An Alternative Test of Purchasing Power Parity

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Abstract: The long-horizon approach of Fisher and Seater (1993) is applied to the data developed by Taylor (2002) to test for purchasing power parity (PPP). Even after accounting for the low power of the test, the evidence is generally supportive of PPP.

1. Introduction

In recent years, purchasing power parity has been extensively tested using more powerful unit root tests, cointegration tests, and nonlinear methods. Rogoff (1996), Sarno and Taylor (2002), and Taylor and Taylor (2004) provide surveys of this literature. Although the evidence is not conclusive, the empirical work generally provides some support for PPP in the long run although most researchers would probably agree that deviations from PPP may exist and persist in the short run.[1]

The Fisher-Seater (1993) test has been applied to long run monetary neutrality and superneutrality; however, there is just one published paper, Serletis and Gogas (2004), that uses this method to test for purchasing power parity, and that paper examines only the post-Bretton Woods period. In this paper, the long-horizon approach of Fisher-Seater (henceforth FS) is applied to the data set, developed by Taylor (2002), which includes at least a century of observations for twenty countries. Results tend to support Taylor's conclusions that PPP cannot be rejected for most included countries.[2] In the following section, the data and FS procedure are briefly described. The empirical results are more fully discussed in section 3 and with conclusions offered in section 4.

2. Data and Methodology

The data set includes annual observations for the nominal exchange rate and the consumer price index for twenty countries.[3] The data run through 1996, with beginning dates varying from 1870 to 1893, allowing PPP to be tested using at least 100 annual

[1] More accurately, as emphasized by Taylor and Taylor, the evidence supports mean reversion of the real exchange rate, a necessary but not sufficient condition for PPP. Implicitly, researchers tend to assume that mean reversion implies that the real exchange rate is reverting to its PPP level and we follow this practice.
[2] Taylor tested for stationarity of the real exchange rates of these countries using a generalized least squares version of the ADF test.
[3] Countries include Argentina, Australia, Belgium, Brazil, Canada, Denmark, Finland, France, Germany, Italy, Japan, Mexico, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and the United States.

observations for each country. Small gaps in the series, generally corresponding to war years, are eliminated by linear interpolation as in Taylor. His paper may be consulted for a more complete description of the data.

Serletis and Gogas use the FS test to assess PPP for 21 OECD countries using quarterly data for 1973:1-1998:4. The correct specification of the FS test depends on the orders of integration of the variables of interest. Because the nominal exchange rate and the price level variables are I(1) for all countries in the Serletis and Gogas data set, their version of the FS test is given by equation (1),

$$s_t - s_{t-k-1} = q_k + h_k\left(x_t - x_{t-k-1}\right) + u_{kt} \qquad \text{k=1…K} \qquad (1)$$

where s_t is the logarithm of the period t nominal exchange rate measured as the price of a unit of foreign currency in terms of either the US dollar, German Deutschemark, or Japanese yen and x_i is the logarithm of the ratio of the domestic price level to the foreign price level.[4] The test involves regressing the k+1 period change in the nominal exchange on the k+1 difference in the relative price levels for k ranging from 1 to a pre-selected maximum K. The terms q_k and h_k are the intercept and slope coefficient, respectively, for the k+1 difference while u_{ki} is the period i white noise error term. They find some weak support for PPP, although they note that the power of the FS test is low, a problem originally addressed by Coe and Nason (2002).

As in Serletis and Gogas, all the variables in Taylor's data set are integrated of order one, however, our formulation of the FS test, given by equation 2, differs somewhat from theirs.

$$d_t - d_{t-k-1} = a_k + b_k\left(p_t^{US} - p_{t-k-1}^{US}\right) + \varepsilon_{kt} \qquad \text{k=1…K} \qquad (2)$$

[4] See their paper for more detail on the derivation of the test as applied to PPP.

