Macroeconomic Issues

PPP Persistence within Sectoral Real Exchange Rate Panels

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Recent studies about estimating half-lives of purchasing power parity argues that heterogeneity bias resulting from aggregating the real exchange rate across sectors is important and should be taken into account. However, they do not use appropriate techniques to measure persistence. In this paper we use the extended median-unbiased estimation method in panel context for each sector separately and calculate both point estimates and confidence intervals. We conclude that controlling for sectoral heterogeneity bias and small sample bias will not solve the PPP puzzle.

Introduction

In the field of international macroeconomics, the persistence of real exchange rate shocks has attracted many macro economists specifically concentrating on the Purchasing Power Parity puzzle. Rogoff (1996) describes the puzzle as the problem of reconciling the high short–term volatility of real exchange rates with an extremely slow rate at which shocks to dissipate. He explains a consensus view of 3 to 5 years of the half life of PPP deviations among some studies based on long-horizon data sets in which the fixed and floated exchange rate is mixed. There were several papers that attempted to estimate the half life to PPP but didn't use modern techniques for measuring the persistence of real exchange rate including Frankel (1986), Abuaf and Jorion (1990), and Lothian and Taylor (1996). For example Lothian and Taylor (1996) find evidence for long-horizon real exchange rates that they are mean reverting but the speed of reversion is very slow. They estimate the half-life for PPP deviations as 5.78 years for dollar-sterling real exchange rate. However this strongest evidence of mean reversion comes from the Least Square estimates.

Recently Murray and Papell (2002) use appropriate methods to measure the persistence of real exchange rates for long-horizon (annual) and post-1973 (quarterly) data. Their estimates accounts for the serial correlation and small sample bias. Using median unbiased estimates allowing for serial correlation on these two data sets, the point estimates of half lives are estimated as consistent with the "*consensus view*" while the confidence intervals are too wide providing no information on the size of the half-lives. Also, Murray and Papell (2005a) show that the methods used in Lothian and Taylor (1996) underestimate the half-lives of PPP deviations and overestimate the speed of mean reversion using median-unbiased estimation technique.

The recent study of Imbs, Mumtaz, Ravn and Rey (hereinafter IMRR) (2005) shows that sectoral heterogeneity matters for the persistence of relative prices. They use monthly non-harmonized price indices for consumption goods and services specifically for 19 foods categories and 13 countries for the period 1981-1995[1]. The aggregation bias which comes from heterogeneity is positive if there are no strong and systematic asymmetries in the price indices. They find that when the heterogeneity is taken into account, the half-life for sectoral real exchange rate decreases to 11 to 18 months which excludes the consensus view of Rogoff (1996). On the other hand, Chen and Engel (2004) reexamine the claim in IMRR. They investigate the same data set with a few corrections and additions. Then they find that the half-life estimate is even higher than Rogoff"s claim. So they conclude the sectoral heterogeneity is not an important source of bias and it doesn't seem to explain the PPP puzzle.

This consensus view comes mostly from univariate studies of long-horizon data. Some recent panel studies includes Wu (1996), Papell (1997, 2002), and Fleissing and Strauss (2000) find shorter half-lives from the univariate studies. However they do not use the appropriate techniques to measure the persistence. Murray and Papell (2005b) using quarterly aggregate post-1973 data, extend the median unbiased estimation technique to the panel context. After estimating the point estimates and confidence interval estimates, they find strong evidence confirming the consensus view. Although panel regressions provide more information than the univariate regressions, they still do not help to solve the PPP puzzle.

Until now, there is no research that accounts for sectoral heterogeneity bias and for small sample bias[2]. Murray and Papell (2005b) paper uses panel regressions for aggregate data. Even though their estimates improve the results, since their data is at aggregate level, it

[1] Because harmonized price indices are available only for short period time.

