ADJUSTING TOWARD LONG-RUN PURCHASING POWER PARITY

Kian Ong
University of Nottingham Ningbo China

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WHY IS THE PPP IMPORTANT?

- What determines the exchange rate?

- A long-run theory of exchange rates: trade in goods and services would equalise exchange rates and relative prices across countries.

- $P = EP^*$. PPP implies that the real exchange rate, EP^*/P, equals one for the same goods. Given price indices, we consider adjustment to relative parity.

THIS PAPER TESTS RELATIVE PPP

- "About one-half the total citations count among prominent exchange rate research are attributable to studies dedicated to testing the empirical validity of PPP." Vo and Vo (2022, p.20)

- The validity of PPP continues to be questioned (Rogoff, 1996; Burstein and Gopinath, 2014; Itskhoki and Mukhin, 2021), spawning literature why the PPP does not hold, at least in the short to medium run (Balassa, 1964; Samuelson, 1964; Harding et al., 2020).

- This paper tests relative PPP and measures the speed of adjustment toward a constant real exchange rate in the long run —151 years (1870-2020) in 16 advanced economies to the U.S.
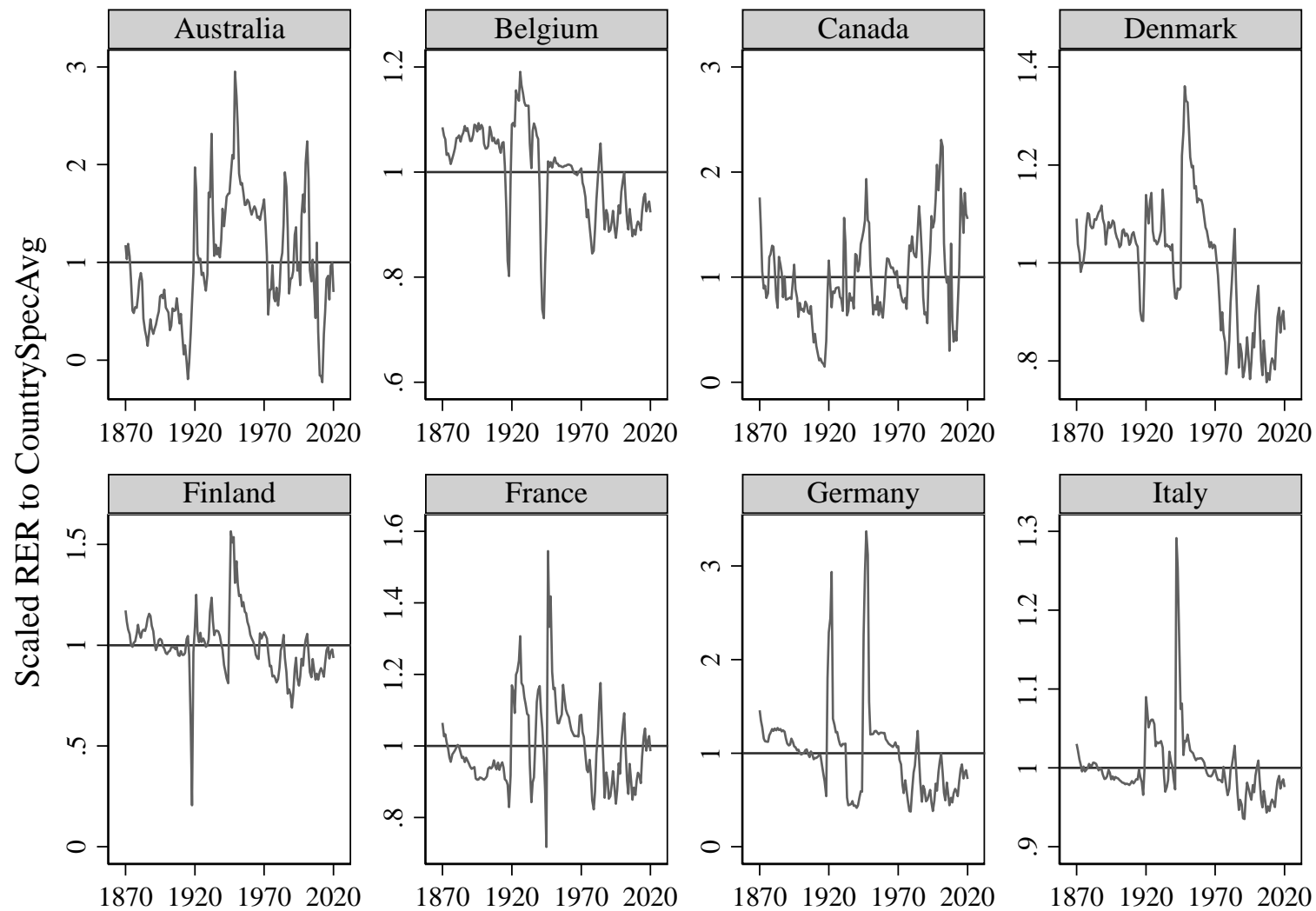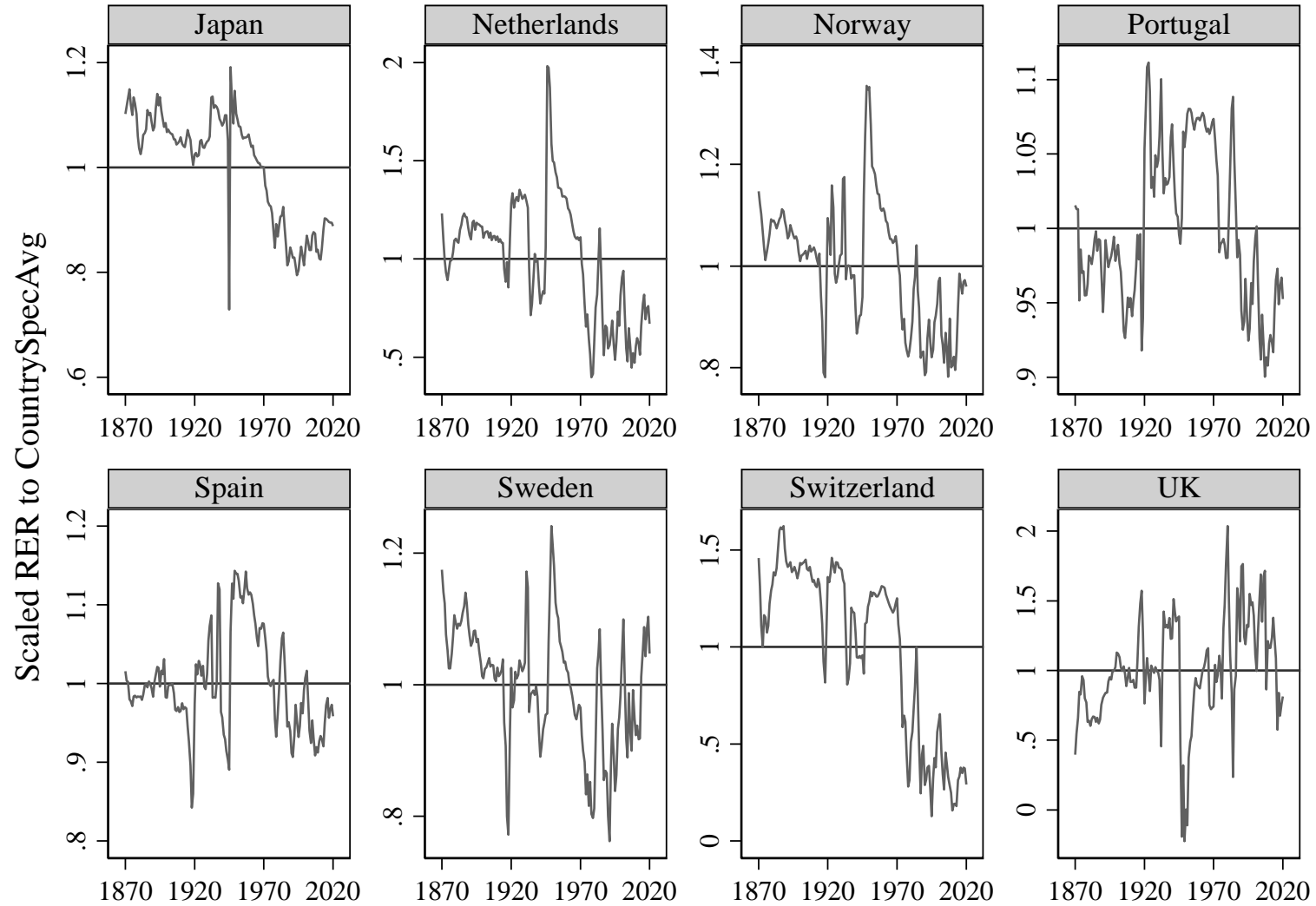
FIGURE A2. REAL EXCHANGE RATE