Here d_t is the log of the dollar denominated foreign price level defined as:

$$d_t = p_t^f + s_t \qquad (3)$$

where p_t^f is the log of the product of the foreign price level, and s_t is the log of the nominal exchange rate (quantity of US dollars per unit of foreign currency).

p_t^{US} is the time t US price level, a_k and b_k are parameters, and ε_{kt} is a white noise error term. If PPP holds the b_k will approach one as k gets larger.

Standard practice is to estimate b_k for each value of k using OLS and construct 95-percent confidence intervals for the b_k's using the Newey-West correction and a t-distribution with T/k degrees of freedom. T is the total number of observations. Under the null hypothesis that PPP holds, the b_k converge to one as k increases, and PPP is rejected if the confidence interval does not include unity as k becomes large.

There are two reasons for the change in the formulation of the test from that derived in Serletis and Gogas. First, if the k+1 period change in the nominal exchange rate were the dependent variable as in their work, zeroes would frequently appear because our study spans extended periods of fixed exchange rate regimes.[5] Use of the change in the dollar-denominated price level as the dependent variable avoids this situation by allowing changes in either the nominal exchange rate or the foreign price level to adjust the dollar denominated foreign price level to maintain PPP. Second, the FS test requires that the explanatory variable be exogenous. While the foreign price level may not be independent of the nominal exchange rate for those countries in which foreign trade accounts for a

[5] Note that their data set includes only the post-Bretton Woods period of floating exchange rates while ours includes periods of both fixed and floating exchange rate regimes with most of observations from times of fixed nominal rates.

significant share of GDP, the US price level is more likely to be exogenous with respect to the dollar-denominated price level elsewhere.

3. Test results.

The FS methodology requires that the orders of integration of the U.S. price level and each of the foreign, dollar denominated price levels be determined. All series show upward movement, therefore the ADF test equations contain both a constant and trend. Because the results may depend on the number of lags, the ADF tests are carried out using four alternative lag selection techniques. Lag length is determined using the AIC, BIC, and an LM test criteria, as well as a general to simple (GS) technique. For the LM test sufficient lags are included in the test equation to reject serial correlation in the test equation residuals at a 5% significance level. The GS technique begins with a maximum number of lags and then the last lag is eliminated if it is not significant at a 5% level. The process is repeated until the last lag in the test equation is significant. A maximum lag length of four years was considered in each approach. All of the ADF tests fail to reject unit roots in the U.S. price level and all the dollar equivalent foreign price levels.[6]

The ADF-GLS test developed by Elliott, Rothenberg, and Stock (1996), which has greater power than standard ADF test, also is employed. Again, a unit root cannot be rejected for each series. Finally, the Kwiatkowski, Phillips, Schmidt, Shin (1992) or KPSS test of the null hypothesis of trend stationarity versus an alternative hypothesis of a random walk with drift is used. For each series, trend stationarity is rejected in favor of the unit root alternative. Given that all the test results suggest each series has a single

