non-alcoholic beverages	2010:Q3	64	8
	Fuels and lubricants	2008:Q1	2	1
	Recreation and culture	2013:Q4	79	23
South Africa (ZAF)	Food and non-alcoholic beverages	2010:Q4	88	5
	Fuels and lubricants	2008:Q1	3	1
	Recreation and culture	2011:Q2	61	4
United Kingdom (GBR)	Food and non-alcoholic beverages	2010:Q3	139	22
	Fuels and lubricants	2009:Q1	3	1
	Recreation and culture	2010:Q3	106	11
United States (USA)	Food and non-alcoholic beverages	2008:Q2	180	27
	Fuels and lubricants	2008:Q3	4	43
	Recreation and culture	2008:Q1	124	20

Table 1: Summary Statistics

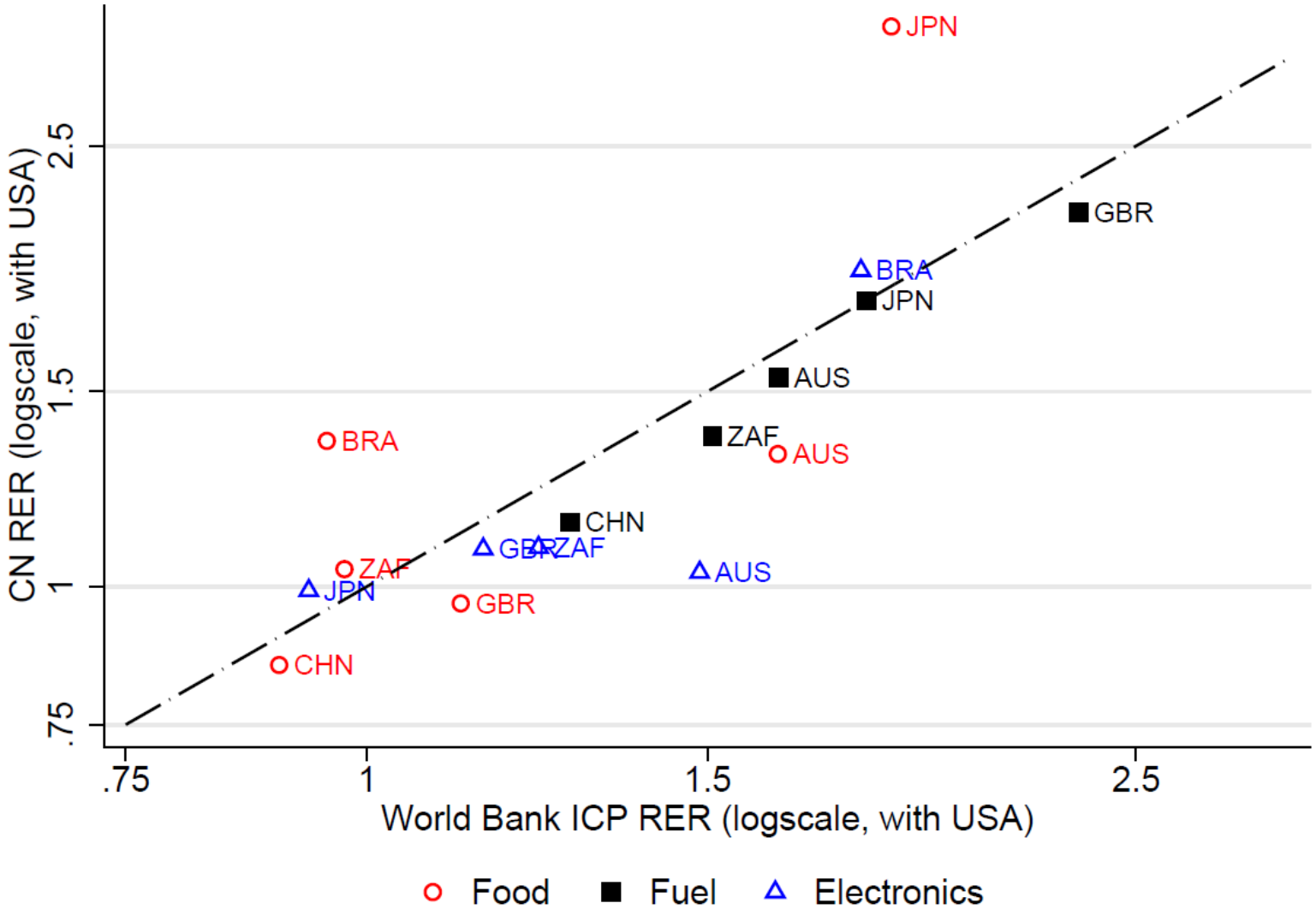
Compared to other Price Level Databases

	Online Data	World Bank ICP - OECD - Eurostat	Cost of Living Indices (EIU, Mercer, others)	Single-Product (Big Mac, Ikea Billy)
Coverage	Goods (mostly tradables)	Goods and Services	Goods and Services	-
Countries	9	164	93	120, 38
Products	350	1107 (409 in food, fuel, electronics)	150	1
Varieties per product	30	10-15 if homogeneous, 70-100 heterogeneous	?	1
Product Matching	Close	Close	Broad	Identical
Comparable over time	Yes	Complicated (methods change)	Yes	Yes
Frequency	Daily/ Monthly	5 years (3 OECD)	Annual	Quarterly / Monthly

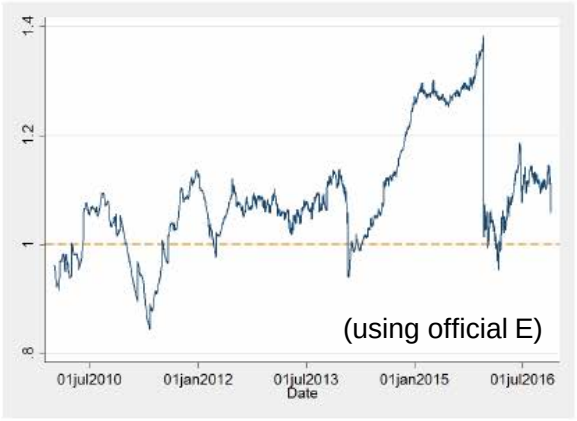
2011 Comparison with World Bank's ICP at 3-digit level



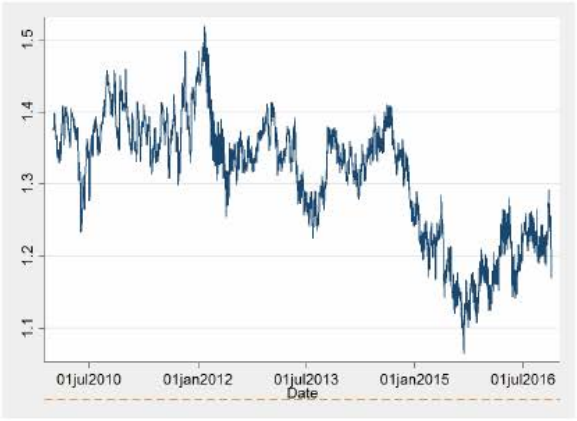
2011 Comparison with World Bank's ICP at 1-digit level



Real Exchange Rates and Components (3 sectors)



(a) ARGENTINA RER



(b) AUSTRALIA RER

(c) BRAZIL RER

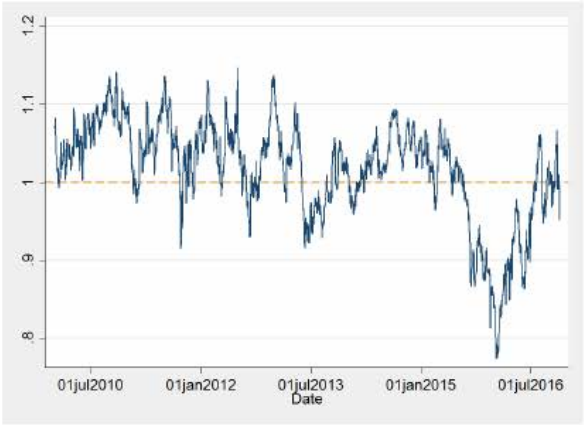
(d) ARGENTINA RP & E

(e) AUSTRALIA RP & E

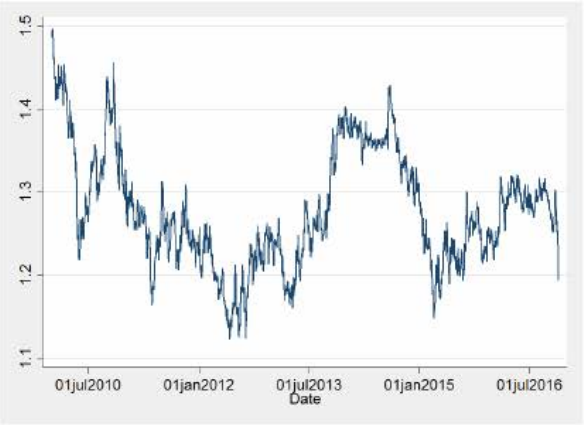
(f) BRAZIL RP & E

Figure A.23: Real Exchange Rates, Relative Prices, and Nominal Exchange Rates - All Sectors

Real Exchange Rates and Components (3 sectors)



(a) SOUTHAFRICA RER



(b) GERMANY RER

(c) ARGENTINA BLACK MARKET RER

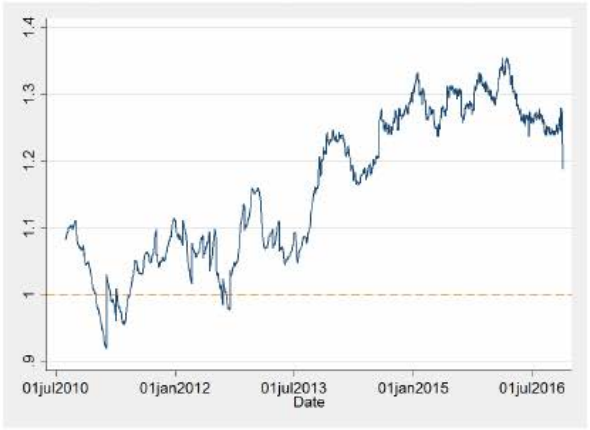
(d) SOUTHAFRICA RP & E

(e) GERMANY RP & E

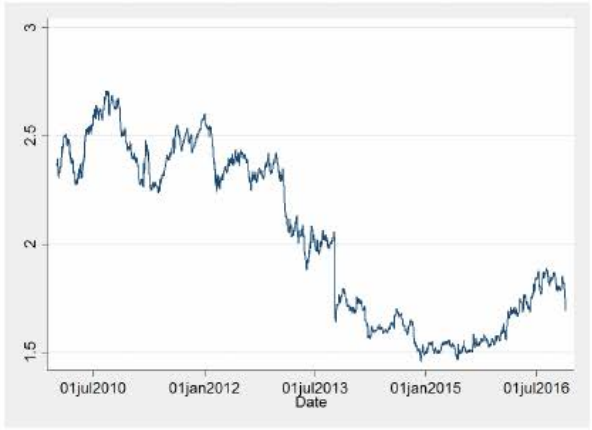
(f) ARGENTINA BLACK MARKET RP & E

Figure A.24: Real Exchange Rates, Relative Prices, and Nominal Exchange Rates - All Sectors