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THIS PAPER APPROACHES TESTING PPP IN THREE WAYS

1. The real exchange rate is persistent. We use long-span data.

2. Episodic failures when cointegration between exchange rates and relative prices fails. "[m]ajor shocks such as wars, depressions, natural disasters, or important policy failures." We pool the long-run elasticity but allow country-specific adjustments.

3. We use the system approach to measure adjustment of exchange rate and relative prices toward long-run PPP.

With long-span data and the System Pooled Mean Group estimator (Chudik et al., 2023), we detect consensus for long-run PPP. We measure the half-lives.

MAIN FINDINGS

1. The SPMG estimate of long-run elasticity between exchange rate and relative prices is 0.990 (0.978-1.002). Cross-section dependence.

2. We find evidence of adjusting toward relative PPP in 16 countries from exchange rates and relative prices. The exchange rates adjust faster, 8%, twice the pace of the relative prices, 3%, toward PPP.

3. Using the median unbiased estimates of Hansen (1999), we find finite half-lives for 11/16 countries based on 95% confidence intervals. The average is 4.87 years, within the "consensus range" of 3 to 5 years (Rogoff, 1996).

IMPLICATIONS FOR THE PPP LITERATURE: EPISODIC COINTEGRATION

- Papell and Prodan (2020) use similar data (1870-2013) to us but a different estimator: the covariability approach of Müller and Watson (2018).

- They find that the unit long-run elasticity between exchange rate depreciation and inflation differential cannot be rejected for 9 of 16 countries at a 10% significance level.

- We use the SPMG approach. Considering both adjustment channels, we find evidence of PPP in 14 out of 16 countries at a 10% significance level.

IMPLICATIONS FOR THE PPP LITERATURE: SPAN MATTERS

- Using quarterly post-1973 real exchange rates, Murray and Papell (2002) and Rossi (2005) find that the upper confidence limit of the half-life is infinite. Steinsson (2008, p.521) says that "even 30 years after the breakdown of Bretton Woods, it is not possible to estimate the half-life of the real exchange rate with much precision."

- Using the median unbiased estimates of Hansen (1999), we find finite half-lives for 11 of 16 countries based on 95% confidence intervals. Our median 95% lower bound, 3.16 years, is consistent with Lopez et al. (2013), who cover the same countries (1870-1998).

- But we can reject unit root in more countries; the margin of error and upper confidence limit are also much lower. This is owing to a larger span of data.

OVERVIEW

1. DATA

2. MODELS: WHAT WE DO

3. RESULTS

4. CONCLUSION

JORDÀ-SCHULARICK-TAYLOR MACROHISTORY DATABASE

- We use spot exchange rates and consumer price indices from the Jordà-Schularick-Taylor macrohistory database (Jordà et al., 2017).

- Using the U.S. as the benchmark, an almost balanced panel comprises N=16 and T=151 (1870-2020).

- Prices are measured with Consumer Price Indexes (1990=100 is the base year). We can only test for relative PPP that considers changes in absolute PPP.

THE VECTOR ERROR CORRECTION MODEL

$$\Delta y_{it} = a_{10,i} + a_{11,i}\left(y_{i,t-1} - \textcolor{red}{\theta_{yi}} x_{i,t-1}\right) + \sum_{\ell=1}^{p-1} \psi'_{1\ell i} \Delta w_{i.t-\ell} + u_{1it}$$

(1)

$$\Delta x_{it} = a_{20,i} + a_{21,i}\left(y_{i,t-1} - \textcolor{red}{\theta_{xi}} x_{i,t-1}\right) + \sum_{\ell=1}^{p-1} \psi'_{2\ell i} \Delta w_{i.t-\ell} + u_{2it}$$

(2)

- y_{it} is the log of the spot exchange rate, x_{it} is the log of the price differential ($\log p_{it} - \log p^*_{it}$) where p^*_{it} is the U.S., where $\Delta y_{it} = y_{it} - y_{i,t-1}$, $\Delta x_{it} = x_{it} - x_{i,t-1}$ and $\Delta w_{it} = (\Delta y_{it}, \Delta x_{it})'$.

JOHANSEN VECM

$$\Delta y_{it} = a_{10,i} + a_{11,i}\big(y_{i,t-1} - {\color{red}\theta_i} x_{i,t-1}\big) + \sum_{\ell=1}^{p-1} \psi'_{1\ell i} \, \Delta w_{i.t-\ell} + u_{1it}$$

$$\Delta x_{it} = a_{20,i} + a_{21,i}\big(y_{i,t-1} - {\color{red}\theta_i} x_{i,t-1}\big) + \sum_{\ell=1}^{p-1} \psi'_{2\ell i} \, \Delta w_{i.t-\ell} + u_{2it}$$

$$(3)$$

- PPP implies a common elasticity. The PPP null hypothesis is $H_0: \theta_i = 1$, a unit long-run elasticity.

THE SYSTEM POOLED MEAN GROUP (SPMG) ESTIMATOR

$$\Delta y_{it} = a_{10,i} + a_{11,i}\left(y_{i,t-1} - \theta x_{i,t-1}\right) + \sum_{\ell=1}^{p-1} \psi'_{1\ell i}\, \Delta w_{i.t-\ell} + u_{1it}$$

$$\Delta x_{it} = a_{20,i} + a_{21,i}\left(y_{i,t-1} - \theta x_{i,t-1}\right) + \sum_{\ell=1}^{p-1} \psi'_{2\ell i}\, \Delta w_{i.t-\ell} + u_{2it}$$

$$(4)$$

- The SPMG model allows testing of H_0: $\theta_i = \theta = 1$ for all i.

- We could impose a unit coefficient on the exchange rate and relative prices ($\theta = 1$) if we do not reject the null.

UNIVARIATE REAL EXCHANGE RATE EQUATION

$$\Delta q_{it} = b_{0,i} + b_{1,i} q_{i,t-1} + \sum_{\ell=1}^{p-1} \varphi_{\ell i} \Delta q_{i.t-\ell} + u_{it}$$

$$(6)$$

- We can combine the exchange rates and prices equations in (5) to give a real exchange rate equation to obtain a median unbiased estimate of the half-life.