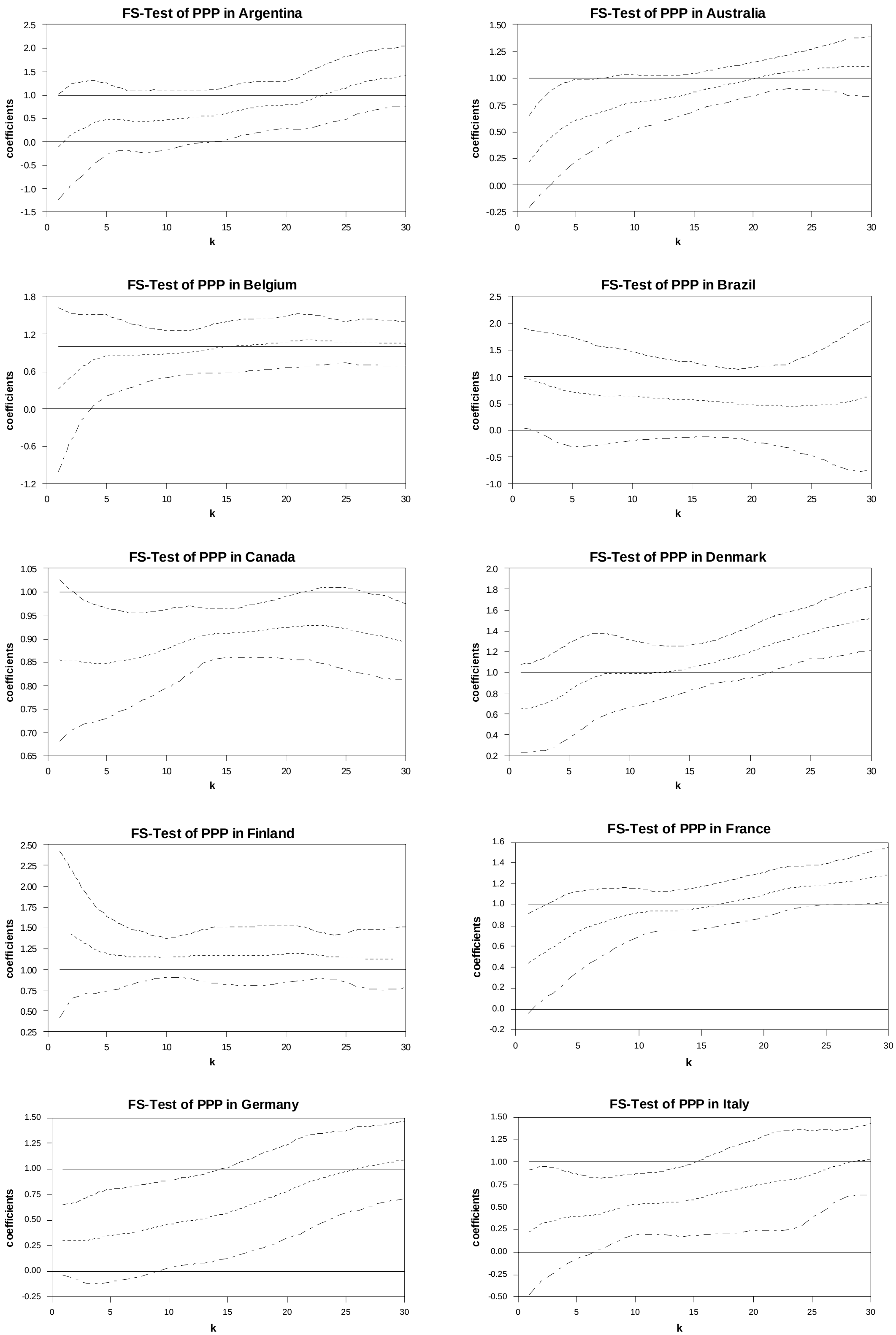
[6] ADF test results and those of the other unit root procedures discussed below are available from the authors.

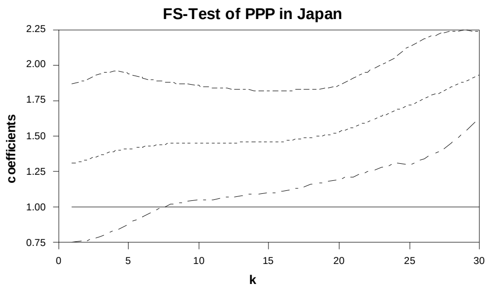
unit root, the FS test as presented in equation (2) can be used to test long-run PPP between the US and the other nineteen countries in the sample.[7]