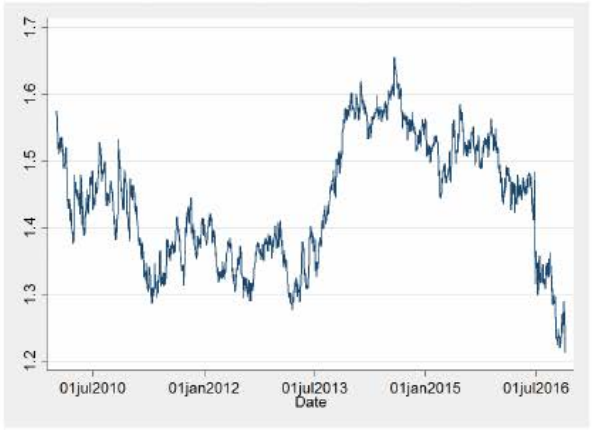
Real Exchange Rates and Components (3 sectors)



(a) CHINA RER

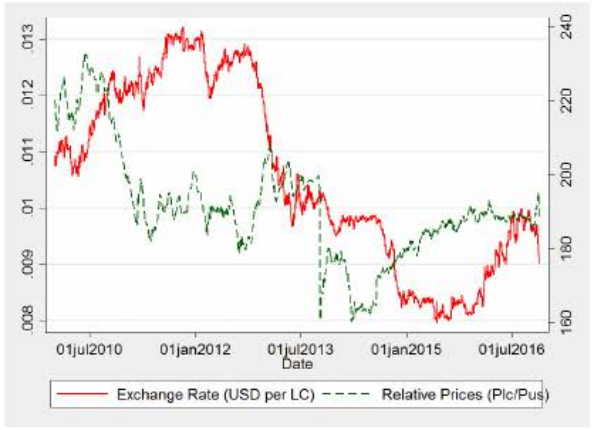


(b) JAPAN RER

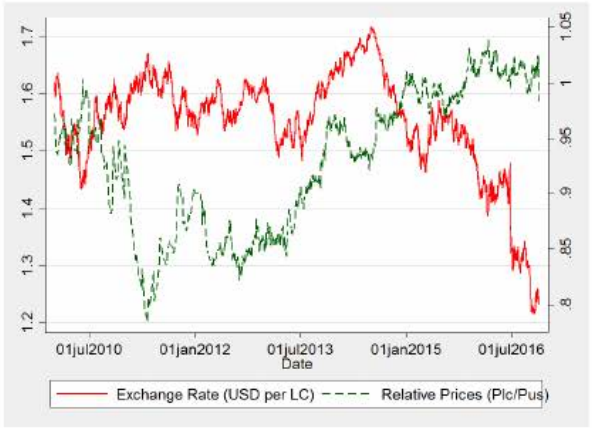


(c) UK RER

(d) CHINA RP & E



(e) JAPAN RP & E



(f) UK RP & E

Relative Prices and Exchange Rates

- Graphs suggest strong co-movement of relative prices and exchange rate
  - Not seen in the literature with CPIs, where RPs for tradable goods are far more stable

- Many ways to quantify this:
  - Correlations and Granger Causality
  - AR1s and Stationarity Tests
  - Vector Error Correction Models
  - **Passthrough regressions**

Relative Passthrough Regressions

- We estimate a simple passthrough regression with relative price *levels*

$$\ln\left(rp_t^{yz}\right) = \alpha^{yz} + \beta \ln\left(e_t^{zy}\right) + \epsilon_t^{yz},$$

- We find
  - β = - 0.75 with matched retail prices
  - β = - 0.34 with CPIs (same countries, sectors, period)
- Literature (differences in method)
  - ~ -0.3 with CPIs
  - ~ -0.5 with IPIs (at the dock)

Relative Passthrough is 75% on average

Relative Price	3 Sectors (1)	Ex-Fuel (2)	Food (3)	Fuel (4)	Electronics (5)
(1) All Countries	-0.749	-0.721	-0.738	-0.955	-0.553
	(0.013)	(0.025)	(0.027)	(0.016)	(0.031)
(2) Argentina	-0.790	-0.987	-1.010	-0.914	-0.988
	(0.029)	(0.055)	(0.058)	(0.041)	(0.105)
(3) Australia	-0.655	-0.508	-0.577	-0.855	-0.164
	(0.027)	(0.044)	(0.052)	(0.031)	(0.065)
(4) Brazil	-0.852	-0.575	-0.592	-1.383	-0.392
	(0.042)	(0.052)	(0.053)	(0.057)	(0.062)
(5) China	-1.122	-0.921	-1.062	-1.690	-0.369
	(0.154)	(0.143)	(0.169)	(0.367)	(0.115)
(6) Germany	-0.776	-0.593	-0.580	-0.920	-0.435
	(0.061)	(0.096)	(0.100)	(0.058)	(0.095)
(7) Japan	-0.208	-0.170	-0.266	-0.660	0.106
	(0.037)	(0.066)	(0.075)	(0.046)	(0.090)
(8) South Africa	-0.780	-0.591	-0.508	-0.956	-0.843
	(0.020)	(0.058)	(0.065)	(0.020)	(0.060)
(9) UK	-0.582	-0.113	-0.069	-1.330	-0.219
	(0.097)	(0.113)	(0.149)	(0.108)	(0.055)

Table 4: Passthrough Estimates

Notes: All bilaterals calculated with respect to the United States. Results for benchmark series labelled "CN Overall" in other tables.

Some potential explanations for higher pass-through

1. Difference online vs. offline prices

1. Differences in Online and Offline Prices?

- Data comes from large "multi-channel" retailers that sell both online and offline

- Cavallo (2017 AER) "Are Online and Offline prices Similar?"
  - Simultaneous comparison online-offline prices using crowdsourcing + mobile phones
  - Largest retailers in 10 countries, 24K products (56 retailers, subset used for matched PPP data)
  - Online and offline prices are **identical 72% of the time**
  - Similar frequency and size of price changes

Some potential explanations for higher pass-through

1. ~~Difference online vs. offline prices~~
2. Difference in stickiness vs CPI sources

2. Difference in stickiness vs CPI data?

Category	Monthly Frequency		
	US PPP Online Data	US CPI Data Nakamura & Steinsson (08)	Ratio PPP/CPI
Panel A: Weigthed Means by Sector			
3- Sectors (matched)	46.7	48.5	0.96
Food	25.0	32.3	0.77
Fuel	96.1	87.4	1.10
Electronics	20.8	17.9	1.17

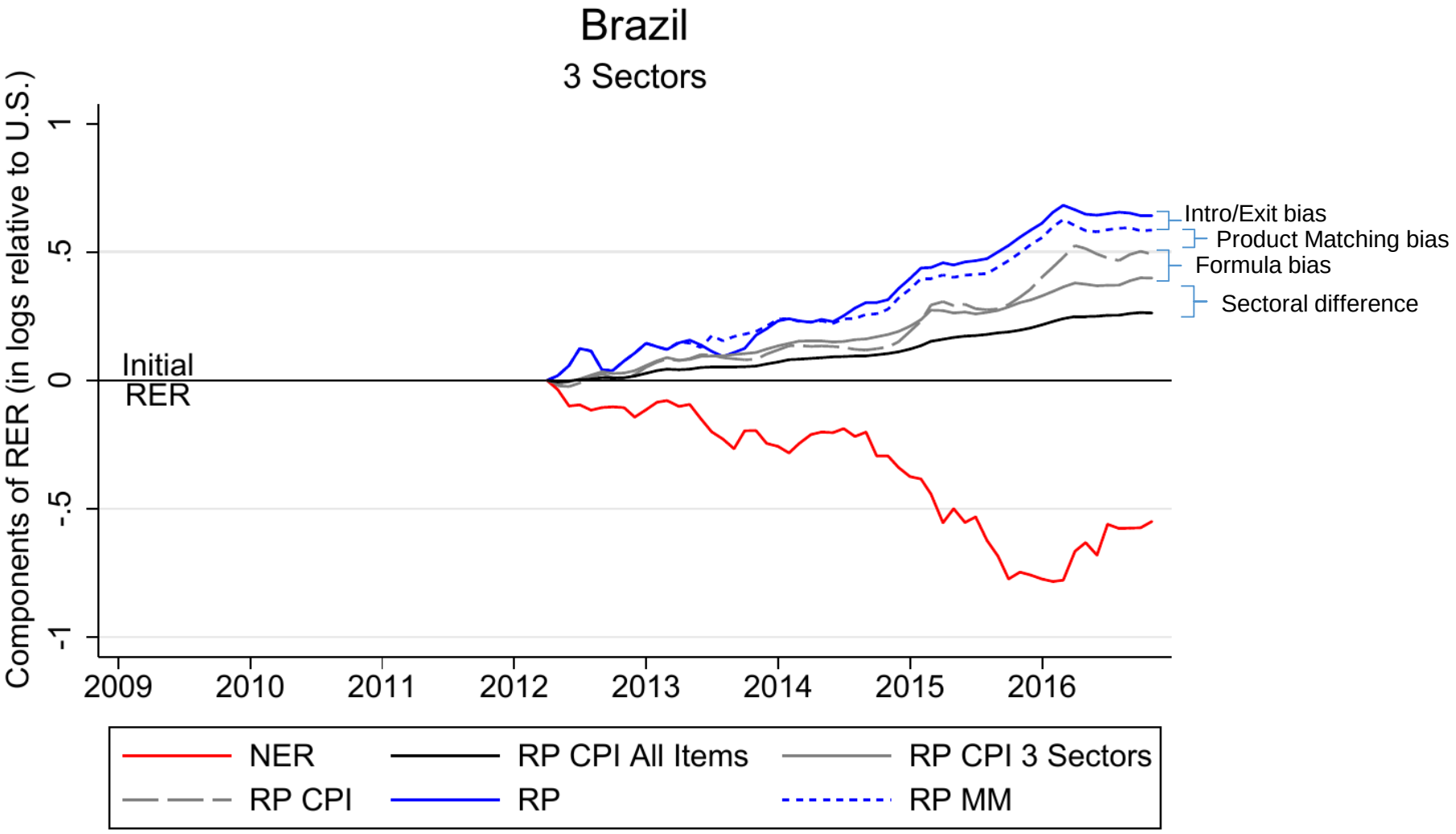
- Our PPP data is actually ***stickier*** than comparable in US CPI data (food drives this result)

- Cavallo (2016 ReStats) → measurement biases in CPI and scanner data (time averages and imputations) can make prices look more flexible than what they really are.