- Consider $q_{it} = y_{i,t} - x_{i,t}$ as the log of real exchange rate

- The real exchange rate equation imposes common speeds of adjustment in the SPMG model.

RESULTS

1. TABLE 1. COUNTRY-SPECIFIC ELASTICITIES FROM THE VECM

2. SPMG ESTIMATE

3. FIGURE 1. HISTOGRAM OF t-RATIOS AND SPEED OF ADJUSTMENT OF SPOT EXCHANGE RATES AND INFLATION DIFFERENTIAL TO RELATIVE PPP

4. FIGURE 2. HISTOGRAM OF t-RATIOS AND SPEED OF ADJUSTMENT OF REAL EXCHANGE RATES TO RELATIVE PPP

5. TABLE 4. MEDIAN-UNBIASED HALF-LIVES OF REAL EXCHANGE RATES

4.1 COUNTRY-SPECIFIC LONG-RUN ELASTICITIES

- Using unrestricted VECM, the country-specific long-run elasticities in the two equations are quite dispersed.

- The cross-country average of the Johansen estimates is 0.981 (0.099). Again it is not significantly different from one, but more precisely estimated with a smaller cross-country dispersion than in the individual equations.

- However, considerable dispersion remains and the 90% confidence interval does not cover a unit elasticity in 7 out of 16 countries. The large shocks and episodes where cointegration fails could be an explanation and pooling the data may reduce these problems.

4.2 THE SPMG ESTIMATOR

- The SPMG long-run elasticity point estimate of equation (4) is 0.990.

- There are significant degrees of cross-section dependence; therefore, we focus on the bootstrapped 95% confidence interval.

- The bootstrapped 95% confidence interval is tight (0.978-1.002). The SPMG long-run elasticity estimate supports the relative PPP, with a tight range that is very close to 1.

- This gives us the confidence to impose a unit long-run elasticity across countries and examine the evidence of relative PPP based on the adjustments. Imposing a unit long-run elasticity also increases efficiency.

4.2 THE SPMG ESTIMATOR

- We find evidence of relative PPP in 16 countries through either exchange rates or relative prices adjusting to the parity.

- The evidence of adjusting toward parity is more common from the relative price than the exchange rate channel. All countries' relative prices adjust to PPP, but the exchange rates in Germany and Italy did not adjust to PPP.

- Third, the exchange rate does the bulk of adjustment to the parity. 9 countries' exchange rate adjusts faster than 5%, but 11 countries' inflation adjusts slower than 5% (Figure 1). Friedman (1953) argues that internal prices adjust slower than exchange rates when arguing for flexible exchange rates.