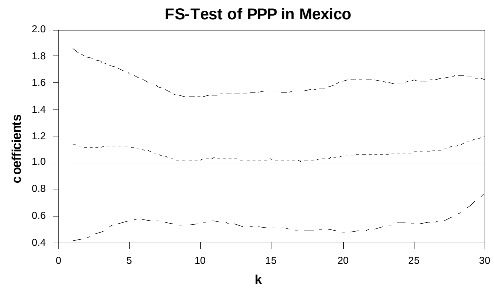
Results of the FS tests are presented in the figures in Panel A. For seven of the 19 series tested, none of the b_k is significantly different from one (i.e. one is within the 95% confidence interval), thus PPP cannot be rejected in these cases. The seven countries are Argentina, Belgium, Brazil, Finland, Mexico, Sweden, and the U.K. For three additional countries (Australia, Germany, and Italy) we conclude that the PPP null cannot be rejected because the b_k for large values of k are not significantly different from one. In two indeterminate cases, France and Norway, the lower confidence bound is very close to one for some large values of k. The FS test results clearly do not support PPP for the other seven countries. PPP is rejected at most values of k for Canada and Japan and at large values of k for Denmark, the Netherlands, Portugal, Spain, and Switzerland.

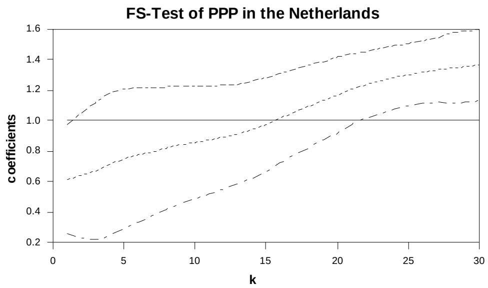
[7] There is no indication of a second unit root in any of the series.

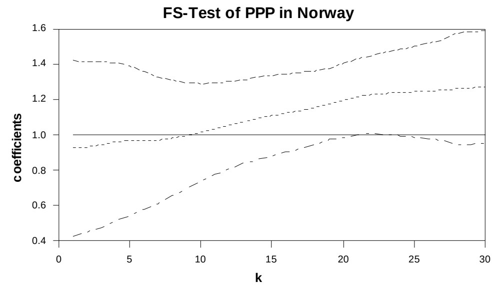
Panel A-Plots of the b_k Coefficients and 95% Confidence Intervals

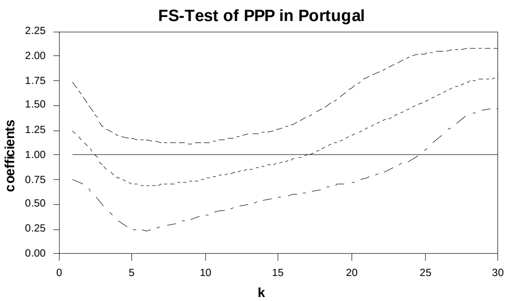


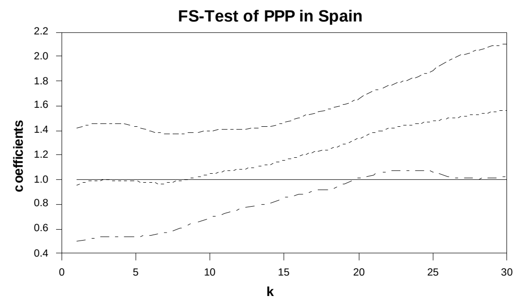

FS-Test of PPP in Japan
2.25
2.00
1.75
1.50
1.25
1.00
0.75
coefficients
0
5
10
15
20
25
30
k

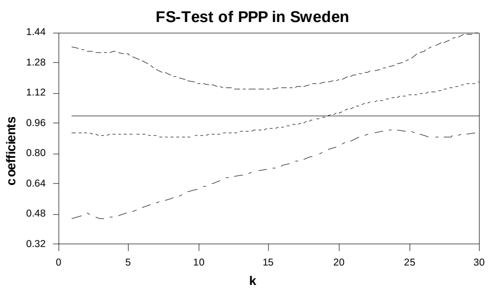

FS-Test of PPP in Mexico
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
coefficients
0
5
10
15
20
25
30
k