[2] Reidel and Szilagyi (2004) find that the interaction between the small sample bias and sectoral heterogeneity bias is non-trivial and these biases shouldn't be analyzed separately.

doesn't address sectoral heterogeneity. So the main aim of the paper is to use their methodology and look at the sectoral data. We utilize IMRR (2005) monthly sectoral data set from Eurostat. We will calculate the point estimates and confidence intervals of the speed of adjustment to PPP for sectoral real exchange rates, in the panel context and using median-unbiased estimation technique. Using the nominal exchange rates and sectoral Consumer Price indices for USA and for other 12 European countries, we constructed the real sectoral exchange rates for the period 1981:01-1995:12.

The remainder of the paper is structured as follows. The next section focuses on the estimation techniques of persistence of PPP and demonstrates some examples using this data set for comparison reasons. Then the third section describes the details of data and presents estimation results. In the final section we give concluding remarks.

Estimation Techniques for Persistence of PPP

The aggregate real exchange rate with the United States dollar as the numeraire currency is calculated as

$$(1)\quad q = e + p^{*} - p$$

where q is the logarithm of the real exchange rate, e is the logarithm of the nominal (dollar) exchange rate, p is the logarithm of the domestic CPI, and p^* is the logarithm of the U.S. CPI. In particular the sectoral real exchange rate is calculated as (1). The only difference in the equation is as follows:

$$(2)\quad q_i = e + p_{i,US}^{*} - p_i$$

where q_i is the logarithm of the real exchange rate for the sector i, e is the logarithm of the bilateral nominal exchange rate between each country and the US dollar, p_i is the logarithm of the domestic CPI for the sector i and $p_{i,US}^*$ is the logarithm of the U.S. CPI for sector i.

Univariate Estimates

After we calculated the sectoral real exchange rates using equation (2) we can estimate the speed of adjustment to PPP. The Dickey-Fuller (DF) model regresses

$$(3)\quad q_{i,t} = c_i + \alpha_i q_{i,t-1} + u_{i,t}$$

the real exchange rate for each sector on a constant and its lagged level[3]. Then the half-live, the number of periods required for a unit shock to dissipate by one half, is calculated as ln(0.5)/ln(α).

This AR(1) specification is valid when the error terms are serially uncorrelated. When we take into account the serial correlation, we estimate the Augmented-Dickey Fuller regression (ADF):

$$(4)\quad q_{i,t} = c_i + \alpha_i q_{i,t-1} + \sum_{j=1}^{k_i} \psi_{i,j} \Delta q_{i,t-j} + u_{i,t}$$

In this paper we choose the lag length, k, via the GS-general to specific- criterion studied by Hall (1994) and and Ng and Perron (1995)[4]. k_i denotes the sector specific lag length.

[3] We do not include a time trend to this regression as it would be theoretically wrong. See the details in Papell and Prodan (2004).

However there is a problem with the half-life estimation when we use Least Square estimates, because α is significantly downward biased when we have small sample[5]. To deal with the problem we use the exact bias correction which is median-unbiased estimator from Andrews (1993)[6]. He proposes a technique which allows us to calculate the exactly median-unbiased estimator of α and exact confidence intervals for this parameter. The essence of bias correction method for the LS estimator of α is as follows. If the LS estimator of α is equal to 0.9, say, we find the value of "α" such that the median of the least squares estimate is 0.9.

When we have a monotonic transformation, in our case the half-life: ln(0.5)\ln(α) is a monotonic transformation for α, the median unbiased estimator and its coverage probabilities of their confidence intervals are reserved. For example if the α_{MU} is a median unbiased estimator for α_{LS} then the half-life: ln(0.5)\ ln(α_{MU}) will be median unbiased too.

For the Dickey-Fuller regression, it is easier to calculate the median-unbiased estimator of HL as it is assumed that the HL calculated from AR (1) model shows that the shocks to the real exchange rate die out monotonically. Briefly, we estimate the α_{LS} from equation (3) and estimate α_{MU} looking at the tables of Andrews (1993) then we calculate the HL: ln(0.5)\ ln(α_{MU}) and the speed of convergence to PPP.