FIGURE 1. HISTOGRAM OF t-RATIOS AND SPEED OF ADJUSTMENT OF SPOT EXCHANGE RATES AND INFLATION DIFFERENTIAL TO RELATIVE PPP
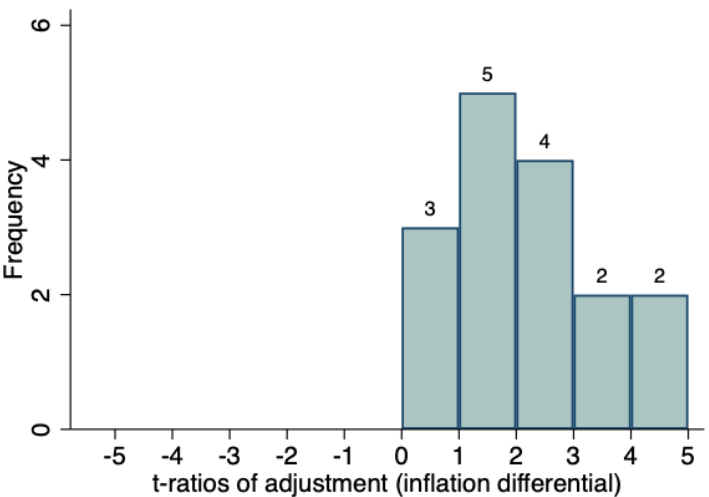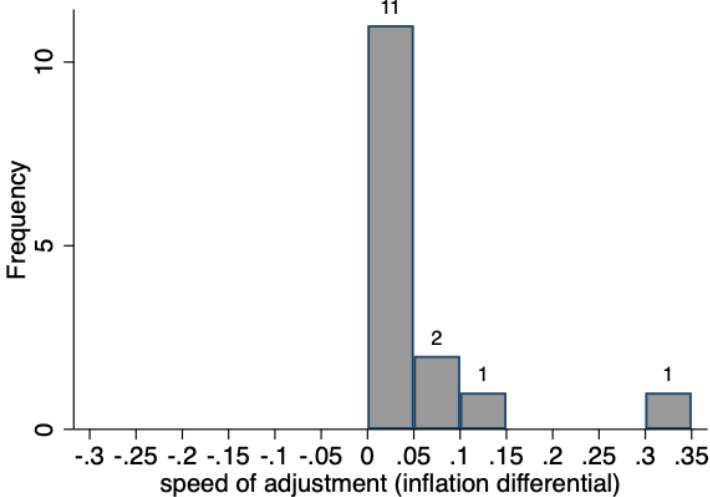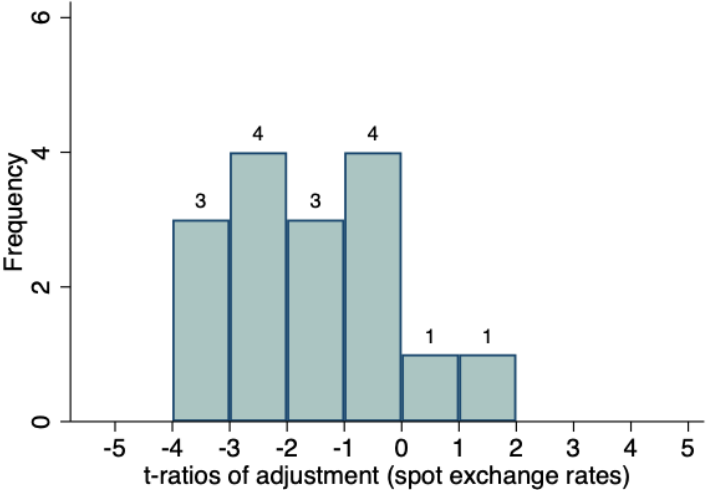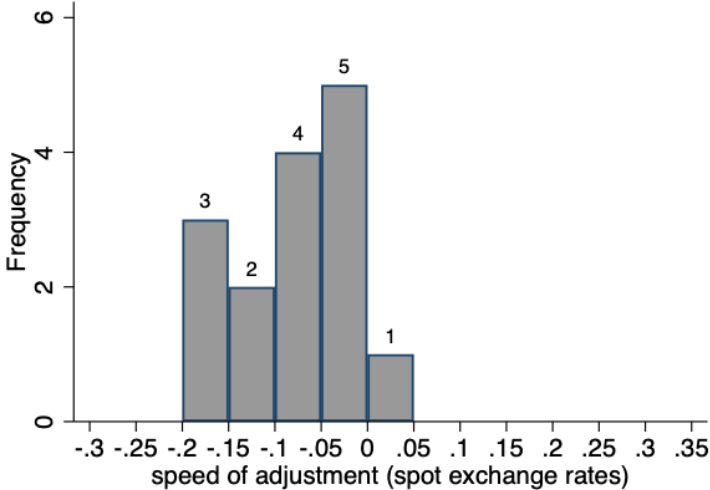
4.3 THE UNIVARIATE REAL EXCHANGE RATE EQUATION

- Even if one channel is destabilising, as with Germany's and Italy's exchange rate, the net effect can stabilise if the other adjusts fast enough. Therefore, the real exchange rate in 16/16 countries adjust to PPP (Table 3).

- Second, we can be more confident about the evidence of relative PPP based on the univariate approach. 11 and 10 countries lap the thresholds, two and three, respectively (Figure 2).

- However, when we are unsure about a real exchange rate adjustment in Denmark, Japan, and Switzerland (the 90% confidence interval contains zero), we can be more confident based on the relative prices adjusting to PPP in these countries.