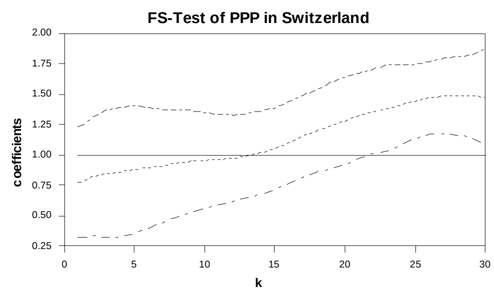

FS-Test of PPP in the Netherlands
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
coefficients
0
5
10
15
20
25
30
k

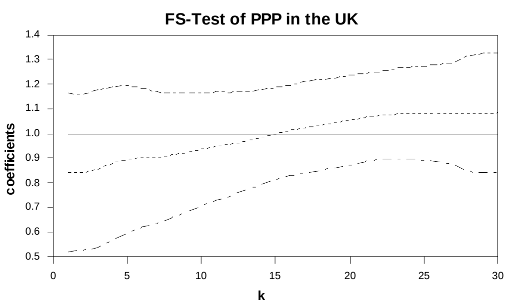

FS-Test of PPP in Norway
1.6
1.4
1.2
1.0
0.8
0.6
0.4
coefficients
0
5
10
15
20
25
30
k


FS-Test of PPP in Portugal
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
coefficients
0
5
10
15
20
25
30
k


FS-Test of PPP in Spain
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
coefficients
0
5
10
15
20
25
30
k


FS-Test of PPP in Sweden
1.44
1.28
1.12
0.96
0.80
0.64
0.48
0.32
coefficients
0
5
10
15
20
25
30
k


FS-Test of PPP in Switzerland
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
coefficients
0
5
10
15
20
25
30
k


FS-Test of PPP in the UK
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
coefficients
0
5
10
15
20
25
30
k

The relatively wide confidence intervals shown in the figures are consistent with the conclusion of Coe and Nason (2002, 2004) that the FS test has low power. To assess the extent of this problem, we employ the inverse power (IP) function derived by Andrews (1989). Table 1 displays the b_k coefficient estimates for k = 10, 15, 20, 25, 30 for each country for which the FS test fails to reject PPP. Also shown is the corresponding interval, $1 \pm b_{k.50}$, obtained from the IP function. Only if the true b_k coefficient lies outside this interval would the FS test reject a false null hypothesis of PPP at a 50% or better probability. Thus, as the $1 \pm b_{k.50}$ interval becomes wider, the power of the FS test decreases.

Taking Argentina as an example, only if the true b_{30} were outside the interval (.5427, 1.4573) would the FS test have a 50% or better chance of rejecting PPP. This relatively wide interval indicates that it would be difficult to reject PPP for Argentina even if the proposition were false. Thus, the FS test's failure to reject the null hypothesis must be regarded as weak support, at best, for PPP. Similarly, the interval for Brazil at k = 30 is (.0118, 1.9882) suggesting that the failure to reject PPP for Brazil is almost meaningless, as one would fail to reject PPP for almost any reasonable parameter values.

However, the situation is better for the other countries, with the widest interval at k = 30 for Mexico (.6998-1.3002) and the tightest for the UK (.8277-1.1723), giving us more confidence in the FS results for the remaining countries. In summary, the best support for long run PPP, relative to the US price level, is found for Australia, Belgium, Finland, France, Germany, Italy, Mexico, Norway, Sweden, and the UK. The FS tests reject PPP in Canada, Denmark, Japan, the Netherlands, Portugal, Spain, and

Switzerland. For Brazil and Argentina, the FS tests fail to reject PPP, but the IP function shows that the results for these two countries are not informative.