Table1. Exactly Median Unbiased Half-lives in Dickey-Fuller Regressions Aggregate Monthly data: 1981:01- 1995:12

$$q_t = c + \alpha q_{t-1} + u_t$$

country	α_{LS}	α_{MU}	*95%CI MU*	HL_{MU} *(yearly)*	*95%CI(yearly) For* HL_{MU}
Belgium	0.9884	1	[0.975,1]	∞	[2.28, ∞]
Germany	0.9903	1	[0.980,1]	∞	[2.86, ∞]
Denmark	0.9923	1	[0.985,1]	∞	[3.82, ∞]
Spain	0.9931	1	[0.985,1]	∞	[3.82, ∞]
Italy	0.9879	1	[0.975,1]	∞	[2.28, ∞]
France	0.9856	1	[0.970,1]	∞	[1.90, ∞]
Greece	0.9882	1	[0.975,1]	∞	[2.28, ∞]
Netherlands	0.9864	1	[0.975,1]	∞	[2.28, ∞]
Portugal	0.9961	1	[0.990,1]	∞	[5.75, ∞]
Finland	0.9865	1	[0.975,1]	∞	[2.28, ∞]
United Kingdom	0.9683	0.99	[0.945,1]	5.75	[1.02, ∞]

Note: The sample sizes are 179 for each country. Using the method in Andrews (1993) paper for T+1=179 the tables for median unbiased estimators are simulated.

4 The is also another lag selection method by Ng and Perron (2001) called modified Akaike information criterion (MAIC). Due to high computational expenses we will not apply this method for sensitivity analysis.

5 In Andrews (1993): If the AR models that contain an intercept and α is very large (close to 1) then there is a significant downward bias in the standard parameters.

6 Other than median-unbiased technique, there is also mean-unbiased ness to correct for the small sample bias of least square estimators. Mean-unbiased ness means that the expected value of an estimator is equal to the true parameter value. Killian (1998) suggested similar corrections based on mean-unbiased estimates of AR parameters. He estimated the bias corrected AR coefficients and confidence intervals for impulse response functions by applying a bootstrap-after-bootstrap method. However even though both method will work well under AR(p>1), for estimating the half-life for AR(1) mean unbiased ness technique will not be unbiased under the HL transformations. To be consistent throughout the paper we will use median-unbiased technique for all models.

For demonstration look at the Table 1 which prints the exactly median unbiased half-lives for aggregate monthly data. For example, in Germany while α_{LS} is 0.9903, α_{MU} is 1 like most of the other countries. So the size of the bias is -0.0097 proving the downward bias in the least square estimate. The half life median unbiased estimates are infinity for all European countries except for United Kingdom which can be considered as in the consensus view as HL_{MU} is 5.75 years.

Table 2. Exactly Median Unbiased Half-lives in Dickey-Fuller Regressions : Sectoral Monthly data for Germany : 1981:01- 1995:12