FIGURE 2. HISTOGRAM OF t-RATIOS AND SPEED OF ADJUSTMENT OF REAL EXCHANGE RATES TO RELATIVE PPP
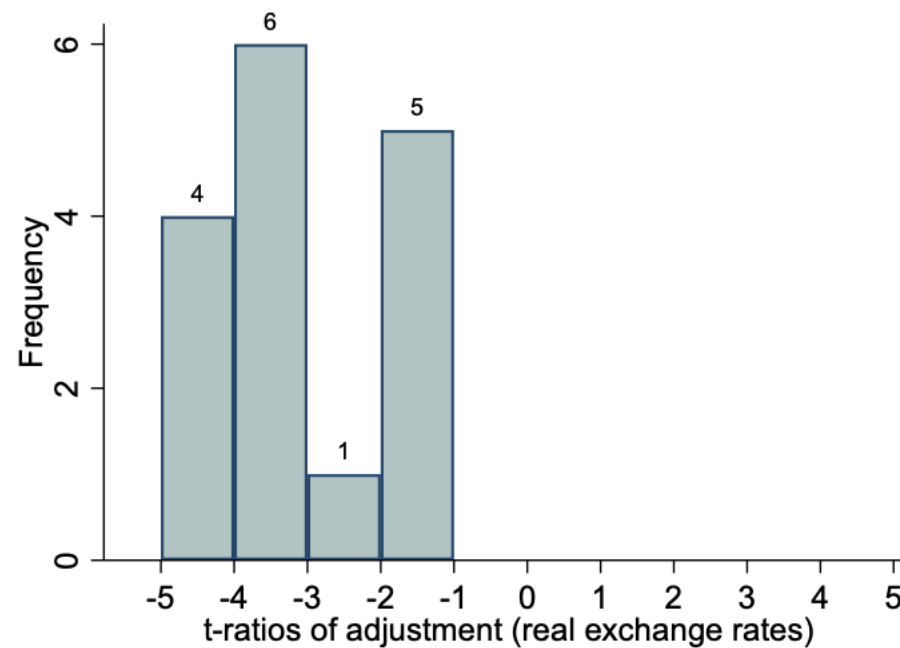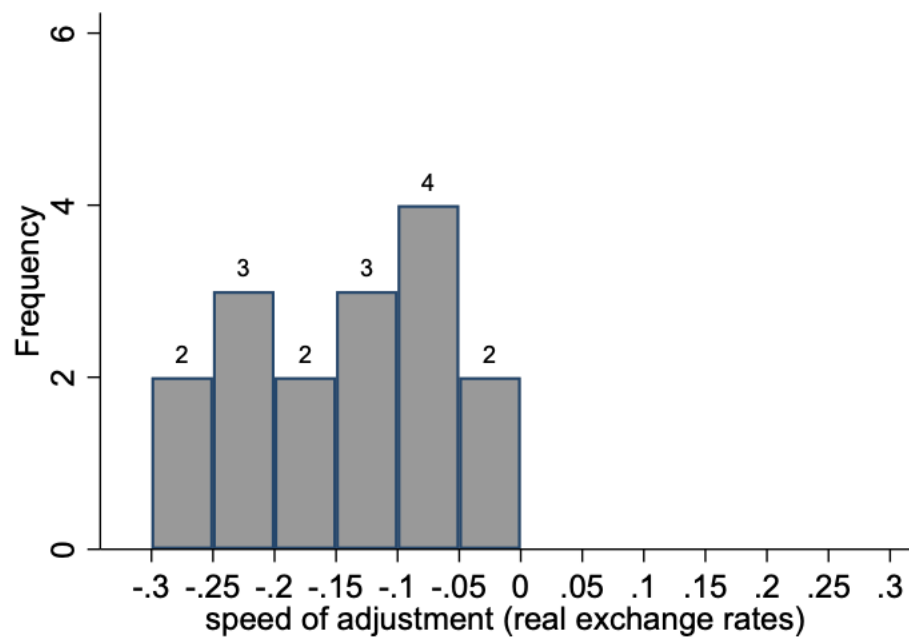
4.3 THE UNIVARIATE REAL EXCHANGE RATE EQUATION

- Using a 95% confidence interval, we can't be sure that the half-life is finite in 5/16 countries: Denmark, Japan, Norway, Spain and Switzerland. These are also the countries where we do not reject the unit root null hypothesis based on the ADF critical values.

- For the other eleven countries where we are confident that the half-life is finite, the point estimates range from 2.25 years (France) to 8.92 years (Netherlands). The average is 4.87 years, which is within the "consensus range" of 3 to 5 years (Rogoff, 1996).

TABLE 4. MEDIAN UNBIASED HALF-LIVES OF REAL EXCHANGE RATES

	Country	Lag	α_{OLS}	α_{MU}	95% CI		$HL_{IRF,MU}$	95% CI	
1	France	0	0.713	0.732	[0.643,	0.824]	2.25	[1.62,	3.60]
2	Italy	0	0.745	0.763	[0.675,	0.855]	2.59	[1.80,	4.45]
3	Finland	3	0.792	0.818	[0.722,	0.916]	2.63	[2.02,	6.68]
4	Germany	5	0.799	0.820	[0.729,	0.907]	3.69	[3.16,	8.64]
5	UK	8	0.766	0.798	[0.696,	0.918]	3.69	[1.86,	9.65]
6	Canada	0	0.810	0.829	[0.740,	0.913]	3.71	[2.34,	7.66]
7	Sweden	1	0.828	0.843	[0.758,	0.914]	4.74	[3.22,	8.36]
8	Belgium	1	0.866	0.877	[0.800,	0.928]	6.23	[4.21,	10.12]
9	Australia	0	0.883	0.904	[0.813,	0.972]	6.86	[3.37,	24.60]
10	Portugal	1	0.895	0.914	[0.825,	0.974]	8.32	[4.08,	26.84]
11	Netherlands	1	0.902	0.918	[0.832,	0.969]	8.92	[4.63,	23.56]
12	Spain	7	0.907	0.955	[0.837,	1.000]	12.18	[2.86,	∞]
13	Norway	6	0.923	0.959	[0.853,	1.000]	14.60	[4.55,	∞]
14	Switzerland	1	0.970	0.994	[0.919,	1.000]	121.71	[9.07,	∞]
15	Denmark	6	0.955	0.998	[0.885,	1.000]	∞	[5.05,	∞]
16	Japan	2	0.947	0.999	[0.877,	1.000]	∞	[0.89,	∞]

CONCLUSIONS

- Relative PPP is a long-run theory of exchange rates that says that trade in goods and services would equalise exchange rate changes and inflation differential across countries. Its empirical validity continues to be questioned.

- We use the System Pooled Mean Group (SPMG) model to study the adjustment of exchange rates and relative prices to PPP in 16 advanced economies to the U.S. dollar and prices over 151 years (1870-2020).