Some potential explanations for higher pass-through

1. ~~Difference offline vs. online prices~~
2. ~~Difference in stickiness vs CPI sources~~
3. Sector/ Compositional differences
4. Formula: CPIs cause an 'extrapolation' bias
5. Product-matching:
   - 'Matchable' goods may be more tradable \
   - Better matching in relative price regression → controls for omitted foreign prices
6. Entry/ Exit: CPIs ignore price levels at introduction and exit of products → some price adjustment can happen via variety entry/ exit

Measurement Biases in Real Exchange Rates



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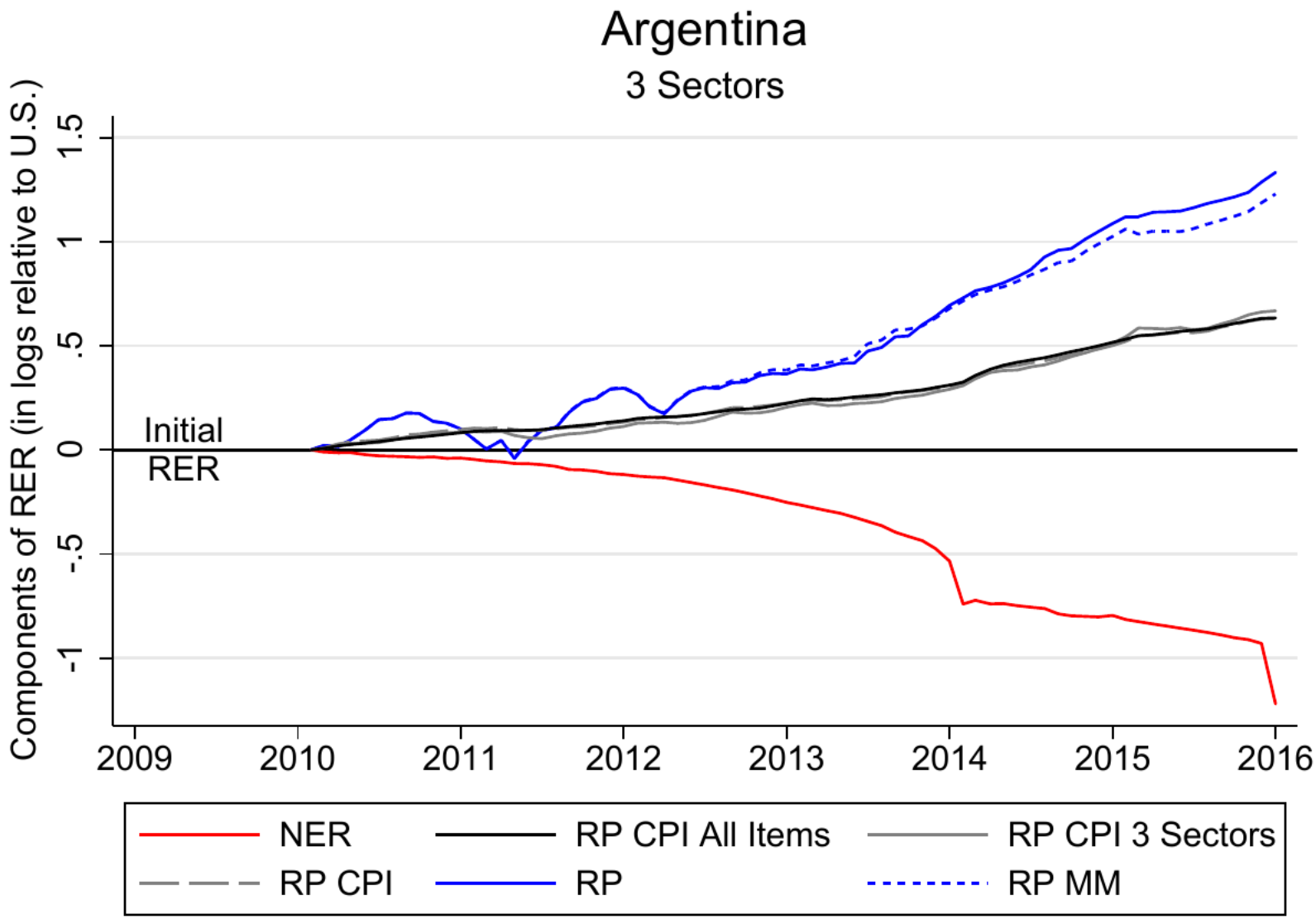
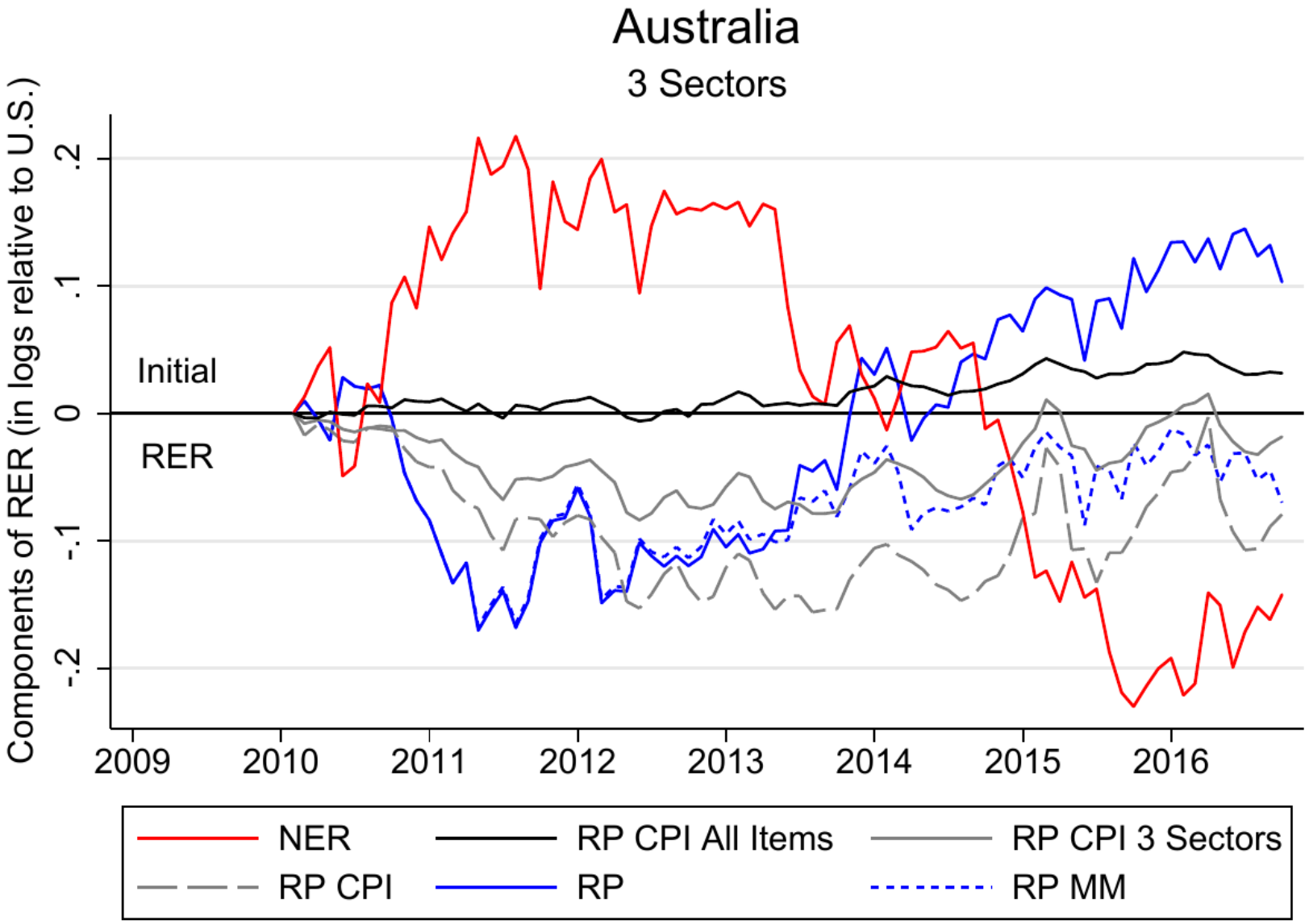


Measurement Biases in Real Exchange Rates



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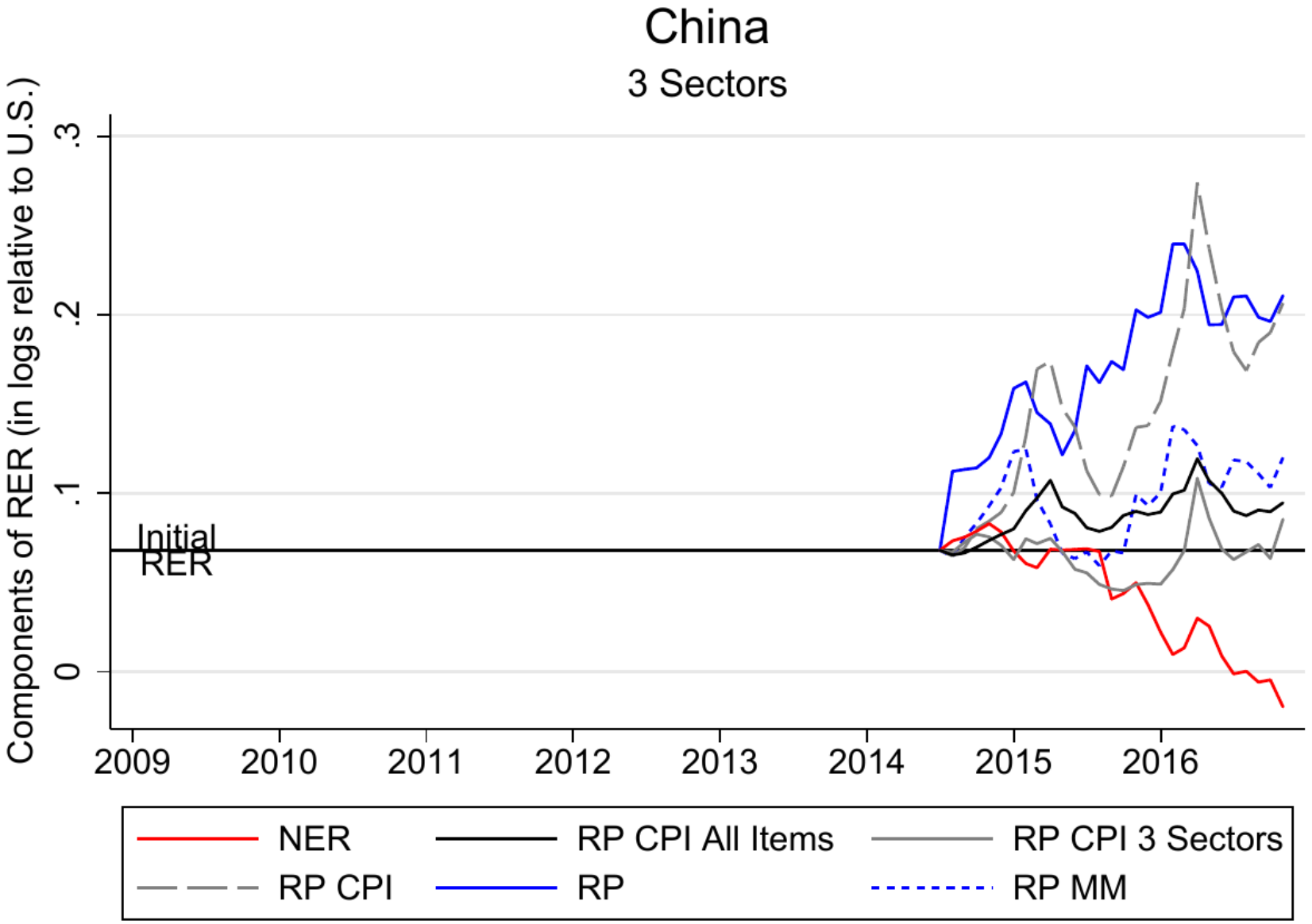