$$q_{i,t} = c_i + \alpha_i q_{i,t-1} + u_{i,t}$$

sectors	No:	Sample size	α_{LS}	HL_{LS} (yearly)	α_{MU}	95%CI MU	HL_{MU} (yearly)	HL_{MU} (yearly) 95%CI
Bread	1	173	0.9860	4.1	1	[0.97,1]	∞	[1.9, ∞]
Meat	2	175	0.9891	5.29	1	[0.975,1]	∞	[2.28, ∞]
Dairy	3	175	0.9890	5.21	1	[0.975,1]	∞	[2.28, ∞]
Fruits	4	175	0.8731	0.43	0.89	[0.815,0.975]	0.5	[0.28,2.28]
Tobacco	5	175	0.9470	1.06	0.97	[0.91,1]	1.9	[0.61, ∞]
Alcohol	6	175	0.9926	7.73	1	[0.985,1]	∞	[3.82, ∞]
Clothing	7	175	0.9970	19.3	1	[0.99,1]	∞	[5.75, ∞
Footwear	8	175	0.9995	116	1	[0.995,1]	∞	[11.5, ∞]
Rents	9	175	0.9993	83.2	1	[0.995,1]	∞	[11.5, ∞]
Fuel	10	175	0.9855	3.94	1	[0.97,1]	∞	[1.9, ∞]
Furniture	11	166	0.9943	10.1	1	[0.985,1]	∞	[3.82, ∞]
Dom.Appl.	12	166	0.9939	9.46	1	[0.985,1]	∞	[3.82, ∞]
Vehicles	13	175	0.9992	73.5	1	[0.995,1]	∞	[11.5, ∞]
Pub.Transp.	14	175	0.9823	3.24	1	[0.965,1]	∞	[1.62, ∞]
Comm.	15	175	0.9669	1.72	0.99	[0.94,1]	5.75	[0.93, ∞]
Sound	16	175	0.9938	9.24	1	[0.985,1]	∞	[3.82, ∞]
Leisure	17	175	0.9882	4.88	1	[0.975,1]	∞	[2.28, ∞]
Books	18	175	0.9884	4.95	1	[0.975,1]	∞	[2.28, ∞]
Hotels	19	175	0.9473	1.07	0.97	[0.91,1]	1.9	[0.61, ∞]

Note: Using the method in Andrews (1993) paper for T+1=sample size (n) the tables for median unbiased estimators are simulated.

Murray and Papell (2002) compute the same table for more countries and for the quarterly data in the longer period of time 1973:01-1998:02. Their estimates for HL_{MU} are much smaller because when we go from quarterly data to monthly data the more serial correlation happens, persistence increases. Monthly data contains more noise causing the estimates for half-life to rise.

Table 2 shows the exactly median unbiased half-lives for sectoral monthly data only for Germany[7]. Because of the sectoral heterogeneity bias α_{MU} is not equal to 1 in all sectors as it was 1 at the aggregate level[8]. When we focus on the average of half lives of lower confidence intervals, it is 3.82 years which is higher than the aggregate level of that (2.82 years). The puzzle seems to get worse in contrast to the result in IMRR (2005).

As for Augmented Dickey-Fuller regression, when there is a serial correlation we have to model it as AR(p). Andrews and Chen (1994) extend the median unbiased estimator to the

[7] These sectoral half lives are estimated for all the European countries. Germany is been chosen randomly just to emphasize the difference in half lives between the sectoral and aggregate data levels.
[8] Usually the half-life median unbiased estimate for sectors 4, 15 and 19, for almost all the European countries are consisted with the consensus view.

AR(p) case. They introduce approximately median-unbiased estimators and confidence intervals for univariate AR(p) models[9]. However in this case to be able to estimate the HL, it is not sufficient to estimate α, as the shocks do not decay at a constant rate. So we utilize the impulse response function of an AR (k+1=p) to calculate the half-lives. Andrews and Chen (1994) proves that their technique for AR(2) is median unbiased for all lags but for higher order AR models (p>2), the impulse response estimates are downward median-biased. However the downward bias is worse in the least square estimates.

Andrews and Chen (1994) describes a computationally intensive and iterative method for obtaining approximately median-unbiased estimators of the parameters of the univariate augmented Dickey-Fuller model ($\alpha,\psi_1,\ldots,\psi_k$). The basic intuition is the same as to find median-unbiased estimate for AR(1) case. Since $\psi_1,\ldots,\psi_k$ are unknown, they suggest a simple iterative procedure that yields an approximately median-unbiased estimator. First, compute the least square estimates of $\alpha,\psi_1,\ldots,\psi_k$ using ADF regression. Second treating these $\psi_{1,LS1},\ldots,\psi_{k,LS1}$ as though they were true values compute the $\alpha_{1,AMU}$. Third treating $\alpha_{1,AMU}$ as though it was the true value of α and compute a second round of least square estimators $\psi_{1,LS2},\ldots,\psi_{k,LS2}$ (regressing $q_t - \alpha_{1,AMU}*q_{t-1}$ on $\Delta q_{t-1},\ldots \Delta q_{t-k}$,1). Next treat the new $\psi_{1,LS2},\ldots,\psi_{k,LS2}$ as though they were true values compute the $\alpha_{2,AMU}$. Continue to this procedure either for fixed number iterations or until convergence, and call this α_{AMU}. In our paper we will continue till convergence occurs.