- The SPMG model and bootstrapped confidence interval accommodate episodic cointegration and cross-country dependence. We detect consensus for relative PPP because we pool the long-run, allow two-way long-run causality and use long-span data.

Thank you for your attention

Ong, Kian. "Adjusting toward long-run purchasing power parity." *Journal of International Money and Finance* 149 (2024): 103204.

NEXT STEPS

- Use disaggregate data. Law of One Price (with Marina Glushenkova and Wanying Du).

- How does it differ across categories?

- Which channel adjusts?

ROLLING ADJUSTMENTS

- One plausible reason we find more common evidence of adjustment via relative prices than exchange rates could be that the exchange rate is pegged half the time in many countries (see Table A5).

- The pegged exchange rate includes the gold standard (before 1940), the Bretton Woods system (1951-1971), the Exchange Rate Mechanism (1979-1998) and the eurozone (1999-).

- We estimate a thirty-year rolling window of adjustments to PPP in the SPMG model of equation (5) to see how adjustments change over time. There is tension in the characterisation of exchange rate regimes (Ilzetzki et al., 2022) so we use the rolling estimator.
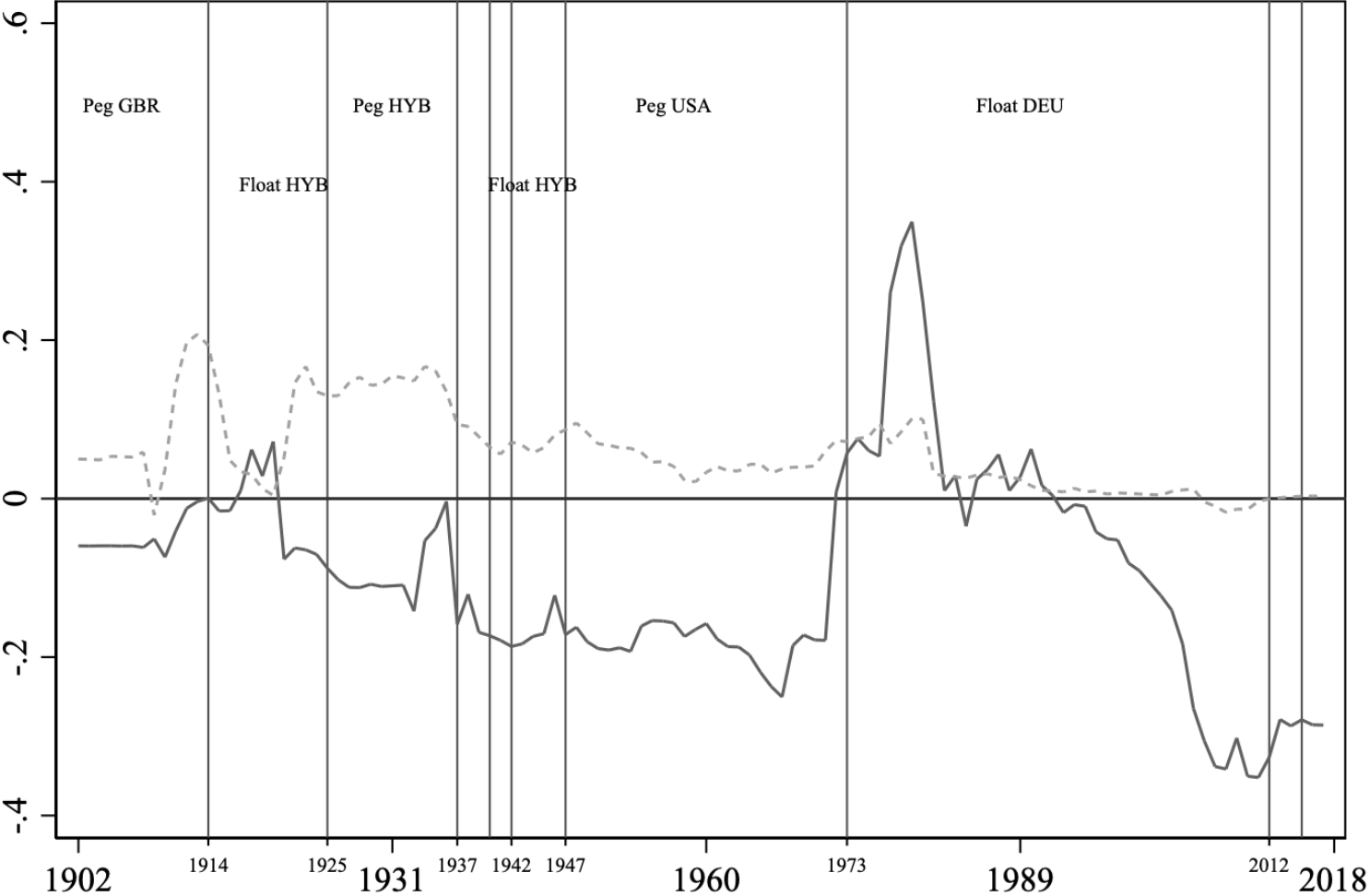
ROLLING ADJUSTMENTS