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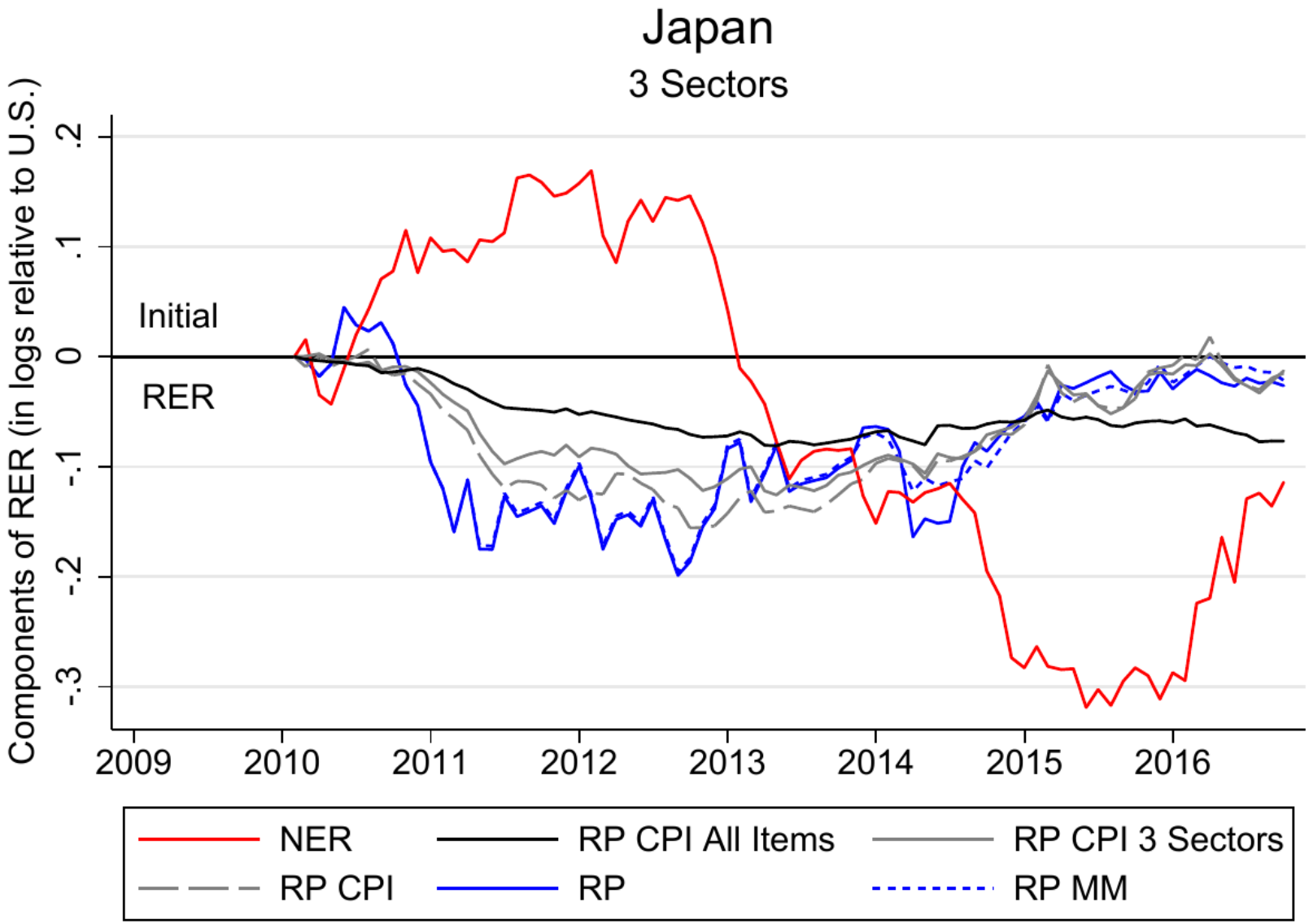

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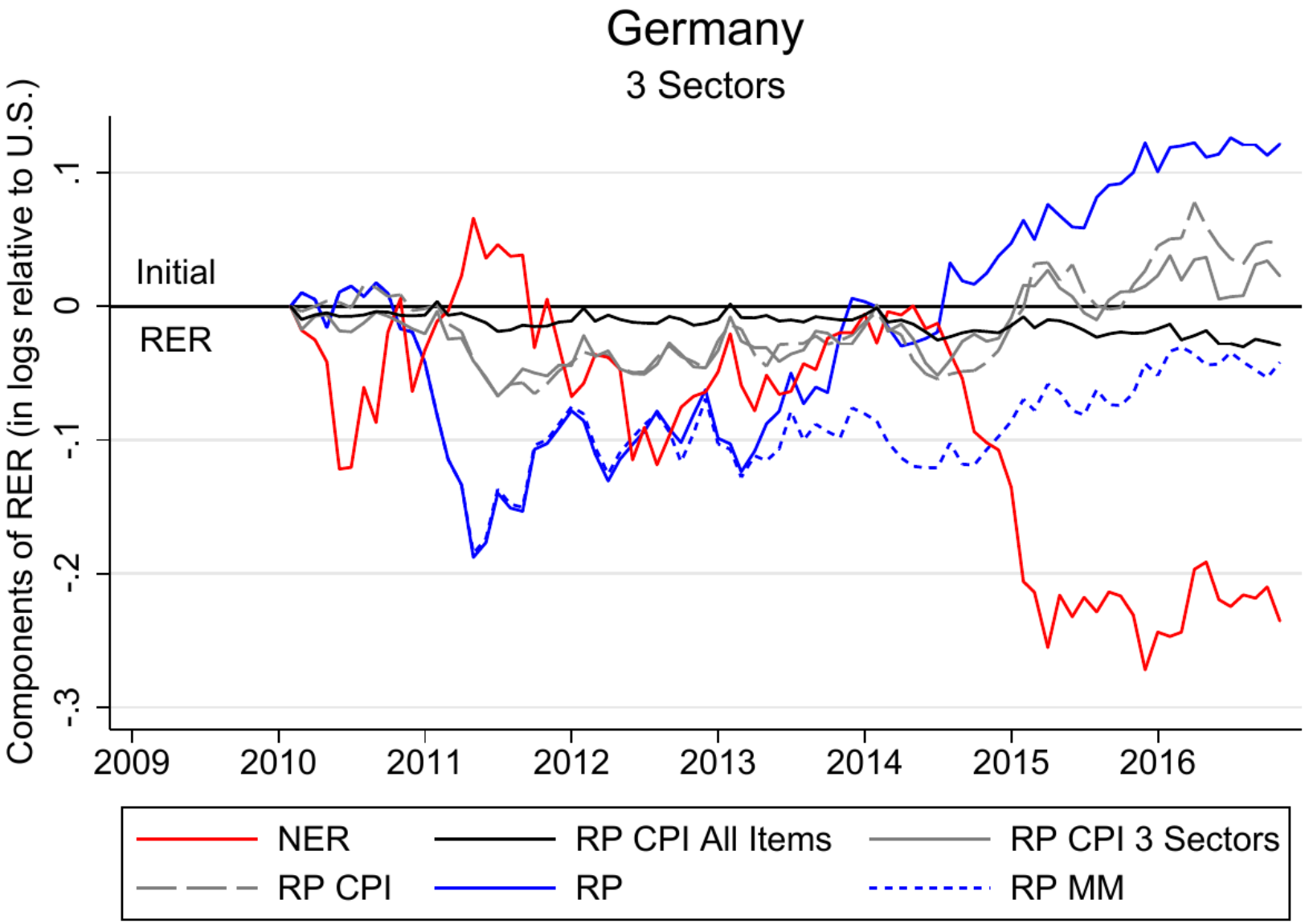

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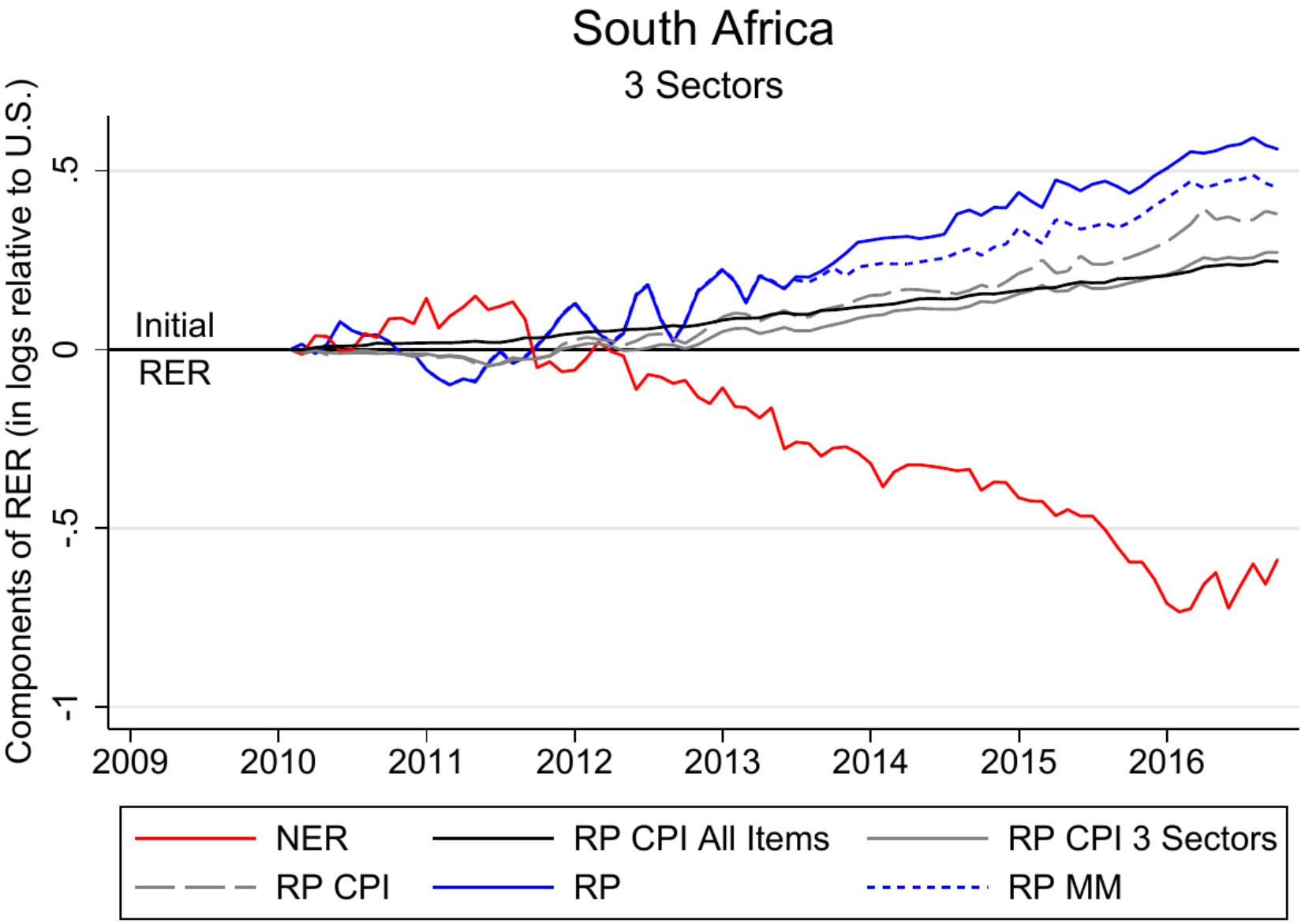