Table 3. Approximately Median Unbiased Half-lives in Augmented Dickey-Fuller Regressions : Sectoral Monthly data for Germany: 1981:01- 1995:12

$$q_{i,t} = c_i + \alpha_i q_{i,t-1} + \sum_{j=1}^{k_i} \psi_{i,j} \Delta q_{i,t-j} + u_{i,t}$$

sectors	No:	Sample size	k	α_{LS}	HL_{LS} (yearly)	α_{MU}	95%CI MU	HL_{MU} (yearly)	HL_{MU} (yearly) 95%CI
Bread	1	173	1	0.9807	2.96	1	[0.965,1]	∞	[1.62, ∞]
Meat	2	175	17	0.9864	4.21	1	[0.965,1]	∞	[1.62, ∞]
Dairy	3	175	1	0.9828	3.34	1	[0.965,1	∞	[1.62, ∞]
Fruits	4	175	24	0.8174	0.29	0.965	[0.745,1]	1.62	[0.2, ∞]
Tobacco	5	175	1	0.9437	1	0.97	[0.91,1]	1.9	[0.61, ∞]
Alcohol	6	175	1	0.9868	4.35	1	[0.975,1]	∞	[2.28, ∞]
Clothing	7	175	1	0.9909	6.29	1	[0.98,1]	∞	[2.86, ∞]
Footwear	8	175	1	0.9941	9.81	1	[0.985,1]	∞	[3.82, ∞]
Rents	9	175	1	0.9939	9.38	1	[0.985,1]	∞	[3.82, ∞]
Fuel	10	175	21	0.9858	4.02	1	[0.96,1]	∞	[1.41, ∞]
Furniture	11	166	1	0.9898	5.62	1	[0.98,1]	∞	[2.86, ∞]
Dom.Appl.	12	166	1	0.9845	3.69	1	[0.98,1]	∞	[2.86, ∞]
Vehicles	13	175	21	0.9942	9.95	1	[0.98,1]	∞	[2.86, ∞]
Pub.Transp.	14	175	17	0.9783	2.63	1	[0.955,1]	∞	[1.25, ∞]
Comm.	15	175	17	0.9678	1.77	0.985	[0.935,1]	3.82	[0.86, ∞]
Sound	16	175	17	0.9861	4.13	1	[0.97,1]	∞	[1.9, ∞]
Leisure	17	175	10	0.9818	3.15	1	[0.965,1]	∞	[1.62, ∞]
Books	18	175	1	0.9841	3.61	1	[0.97,1]	∞	[1.9, ∞]
Hotels	19	175	24	0.9373	0.89	0.97	[0.865,1]	1.9	[0.4, ∞]

note: The sectoral Germany data is tested for k_{max} equal to 24 to select the lag lengths via GS method. Using the method in Andrews and Chen (1994) paper for T+1=sample size, the converged median unbiased estimators are estimated.

[9] The approximation is twofold. The first reason is due to the use of estimators rather than true parameters in the first stage (usual statistical sense). The second reason is due to the use of pseudorandom numbers (numerical sense). See AC(1994) for more explanations.

For comparison reasons, both quarterly and monthly aggregate data for the same period of time are employed to compute approximately Median Unbiased Half life estimates[10]. In sum the upper confidence intervals are infinity in both cases but the average of lower confidence intervals is 1.794 years and 1.235 years for monthly and for quarterly respectively. Again the increase in the half-life boundaries is confirmed with the increase in the frequency of data.

In Table 3 the approximate median unbiased half-lives for sectoral monthly data only for Germany is presented. When we consider the serial correlation there is only a small change with the half-life median unbiased estimate. It is either the same or less except for sector 4 (there is an increase from 0.5 years to 1.62 years). At the average the lower confidence intervals for median unbiased estimates gets smaller. So when we incorporate the serial correlation and estimate ADF regressions the confidence intervals get wide.