4. Conclusions

Our findings are broadly consistent with Taylor's test results. Except for Norway, in each of the countries for which our FS test results support PPP, Taylor rejects a unit root in the real exchange rate at the 5% level or better. Furthermore, Taylor also finds that unit roots can be rejected in real exchange rates for Argentina and Brazil thus consistent with our, admittedly low power, FS results for these two countries. Taylor finds weaker evidence for PPP in the real exchange rates of Canada, the Netherlands, and Portugal with unit roots rejected at only a 10% level at best. Similarly, our FS test results do not support PPP for these three countries. Only for three countries (Denmark, Spain, and Switzerland) do Taylor's unit root tests show evidence for PPP while the FS test results reject purchasing power parity.

Table 1-Selected Estimated b_k & Andrews Inverse Power Bounds

		k=10	k=15	k=20	k=25	k=30
Argentina	$\hat{b}_k$	.4591	.5946	.7816	1.1480	1.4023
	$1-b_{k,.50}$	.4320	.5298	.5944	.5264	.5427
	$1+b_{k,.50}$	1.5680	1.4702	1.4056	1.4736	1.4573
Australia	$\hat{b}_k$	.7758	.8667	.9893	1.0845	1.1076
	$1-b_{k,.50}$	.7680	.8492	.8741	.8560	.8001
	$1+b_{k,.50}$	1.2320	1.1508	1.1259	1.1440	1.1999
Belgium	$\hat{b}_k$	.8815	.9945	1.0733	1.0699	1.0435
	$1-b_{k,.50}$	.6603	.6559	.6726	.7462	.7409
	$1+b_{k,.50}$	1.3397	1.3441	1.3274	1.2538	1.2591
Brazil	$\hat{b}_k$	.6470	.5738	.4839	.4711	.6368
	$1-b_{k,.50}$	.2557	.4189	.4679	.3343	.0118
	$1+b_{k,.50}$	1.7443	1.5811	1.5321	1.6657	1.9882
Finland	$\hat{b}_k$	1.1424	1.1649	1.1876	1.1435	1.1480
	$1-b_{k,.50}$	.7907	.7127	.7285	.7789	.7385
	$1+b_{k,.50}$	1.2093	1.2873	1.2715	1.2211	1.2615
France	$\hat{b}_k$	.9262	.9697	1.0976	1.1949	1.2683
	$1-b_{k,.50}$	.7995	.8265	.8285	.8519	.8166
	$1+b_{k,.50}$	1.2005	1.1735	1.1715	1.1481	1.1834
Germany	$\hat{b}_k$	.4602	.5732	.7807	.9725	1.0830
	$1-b_{k,.50}$	.6148	.6256	.6354	.6969	.7329
	$1+b_{k,.50}$	1.3852	1.3744	1.3646	1.3031	1.2671
Italy	$\hat{b}_k$	.5276	.5866	.7376	.8637	1.0322
	$1-b_{k,.50}$	.6957	.6562	.5997	.6338	.7171
	$1+b_{k,.50}$	1.3043	1.3438	1.4003	1.3662	1.2829
Mexico	$\hat{b}_k$	1.0232	1.0254	1.0495	1.0790	1.1989
	$1-b_{k,.50}$	.5801	.5732	.5657	.6184	.6998
	$1+b_{k,.50}$	1.4199	1.4268	1.4343	1.3816	1.3002
Norway	$\hat{b}_k$	1.0150	1.1088	1.1931	1.2434	1.2704
	$1-b_{k,.50}$	.7508	.8052	.8318	.8053	.7774
	$1+b_{k,.50}$	1.2492	1.1948	1.1682	1.1947	1.2226
Sweden	$\hat{b}_k$	.8932	.9301	1.0175	1.1075	1.1760
	$1-b_{k,.50}$	.7509	.8223	.8624	.8560	.8158
	$1+b_{k,.50}$	1.2491	1.1777	1.1376	1.1440	1.1842
UK	$\hat{b}_k$	.9366	.9997	1.0545	1.0821	1.0844
	$1-b_{k,.50}$	.7930	.8419	.8541	.8547	.8277
	$1+b_{k,.50}$	1.2070	1.1581	1.1459	1.1453	1.1723

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