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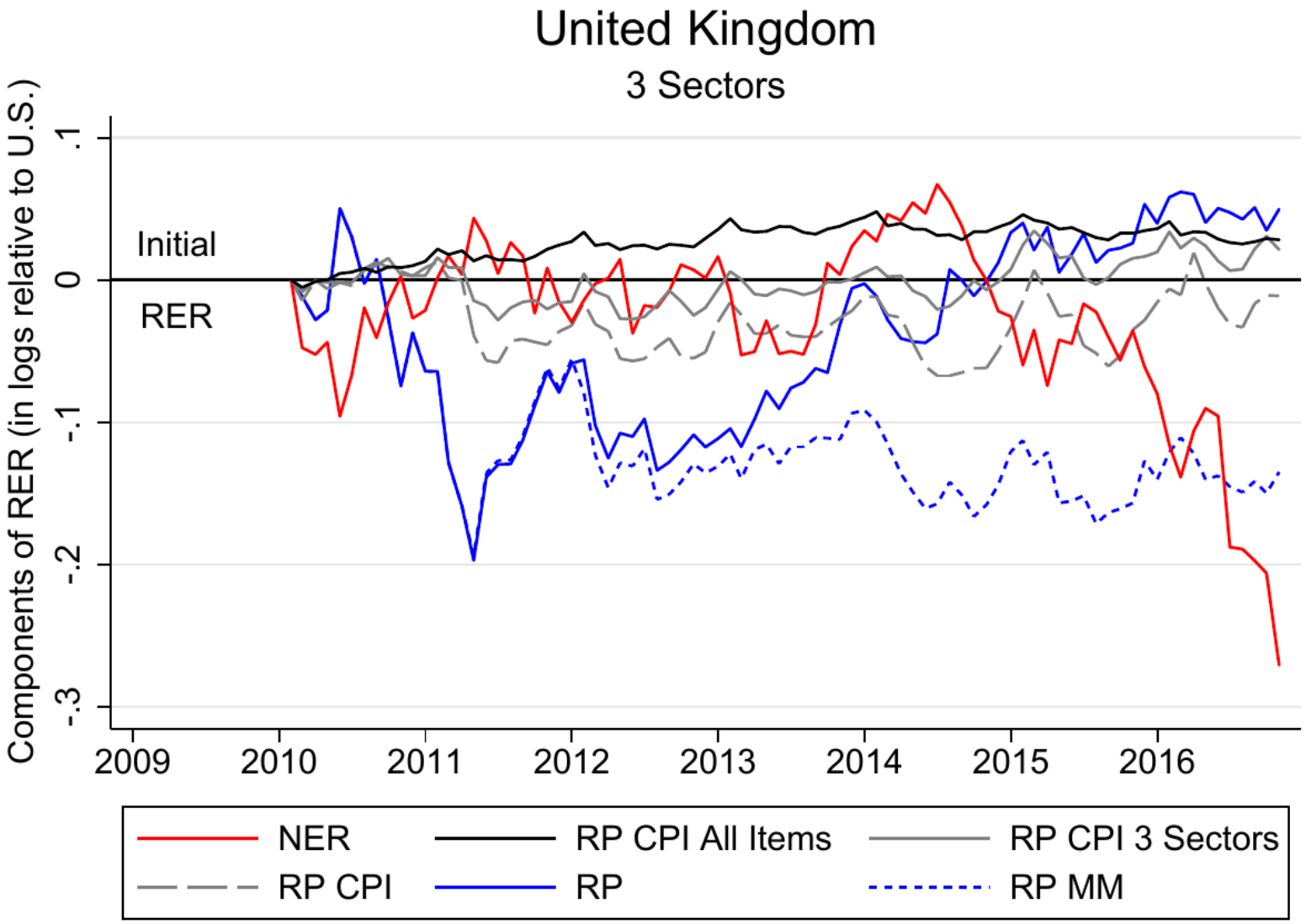

Main Sources of Measurement Bias

Price Measure	Relative Price					Price	
	3 Sectors	Ex-Fuel	Food	Fuel	Electronics	3 Sectors	3 Sectors -USA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) CPI All items	-0.296					-0.374	-0.208
	(0.007)					(0.007)	(0.032)
(2) CPI 1-Digit	-0.344	-0.269	-0.251	-0.452	-0.183	-0.361	0.040
	(0.008)	(0.013)	(0.014)	(0.010)	(0.023)	(0.008)	(0.041)
(3) CPI 3-Digit	-0.414	-0.299	-0.278	-0.743	-0.219	-0.357	0.355
	(0.011)	(0.015)	(0.015)	(0.021)	(0.031)	(0.010)	(0.063)
(4) CPI 3-Digit Fisher	-0.376	-0.268	-0.268	-0.701	-0.194	-0.344	0.431
	(0.010)	(0.015)	(0.014)	(0.019)	(0.028)	(0.010)	(0.062)
(5) PPP Matched Model	-0.638	-0.475	-0.513	-0.948	-0.117	-0.557	
	(0.013)	(0.024)	(0.022)	(0.016)	(0.040)	(0.019)	
(6) PPP Overall	-0.749	-0.721	-0.738	-0.955	-0.553		
	(0.013)	(0.025)	(0.027)	(0.016)	(0.031)		
(7) PPP Overall Branded		-0.662	-0.661		-0.586		
		(0.026)	(0.028)		(0.033)		
(8) PPP Overall Unbranded		-0.69	-0.736	-0.955	-0.348		
		(0.026)	(0.028)	(0.016)	(0.047)		

Table 4: Long-Run Passthrough Estimates - All countries

Sectoral differences

- "Goods CPI" is a rough proxy for tradables (eg. Engel (99)) → non-tradables in categories and sub-categories

- We construct two CPI series for each country:

  - 1-digit CPI : uses official CPIs for level 1 sectors in our data ("Food and Beverages", "Transportation", and "Recreation and Culture")

  - 3-digit CPI: uses level 3 official CPIs (where available), to build an aggregate CPI that excludes sub-sectors that are not in our data → eg non-tradable services, eg. public transport, packaged holidays

Main Sources of Measurement Bias

Same Sector (food, fuel, elect)

Same subsectors

Price Measure	Relative Price					Price	
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Table 4: Long-Run Passthrough Estimates - All countries

Formula or "Extrapolation" Bias

- Following the international comparisons (ICP) literature, we measure RERs using Fisher indices that start with 3-digit relative prices and aggregate up using expenditure weights from both countries.

- When computing RERs with CPIs, the standard procedure is to first get the aggregate CPI in each country separately, and then compute the ratio.

- This can cause a formula or "extrapolation bias" [see Deaton (2012) and Inklaar and Rao (2016)] than affects the passthrough estimates.

$$\triangle \ln rp_t^{yz} = \triangle \ln p_t^y - \triangle \ln p_t^z + \frac{1}{2}\left[\sum_i^N (s_i^z - s_i^y)(\ln \frac{p_{i,t}^y}{p_{i,t-1}^y} + \ln \frac{p_{i,t}^z}{p_{i,t-1}^z})\right]$$

Main Sources of Measurement Bias

Price Measure	Relative Price					Price	
	3 Sectors	Ex-Fuel	Food	Fuel	Electronics	3 Sectors	3 Sectors -USA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
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Table 4: Long-Run Passthrough Estimates - All countries

Formula bias

Main Sources of Measurement Bias

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PPP Data (matched products)

Table 4: Long-Run Passthrough Estimates - All countries

Matched Data

- Row (5) is an index that uses matched data (but does not yet incorporate the effect of entry and exit price levels)
- Passthrough rises 26 percentage points
- Why?

Matched products

1. Products that can be matched across countries must be tradable

Category	Country	Monthly Frequency		
		PPP Online Data	BPP Online Data	Ratio PPP/BPP
3 Sectors	Argentina	38.4	32.2	1.19
	Australia	41.1	33.9	1.21
	Brazil	52.4	38.5	1.36
	China	30.2	16.7	1.82
	Germany	30.8	22.3	1.38
	Japan	25.8	19.5	1.33
	South Africa	37.3	23.8	1.57
	UK	43.2	35.1	1.23
	USA	48.7	30.5	1.60

Table 11: Stickiness - PPP Online Data vs BPP Online Data

Notes: The PPP online data is a sub-set of the BPP online data. It includes only the goods that are matched across countries and used for computing the bilateral RERs.

The matched-product prices change more frequently than other online goods in the BPP databases

Product Matching and Omitted Variable Bias

2. Better matching can help avoid biases in relative passthrough regression:

$$\ln\left(p_t^y\right) = \alpha + \beta \ln\left(e_t^{zy}\right) + \ln\left(p_t^z\right) + \mu_t$$

- We care about prices for the same product in y and z, and they are both correlated with the nominal exchange rate.
- A classical omitted variable bias exist if we do not include the price in country z from the equation above.
- More generally, assume we substitute $\ln\left(p_t^z\right)$ for a similar good (a "proxy") defined as

$$\ln\left(p_t^{proxy}\right) = \nu + \gamma \ln\left(p_t^z\right) + \epsilon_t$$

Product Matching and Omitted Variable Bias

- The regression being estimated is

$$\ln\left(p_t^y\right) - \nu - \gamma \ln\left(p_t^z\right) - \epsilon_t = \alpha + \beta \ln\left(e_t^{zy}\right) + \mu_t$$

- Which means that our estimate for beta will be:

$$\hat{\beta} = \beta + (1-\gamma)\frac{Cov\left(\ln\left(e_t^{zy}\right), \ln\left(p_t^z\right)\right)}{Var\left(\ln\left(e_t^{zy}\right)\right)}$$

- The last term is positive (other country's prices react in opposite direction)
- If perfect matching → gamma = 1 → no bias
- If 0< gamma <1 → estimated passthrough will greater (less negative) than the true beta

Product Matching and Error Bias

- Alternatively, assume the proxy is measured with an error term that is correlated with the exchange rate

$$\hat{\beta} = \beta + \frac{Cov\left(\ln\left(e_t^{zy}\right), -\epsilon_t\right)}{Var\left(\ln\left(e_t^{zy}\right)\right)}$$

- Bias depends on mismatch and its correlation to the NER
  - Different currency of invoicing → if each country uses good invoiced in local currency, then relative passthrough is lower
  - Different degrees of imported inputs
  - Use of varieties that are not really sold in other places (and therefore react less to the nominal exchange rate)