Panel Estimates

The panel extensions for DF and ADF allowing for heterogeneous intercept would be defined as (5) and (6) respectively:

$$(5)\ q_{i,m,t} = c_{i,m} + \alpha q_{i,m,t-1} + u_{i,m,t} \quad \text{(DF)}$$

$$(6)\ q_{i,m,t} = c_{i,m} + \alpha q_{i,m,t-1} + \sum_{i=1}^{k_{i,m}} \psi_{i,m,j} \Delta q_{i,m,t-j} + u_{i,m,t} \quad \text{(ADF)}$$

where the subscript m indexes the country so $c_{i,m}$ indicates the country-specific intercept. $k_{i,m}$ is the lag length for the sector i and country m. In the ADF regression we allow for serially and contemporaneously correlated errors too. In this panel unit root test we restrict the value of α to be equal across countries following Levin, Lin and Chu (2002)[11]. To be able to estimate these panel estimations when we allow for contemporaneously correlated residuals, we use Feasible GLS which is the seemingly unrelated regressions.

In the panel DF and ADF models, we will use only α to estimate the half-life because the lag lengths, $k_{i,m}$ and the serial correlation coefficients differ across countries within the same sector. The small sample bias still exists in the panel construction. As in the univariate case we will exploit from Andrews (1993) and Andrews and Chen (1994) median unbiased estimators. Murray and Papell (2005b) extend their median unbiased estimation technique to the panel context[12]. When there is a serial correlation, the median-unbiased estimator of α is no longer exact, but it is approximate. This comes from the fact that the true serial correlation coefficients ($\psi_{i,m,j}$) are unknown and median unbiased estimator of α depends on these true values.

Philips and Sul (2003) discuss the monotonicity of median function in panel context and they conclude that for N≥5 and T≥20 median function is monotonic. Since in our panel simulations N=10 and T is at least 166 the median function is monotonic therefore the median unbiased estimate is always unique.

[10] The tables can be sent upon request. Quarterly data is taken from MP(2002). The maximum lag length is set to 12 and 24 for quarterly data and for monthly data respectively.
[11] For further details please read Levin, Lin and Chu (2002).
[12] Further details can be found in Murray and Papell (2005b).

Estimation Results

This paper re-examines the IMRR data set for aggregation bias and small sample bias. It is originally from Eurostat, a statistical data source of European Union. The data consists of two-digit non-harmonized sectoral price indices for 19 sectors (good categories and services) and 13 countries. The data is monthly for the period 1981:01-1995:12[13] .

Table 4 . Approximately Median Unbiased Half-lives in PANEL Unit Root Regressions : Sectoral Monthly data for the period: 1981:01- 1995:12

$$q_{i,m,t} = c_{i,m} + \alpha q_{i,m,t-1} + \sum_{j=1}^{k_{i,m}} \psi_{i,m,j} \Delta q_{i,m,t-j} + u_{i,m,t}$$