Japan
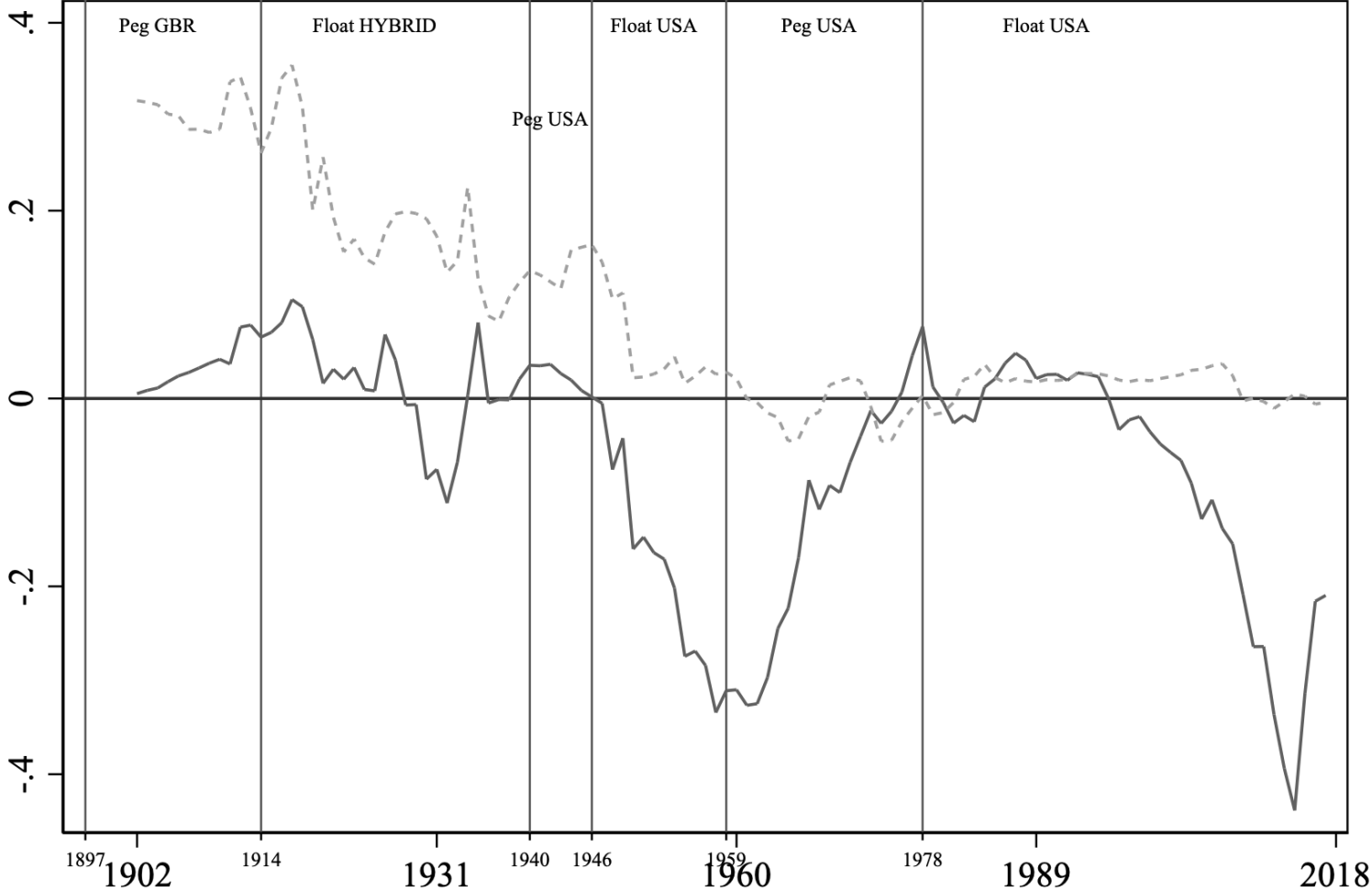
ROLLING ADJUSTMENTS

Switzerland

ROLLING ADJUSTMENTS

- Adjusting via exchange rates to PPP strengthens with floating exchange rates, especially since the end of the Bretton Woods (see Figure 3).

- Germany and Italy, whose exchange rates were not adjusting to PPP based on the full-sample estimates, adjusted to PPP during since the end of the Bretton Woods. Italy's exchange rate was not adjusting to PPP when it was pegged to the dollar.

- For countries where we can't be sure about the exchange rate adjustment (Denmark, Japan, Norway, Spain, Switzerland), we also see a strengthening of the exchange rate adjustment towards the end of the sample.

ROLLING ADJUSTMENTS

- Relative prices adjust to parity when exchange rates do not adjust and vice versa.

- A regression of exchange rate adjustments on relative price adjustments to parity, country by country, finds the pattern in 14/16 countries (see Table A6).

- A positive association indicates substitution between both channels of adjustments, which are explained by the opposite signs of the exchange rates (negative) and relative prices adjusting to the parity (positive).