Main Sources of Measurement Bias

Price Measure	Relative Price					Price	
	3 Sectors	Ex-Fuel	Food	Fuel	Electronics	3 Sectors	3 Sectors -USA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
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Table 4: Long-Run Passthrough Estimates - All countries

PPP Data (matched products)

Similar to literature “at the dock” (Burstein & Gopinath 201

Product Entry/ Exit

- So far, RERs are based on standard continuing-model price indices that ignore price levels at introduction
- This can bias passthrough estimates if firms adjust to exchange rates by product replacement (Nakamura & Steinsson (2012))
- We measure average price levels for each "product" → new and exiting varieties automatically impact the measured RER
- We decompose the RER in two parts: continuing-model (MM) & extensive margin (intro and exit)

$$\Delta \ln q_{t+1}^{yz} = \underbrace{\Delta \ln \left(rp_{t+1}^{yz,MM} \right) + \ln \left(rp_{t+1}^{yz,I} \right) - \ln \left(rp_{t+1}^{yz,X} \right)}_{\Delta \ln \left(rp_{t+1}^{yz} \right)} + \Delta \ln \left(e_{t+1}^{zy} \right)$$

Main Sources of Measurement Bias

Price Measure	Relative Price					Price	
	3 Sectors	Ex-Fuel	Food	Fuel	Electronics	3 Sectors	3 Sectors -USA
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Table 4: Long-Run Passthrough Estimates - All countries

Product Intro and exit

Particularly important for electronics

More standard LRPT Regressions

- Local price passthrough regression with log changes and NER lags

Price Measure	3 Sectors 1 Month (1)	3 Sectors 6 Months (2)
(1) CPI All items	0	-0.085
	(0.006)	
(2) CPI 1-Digit	-0.011	-0.158
	(0.013)	
(3) CPI 3-Digit	-0.032	-0.32
	(0.023)	
(4) CPI 3-Digit Fisher	-0.02	-0.297
	(0.018)	
(5) CN Matched Model	-0.183	-0.466
	(0.030)	
(6) CN Overall	-0.17	-0.473
	(0.032)	

Table A.19: Passthrough Estimates for Changes, All countries

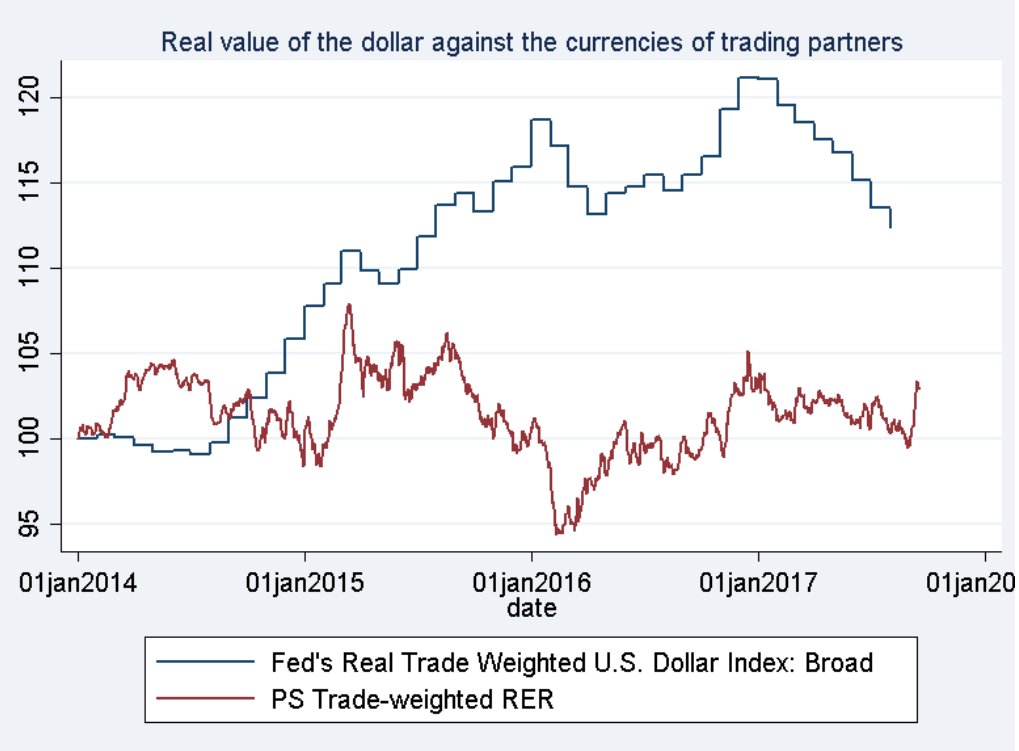
Notes: Regression in log changes. The 6-month result is the sum of the coefficients from lags 0 to 5. All bilaterals calculated with respect to the United States.

Summary

- We build a high-frequency dataset of closely-matched products in 9 countries → construct RER, RP time series
- We find strong co-movement of RP and E (not seen with CPIs)
- We quantify sources of measurement bias in passthrough estimates:
  - Sectoral differences & formula [4 % points]
  - Product matching bias (matched goods, relative prices) [26 % points]
  - Product entry/ exit bias [11 % points]

Related Applications

- RER dynamics, international shock transmission, and PPP-related puzzles.



Related Applications

- RER dynamics, international shock transmission, and PPP-related puzzles.
- Passthrough and inflation forecasting

Related Applications

- RER dynamics, international shock transmission, and PPP-related puzzles.
- Passthrough and inflation forecasting
- Determinants of nominal exchange rates

Argentina – Official and Unofficial Exchange Rates

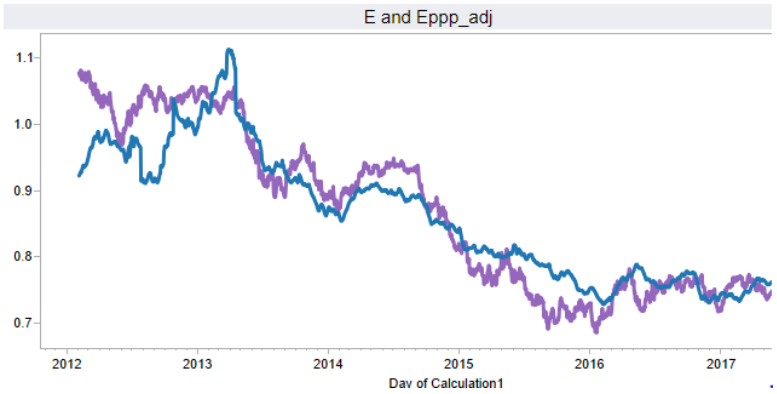
(a) ARGENTINA RER

(b) ARGENTINA RP & E

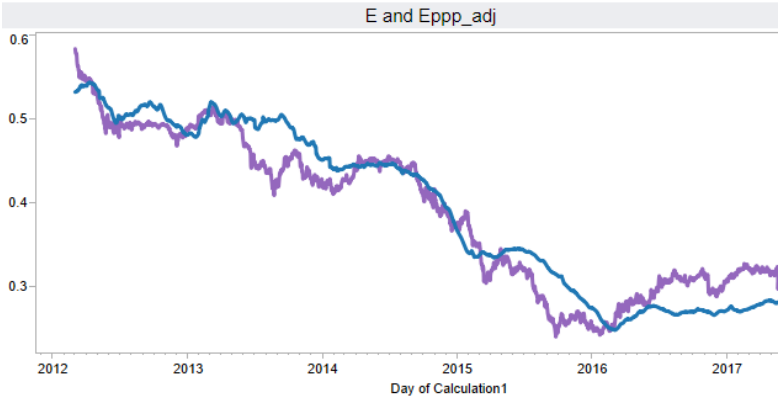
Eppp (Pus/ Plocal) vs NER (USD per lc)

- Eppp adjustmed for average RER

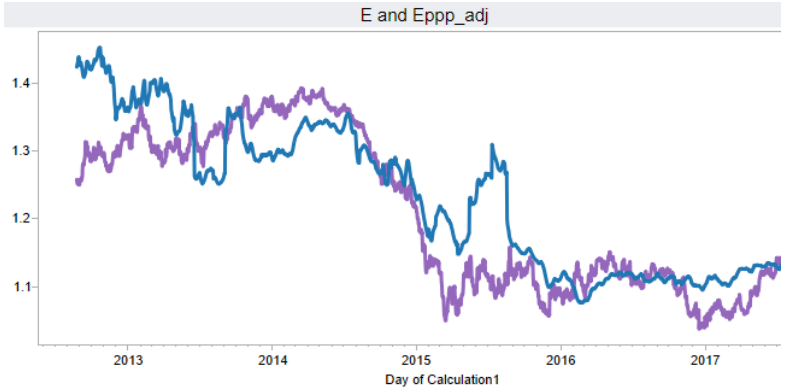
Australia



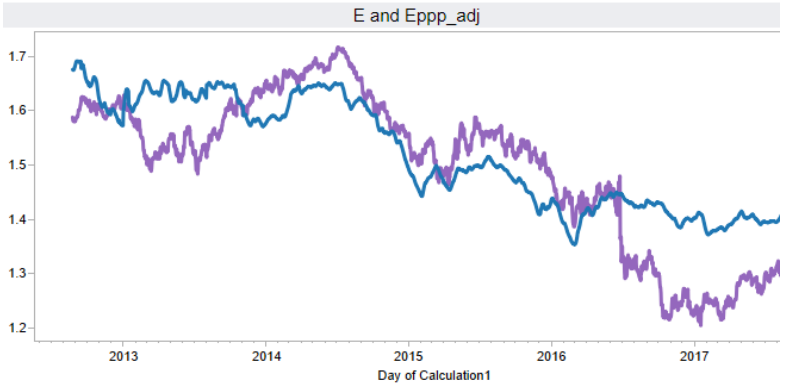
Brazil



Germany



UK



Related Applications

- RER dynamics, international shock transmission, and PPP-related puzzles.
- Passthrough and inflation forecasting
- Determinants of nominal exchange rates
- Higher-frequency PPPs for national accounts (multilateral methods) → improve comparison of GDPs/ poverty and avoid "extrapolation surprises"

Final Quote

- Zvi Griliches (1985), on the "uneasy alliance" between economists and data:

> "... we have shown little interest in improving it [the data], in getting involved in the grubby task of designing and collecting original data sets of our own. Most of our work is on "found" data, data that have been collected by somebody else, often for quite different purposes... "They" collect the data and are responsible for all their imperfections. "We" try to do the best with what we get, to find the grain of relevant information in all the chaff."

- Big/ New Data opportunity in macro/ international → we can now collect our own data, designed to fit our specific research needs


MIT
MANAGEMENT
SLOAN SCHOOL

Extra Slides

Dispersion of USD prices across countries

L3 COICOP Category	Mean CV USD Price (1)	Countries (2)
Fish and seafood	0.23	9
Games, toys and hobbies	0.26	8
Information processing equipment	0.27	8
Photographic and cinematographic equipment and optical instruments	0.28	8
Equipment for the reception, recording and reproduction of sound and picture	0.30	8
Fuels and lubricants for personal transport equipment	0.30	7
Recording media	0.34	8
Sugar, jam, honey, chocolate and confectionery	0.36	9
Milk, cheese and eggs	0.36	8
Coffee, tea and cocoa	0.37	7
Mineral waters, soft drinks, fruit and vegetable juices	0.39	5
Food products n.e.c.	0.39	8
Meat	0.41	8
Bread and cereals	0.41	8
Vegetables	0.44	7
Oils and fats	0.49	8
Fruits	0.53	7

Table 3: Which Categories have Greatest Dispersion in US Dollar Prices?