sectors	*No:*	*Sample size*	α_{LS}	HL_{LS} *(yearly)*	α_{MU}	*95%CI MU*	HL_{MU} *(yearly)*	HL_{MU} *(yearly) 95%CI*
Bread	1	173	0.98288	3.34	1	[0.99,1]	∞	[5.75,∞]
Meat	2	175	0.96777	1.76	0.985	[0.965,1]	3.82	[1.62,∞]
Dairy	3	175	0.96616	1.68	0.985	[0.965,1]	3.82	[1.62,∞]
Fruits	4	175	0.93374	0.84	0.955	[0.93,0.985]	1.25	[0.8,3.82]
Tobacco	5	175	0.97417	2.21	1	[0.975,1]	∞	[2.28,∞]
Alcohol	6	175	0.9839	3.56	1	[0.99,1]	∞	[5.75,∞]
Clothing	7	175	0.98857	5.02	1	[1,1]	∞	[∞,∞]
Footwear	8	175	0.98304	3.38	1	[0.99,1]	∞	[5.75,∞]
Rents	9	175	0.98399	3.58	1	[0.99,1]	∞	[5.75,∞]
Fuel	10	175	0.95911	1.38	0.975	[0.955,1]	2.28	[1.25,∞]
Furniture	11	166	0.97798	2.59	1	[0.985,1]	∞	[3.82,∞]
Dom.Appl.	12	166	0.97599	2.38	1	[0.98,1]	∞	[2.86,∞]
Vehicles	13	175	0.98544	3.94	1	[0.995,1]	∞	[11.5,∞]
Pub.Transp.	14	175	0.9629	1.53	0.985	[0.96,1]	3.82	[1.41,∞]
Comm.	15	175	0.97501	2.28	0.995	[0.98,1]	11.5	[2.86,∞]
Sound	16	175	0.97943	2.78	1	[0.98,1]	∞	[2.86,∞]
Leisure	17	175	0.97514	2.29	1	[0.98,1]	∞	[2.86,∞]
Books	18	175	0.98506	3.84	1	[0.995,1]	∞	[11.5,∞]
Hotels	19	175	0.97899	2.72	1	[0.98,1]	∞	[2.86,∞]

note: The sectoral data is tested for k_{max} equal to 24 to select the lag lengths via GS method. Using the method in Murray and Papell (2005) paper the estimates for median unbiased half lives in panel context are estimated. We exclude Finland from all sectors because it has much smaller sample size causing to lose a lot of information in the panel regressions. For sectors 9 and 16 we do not have data for Portugal. Also for sector 5 we couldn't include Italy's data as there are less data in that sector only.

First of all we used the General to Specific (GS)[14] method to select lag lengths for the panel unit root regressions . Since it is a monthly data we set the lag length to 24. We calculate approximately median unbiased point estimates and confidence intervals for half-lives of PPP deviation in ADF panel context for each sector separately.

The results are reported in Table 4. When we consider the sectoral heterogeneity bias and small sample bias in the panel regressions, surprisingly the half-life median unbiased estimates rise with infinite upper confidence limit. We find the average of half life least

[13] see data appendix from IMRR (2005) for more details. 14 see Hall (1994) and Ng and Perron (1995).

[14] see Hall (1994) and Ng and Perron (1995).

square estimates for 19 sectors as 2.69 years which is slightly greater than 2.35 years that Murray and Papell (2005b) estimated[15]. When we compared the median unbiased half lives we have a huge difference. We estimated it as infinity in almost all sectors excluding only 6 sectors which are meat, dairy, fruits, fuel, public transformation and communication. In the panel regressions the confidence intervals are tighter than their univariate estimates. Since the upper bounds are infinity in both cases it is hard to measure the difference. However looking at the lower bounds we see that width of the intervals get smaller.

At the average the HL_{MU} is infinity while in Murray and Papell (2005b) paper it is estimated as 2.5 years. All the upper confidence intervals for HL_{MU} (except fruit sector which has 3.82 years) are infinity too. When we exclude clothing, the average of lower confidence intervals for HL_{MU} is 4.06 years. It seems that accounting for heterogeneity bias worsens the PPP puzzle instead of helping to solve it. Also the main conclusion is consistent with Chen and Engel (2004).

Conclusion

The basic problem with the real exchange rate theories is that we have highly volatile real exchange rate and deviations from PPP that are much more persistent than can be explained by conventional theories such as nominal price rigidities. The purpose of this paper was to use Murray and Papell's (2005) methodology which estimates the median unbiased half-lives in panel context, and by utilizing IMRR (2005) monthly sectoral data set to see if these methods help to solve the "Purchasing Power Parity Puzzle". When we account for sectoral heterogeneity bias and for small sample bias, we still can not solve the PPP puzzle. The speed of mean convergence for real exchange rate is too slow.

[15] Murray and Papell (2005) data set includes 9 more countries than our data set which can make big differences.

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