Notes: We first calculate the price in USD in each country. We then get the coefficient of variation across countries (by product and month). We then average for all months, and, finally, for all products.

Comparison to the Literature's Regressions

- Passthrough regression with log changes and NER lags

	3 Sectors	
	1 Month	6 Months
Price Measure	(1)	(2)
(1) CPI All items	0	-0.085
	(0.006)	
(2) CPI 1-Digit	-0.011	-0.158
	(0.013)	
(3) CPI 3-Digit	-0.032	-0.32
	(0.023)	
(4) CPI 3-Digit Fisher	-0.02	-0.297
	(0.018)	
(5) CN Matched Model	-0.183	-0.466
	(0.030)	
(6) CN Overall	-0.17	-0.473
	(0.032)	

Table A.19: Passthrough Estimates for Changes, All countries

Notes: Regression in log changes. The 6-month result is the sum of the coefficients from lags 0 to 5. All bilaterals calculated with respect to the United States.

Results Across Countries

Relative Price Measure	ARG		AUS		BRA		CHN		DEU		JPN		ZAF		UK	
	3 Sectors	Ex-Fuel	3 Sectors	Ex-Fuel	3 Sectors	Ex-Fuel	3 Sectors	Ex-Fuel	3 Sectors	Ex-Fuel	3 Sectors	Ex-Fuel	3 Sectors	Ex-Fuel	3 Sectors	Ex-Fuel
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) CPI All items	-0.366		-0.088		-0.334		-0.215		0.044		0.049		-0.286		0.000	
	(0.013)		(0.007)		(0.018)		(0.067)		(0.007)		(0.015)		(0.007)		(0.022)	
(2) CPI 1-Digit	-0.375	-0.404	-0.113	-0.011	-0.481	-0.258	-0.033	-0.568	-0.209	0.039	-0.089	-0.109	-0.350	-0.303	-0.139	0.219
	(0.016)	(0.028)	(0.017)	(0.007)	(0.027)	(0.026)	(0.084)	(0.140)	(0.021)	(0.020)	(0.028)	(0.026)	(0.010)	(0.025)	(0.023)	(0.026)
(3) CPI 3-Digit	-0.369	-0.403	-0.150	0.073	-0.670	-0.364	-1.611	-0.930	-0.375	-0.010	-0.282	-0.198	-0.547	-0.384	-0.201	0.281
	(0.019)	(0.026)	(0.037)	(0.008)	(0.041)	(0.041)	(0.284)	(0.146)	(0.035)	(0.019)	(0.046)	(0.058)	(0.015)	(0.031)	(0.048)	(0.039)
(4) CPI 3-Digit Fisher	-0.354	-0.386	-0.083	0.107	-0.634	-0.322	-1.251	-0.751	-0.275	0.024	-0.150	-0.160	-0.484	-0.330	-0.125	0.304
	(0.013)	(0.026)	(0.036)	(0.008)	(0.041)	(0.041)	(0.226)	(0.145)	(0.029)	(0.018)	(0.033)	(0.050)	(0.013)	(0.029)	(0.038)	(0.042)
(5) CN Matched Model	-0.734	-0.819	-0.223	0.092	-0.741	-0.402	-0.469	-0.339	-0.205	0.077	-0.200	-0.099	-0.620	-0.444	-0.026	0.485
	(0.024)	(0.041)	(0.028)	(0.021)	(0.035)	(0.036)	(0.117)	(0.074)	(0.049)	(0.025)	(0.036)	(0.060)	(0.016)	(0.031)	(0.089)	(0.070)
(6) CN Overall	-0.790	-0.987	-0.655	-0.508	-0.852	-0.575	-1.122	-0.921	-0.776	-0.593	-0.208	-0.170	-0.780	-0.591	-0.582	-0.113
	(0.029)	(0.055)	(0.027)	(0.044)	(0.042)	(0.052)	(0.154)	(0.143)	(0.061)	(0.096)	(0.037)	(0.066)	(0.020)	(0.058)	(0.097)	(0.113)
(7) CN Overall Branded		-0.949		-0.228		-0.423		-0.101		-0.496		-0.171		-0.861		-0.022
		(0.055)		(0.036)		(0.044)		(0.110)		(0.101)		(0.071)		(0.059)		(0.086)
(8) CN Overall Unbranded		-0.981		-0.472		-0.610		-0.591		-0.457		-0.096		-0.473		0.219
		(0.055)		(0.048)		(0.056)		(0.160)		(0.084)		(0.054)		(0.054)		(0.104)

Table 5: Long-Run Passthrough Estimates - By Country

Notes: All bilaterals calculated with respect to the United States.

Stickiness Comparison PPP vs BPP online data

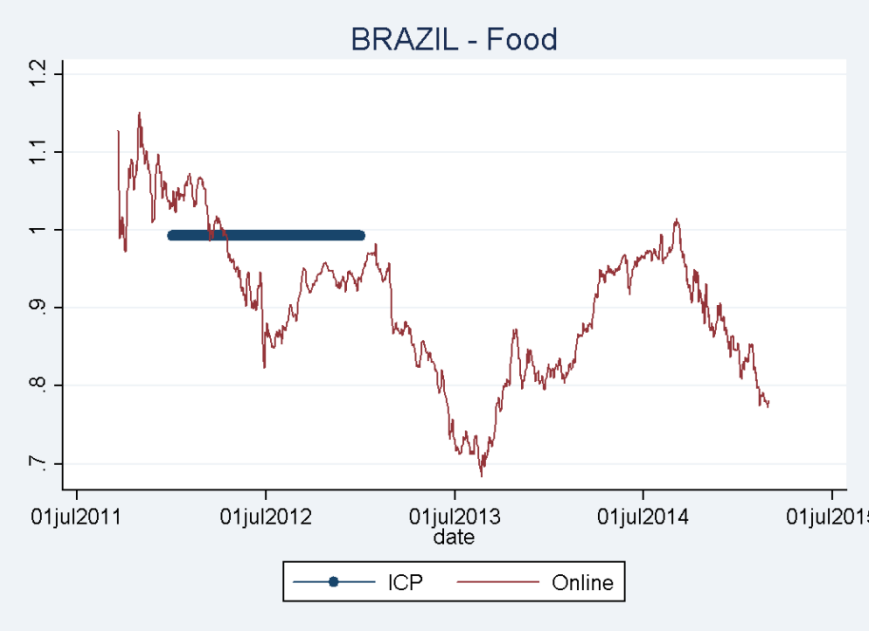
Category	Country	Monthly Frequency PPP Online Data	BPP Online Data	Ratio PPP/BPP
3 Sectors	Argentina	38.4	32.2	1.19
	Australia	41.1	33.9	1.21
	Brazil	52.4	38.5	1.36
	China	30.2	16.7	1.82
	Germany	30.8	22.3	1.38
	Japan	25.8	19.5	1.33
	South Africa	37.3	23.8	1.57
	UK	43.2	35.1	1.23
	USA	48.7	30.5	1.60

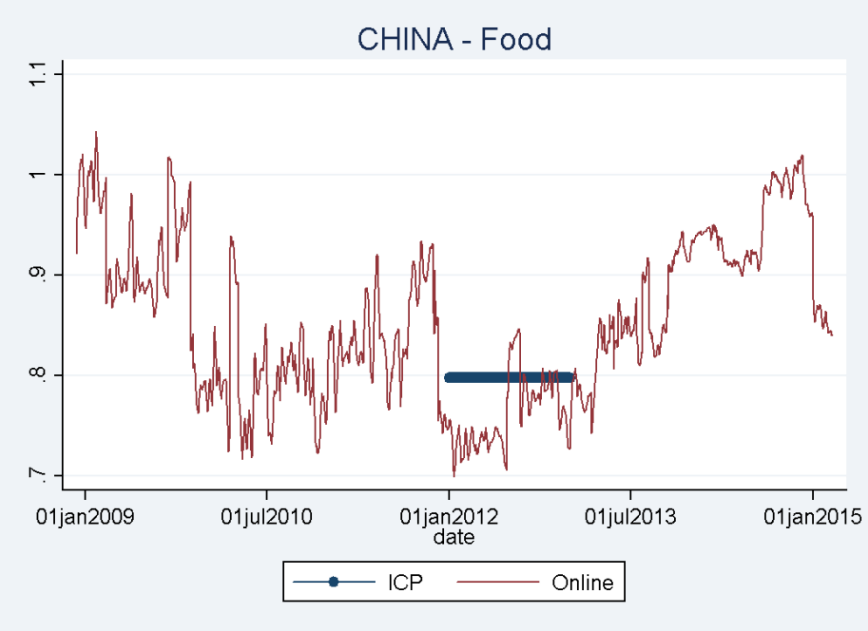
Table 11: Stickiness - PPP Online Data vs BPP Online Data

Notes: The PPP online data is a sub-set of the BPP online data. It includes only the goods that are matched across countries and used for computing the bilateral RERs.

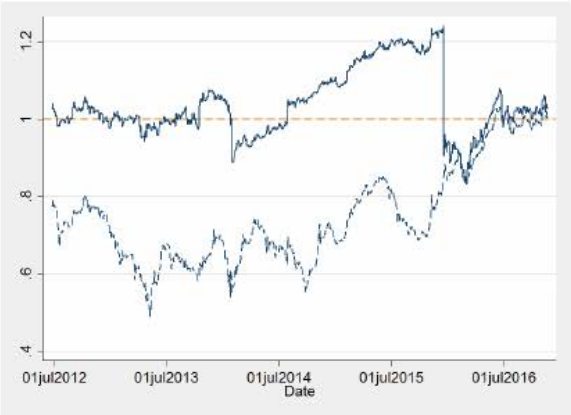
Aggregate Results

- Most RERs appear to fluctuate around certain levels (relative PPP)
  - Are these levels reasonable?
  - Comparison to ICP

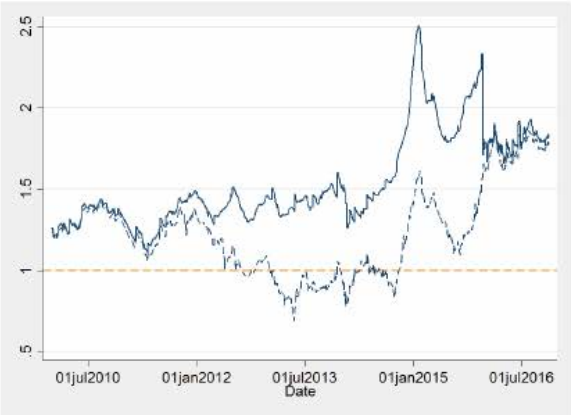




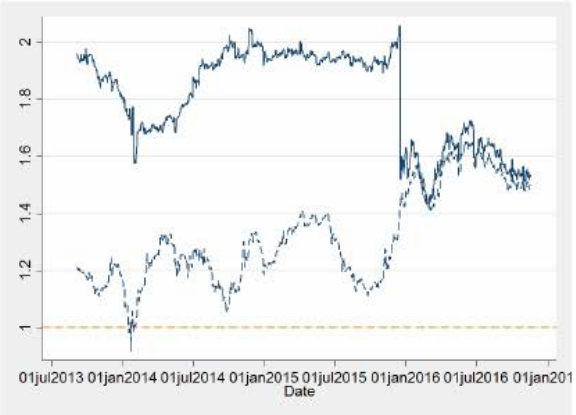
Argentina - Sectors



(a) ARGENTINA FOOD RER



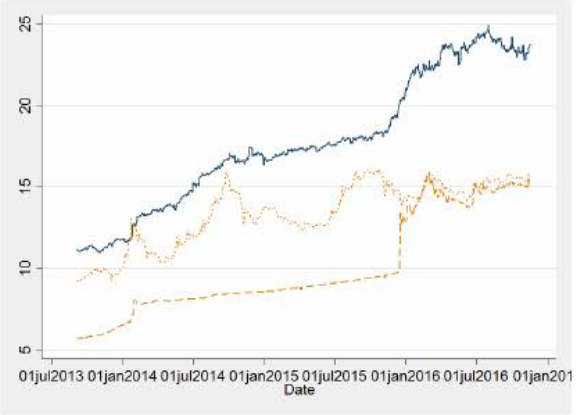
(b) ARGENTINA FUEL RER



(c) ARGENTINA ELECTRONICS RER

(d) ARGENTINA FOOD RP & E

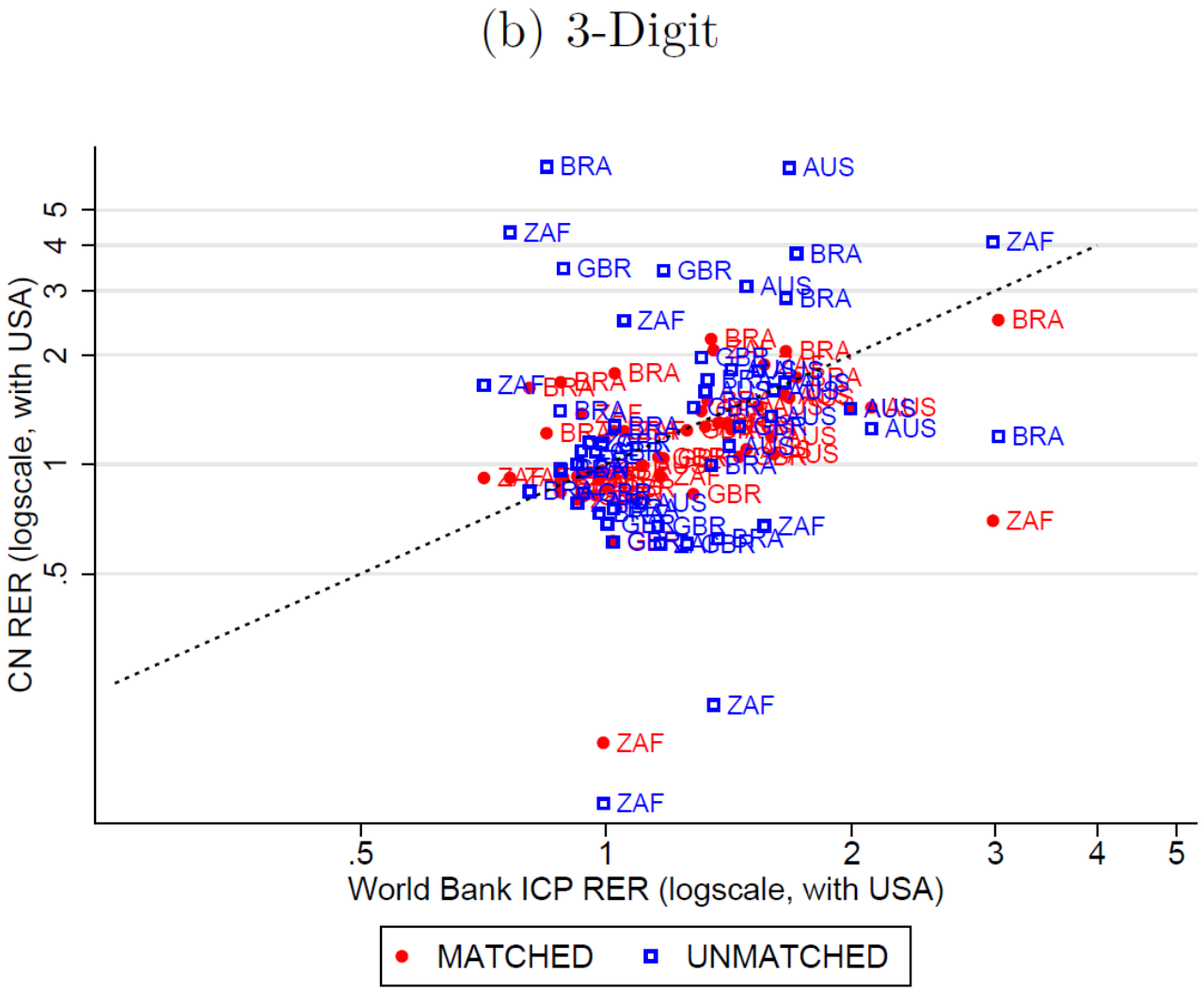
(e) ARGENTINA FUEL RP & E



(f) ARGENTINA ELECTRONICS RP & E

Figure A.29: ARGENTINA - Real Exchange Rates, Relative Prices, and Nominal Exchange Rates - All Sectors

3-Digit Unmatched



Correlation and Granger Causality

Sector	Result	ARG	AUS	BRA	CHN	DEU	JAP	ZAF	GBR
3 Sectors	Correlation	0.95	0.94	0.93	0.81	0.83	0.52	0.97	0.56
	Granger Causality (p-value)								
	E to RP	0.000	0.008	0.000	0.076	0.288	0.018	0.001	0.872
	RP to E	0.126	0.133	0.866	0.362	0.150	0.067	0.092	0.346
Ex-Fuel	Correlation	0.93	0.84	0.84	0.78	0.68	0.38	0.83	0.14
	Granger Causality (p-value)								
	E to RP	0.105	0.417	0.059	0.057	0.867	0.366	0.000	0.634
	RP to E	0.000	0.064	0.937	0.066	0.105	0.391	0.012	0.321
Food	Correlation	0.93	0.83	0.85	0.77	0.65	0.50	0.76	0.06
	Granger Causality (p-value)								
	E to RP	0.460	0.340	0.138	0.087	0.883	0.287	0.000	0.518
	RP to E	0.037	0.052	0.890	0.087	0.051	0.255	0.050	0.437
Fuel	Correlation	0.92	0.95	0.94	0.66	0.88	0.85	0.98	0.80
	Granger Causality (p-value)								
	E to RP	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.401
	RP to E	0.437	0.633	0.083	0.360	0.439	0.108	0.062	0.113
Electronics	Correlation	0.86	0.38	0.71	0.49	0.62	-0.23	0.90	0.55
	Granger Causality (p-value)								
	E to RP	0.276	0.113	0.000	0.131	0.085	0.988	0.001	0.001
	RP to E	0.002	0.862	0.033	0.817	0.232	0.017	0.386	0.049

Table 7: Correlation and Granger Causality between Relative Prices and Exchange Rates

AR1s and Dickey Fuller Test

Level	Source	Statistic	ARG	AUS	BRA	CHN	DEU	JAP	ZAF	UK
Panel A: AR1 Coefficients and T-Statistics from Dickey Fuller Unit Root Tests										
3 Sectors	CPI 3-digit Fisher	AR1 Coeff	0.98	0.96	0.9	0.71	0.9	0.98	0.95	0.96
		AR1 Coeff SE	(0.02)	(0.03)	(0.06)	(0.13)	(0.05)	(0.02)	(0.04)	(0.06)
	CN Overall	AR1 Coeff	0.93	0.86	0.85	0.56	0.86	0.96	0.85	0.92
		AR1 Coeff SE	(0.04)	(0.06)	(0.07)	(0.12)	(0.05)	(0.03)	(0.06)	(0.06)
Panel B: P-values from Dickey Fuller Unit Root Tests										
	CPI 3-digit Fisher	DFT P-value	0.79	0.69	0.4	0.19	0.25	0.71	0.55	0.86
	CN Overall	DFT P-value	0.48	0.14	0.28	0.00	0.06	0.60	0.12	0.54
Panel C: Implied Half-Lives from Dickey Fuller Unit Root Tests										
	CPI 3-digit Fisher	Half-Life	35.45	16.99	6.62	2.04	6.47	28.56	12.88	17.98
	CN Overall	Half-Life	10.15	4.47	4.33	1.21	4.56	18.15	4.29	8.02

Table 6: Stationarity of Disaggregated Real Exchange Rates

Notes: All bilaterals calculated with respect to the United States.

A Vector Error Correction Model

- Passthrough (cointegration) regression

$$rp_t = \beta_0 + \beta_1 e_t + \mu_t$$

- DFT of errors

$$\Delta\widehat{\mu}_t = a_1\widehat{\mu}_{t-1} + \varepsilon_t$$

- VECM

$$\Delta rp_t = \alpha_1 + \alpha_{rp}[rp_{t-1} - \beta_1 e_{t-1}] + \sum \alpha_{11}^i \Delta rp_{t-i} + \sum \alpha_{12}^i \Delta e_{t-i} + \varepsilon_{rpt}$$

$$\Delta e_t = \alpha_2 + \alpha_e[rp_{t-1} - \beta_1 e_{t-1}] + \sum \alpha_{21}^i \Delta rp_{t-i} + \sum \alpha_{22}^i \Delta e_{t-i} + \varepsilon_{et}$$

Vector Error Correction Model

	Coefficient	ARG	AUS	BRA	CHN	GER	JPN	SOU	UK
Panel A: Unconstrained VECM									
3-Sectors	B1	-0.9	-0.66	-0.85	-0.6	-0.78	-0.21	-0.78	-0.58
	E Coefficient	0.053*	-0.196	-0.047	-0.047***	-0.099	0.163**	-0.108	-0.054
	RP Coeficient	-0.055***	-0.242**	-0.099***	-0.019	-0.038	-0.193***	-0.284***	-0.044
Panel B: Constrained VECM (relative PPP)									
3-Sectors	B1	-1	-1	-1	-1	-1	-1	-1	-1
	E Coefficient	0.033**	-0.111	0.007	-0.034***	-0.108*	-0.001	0.056	-0.058
	RP Coeficient	-0.044***	-0.081	-0.081***	-0.012	-0.040	-0.040*	-0.081***	-0.022

Table 8: Vector Error Correction Models

Notes: All bilaterals calculated with respect to the United States. Panel A shows the results for an unrestricted VECM. Panel B restricts the B1 coefficient to be -1, consistent with relative PPP .