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Abstract

This paper analyses the PPP persistence puzzle using a unique data set of black market real exchange rates for 36 emerging market economies. In estimating PPP half-lives, the problems of small sample bias and serial correlation are addressed by using (exact and approximate) median unbiased univariate and panel estimation methods. We construct bootstrap confidence intervals for the half-lives, as well as exact quantiles of the median function for different significance levels using Monte Carlo simulation. From the more powerful panel results, a new dichotomy emerges. Even after accounting for a number of econometric issues, the PPP persistence puzzle is still a striking characteristic of the majority of emerging market countries. However, in a minority of exchange rates, the PPP puzzle is removed. The rationale for this duality is posited as an interesting question for future research.

Keywords: Exchange rate persistence; Half-lives; Black markets; Median unbiased estimation; Bootstrap confidence intervals

JEL Classification: F31; C22; O11

1. Introduction

The purchasing power parity (PPP) hypothesis plays a central role in theoretical open economy macroeconomic models and in the construction of fundamental equilibrium exchange rates. At its basic level, the PPP model states that the nominal exchange rate is equal to the ratio of foreign to domestic prices, or that the real exchange rate is equal to a constant. After summarizing the extensive empirical literature, Rogoff (1996) concludes that even if the real exchange rate converges to its parity in the long run, the speed of adjustment is very slow (generally 3-5 years half-lives[1]). The length of these half-lives, considered too long to be explained by nominal rigidities given the high short-term volatility of the real exchange rate, has been described by Rogoff (1996) as the "Purchasing Power Parity Puzzle."

In a recent paper, Murray and Papell (2002) [hereafter MP] note that most of the empirical evidence is derived from Dickey-Fuller unit root tests where the half-life is calculated from the coefficient on the lagged real exchange rate[2]. MP identify three crucial weaknesses in this approach. Firstly, it is not appropriate if there is autocorrelation and the real exchange rate actually follows an autoregressive (AR) process of order greater than one. Secondly, most previous studies provide only point estimates of half-lives which give an incomplete picture of the speed of convergence. These point estimates need to be supplemented with confidence intervals. Finally, least squares (LS) estimates of the half-lives are biased downwards in the small samples encountered in practice.

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[1] 'Half-Life' refers to the number of years it takes for at least fifty percent of the deviation from PPP to be eliminated, following a real exchange rate shock.

[2] See, for example, Abuaf and Jorion, 1990; Cheung and Lai, 1994; Wu, 1996; Lothian and Taylor, 1996; Papell, 1997.

To address the above econometric issues, MP apply exact and approximate median unbiased estimators to two different data sets (one is an annual data set and the other is a quarterly data set) consisting of US dollar real exchange rates for industrial countries. Strikingly, MP report point estimates for half-lives that concur with the consensus in previous literature but, unfortunately, confidence interval estimates are too wide to allow the point estimates to be of any use[3].

Of course in examining the half-life of real exchange rates, the previous literature has already made the assumption that a long-run PPP parity exists. However, in MP the upper bound of the confidence interval is generally infinity suggesting the possibility that the real exchange rate is possibly a unit root process and that long-run PPP does not hold. This indeterminacy may drive the wide confidence intervals for the half-life point estimates.

In this paper we extend the MP study on the PPP persistence puzzle beyond the industrial country focus of existing studies[4]. We estimate half-lives for the black market real exchange rates of 36 emerging markets economies over the 1973-1998 period. In so doing, five contributions are made to the literature:

Firstly, Cheung and Lai (2000) compare PPP half-lives in emerging and industrial countries and suggest that the former generally show less persistence. However, the methodology used is vulnerable to many of the criticisms made by MP and we correct for this.

[3] Rossi (2004) and Cashin and McDermott (2003) report similar evidence in support of Rogoff's (1996) consensus of half-life estimates.

[4] To our knowledge, Cheung and Lai (2000) is the only study that investigates half-lives in developing economies, despite the distinct characteristics of these countries. Furthermore, Cheung and Lai use official rather than black market exchange rates. However, it is black market rates which provide a better reflection of the true value of domestic currency in these countries.

Secondly, we employ a unique data set[5] that has not been used previously in the literature on the PPP puzzle. In emerging market economies, fixed exchange rate systems combined with foreign trade restrictions, capital controls, high inflation and external deficits have led to the development of thriving black markets for foreign exchange (see, Agenor, 1992; Kiguel and O'Connell, 1999). In most of these countries, black currency markets have a long tradition, are supported by governments and their volume of transactions is very large. So these black markets play an important role in the economies of emerging market countries and it might be argued that the black market exchange rate reflect the true value of domestic currency much better than the official exchange rate. The data on black market exchange rates have been used recently by Reinhart and Rogoff (2004) for developing a new historical classification of exchange rate regimes in the global economy.

Thirdly, we compare our results from black market exchange rates to those from official exchange rates, which enables us to shed some light on the functioning of the black market for foreign currency in emerging markets.

Fourthly, we extend the median unbiased estimation methods to panels, thus obtaining point estimates of half-lives deviations from PPP and confidence intervals for the whole panel of emerging market economies.

Fifthly, we construct exact quantiles of the median function for different significance levels obtained by Monte Carlo simulation, which can also be used by other studies applying the median unbiased estimation method.

[5] Very few studies have investigated the PPP hypothesis using this major source of information from emerging market economies, and these cover only a small number of countries (typically 1-7) using data up to the late 1980s (e.g. Phylaktis and Kassimatis, 1994; Baghestani, 1997; Luintel, 2000; and Diamandis, 2003). But none of these studies has investigated the issue of half-lives of PPP deviations.

The rest of the paper is organized as follows: Section 2 describes the econometric methodologies employed, while section 3 explains the data. Section 4 presents the empirical results on half-lives. Finally, conclusions are reported in Section 5.

2. Modeling persistence

1.2 Median unbiased approach

Consider the following AR(1) model for the real exchange rate, q:

$$q_t = a + bq_{t-1} + u_t \tag{1}$$

with $u_t \sim iidN(0,\sigma^2)$, initial value $q_0 \sim N(0,\sigma^2/(1-b^2)$ and the AR parameter lying within the interval (-1,1). Define b_{LS} as the least square (LS) estimator of b and note that the half-life is calculated as $\ln(0.5)/\ln(b)$.

It is well known that, in small samples, b_{LS} is biased downward with the size of this bias increasing for large values of b (see, for example, Andrews, 1993). The problem of small sample bias of b_{LS} is of particular relevance, especially in empirical works dealing with half-lives, since the calculation of the latter relies on the biased parameter. Different methodologies have been proposed in the literature. For example, it is well known that the jackknife estimator of b is mean unbiased of order $1/T$ for $T \rightarrow \infty$. One problem with this estimator is that it is not clear if the result holds for values of the AR parameter lying in the region of a unit root.

Another way of approaching the problem is by using median unbiased (MU) estimation. Following Andrews (1993) we define the median z of a random variable X as:

$$P(X \geq z) \geq 1/2 \text{ and } P(X \leq z) \leq 1/2 \tag{2}$$

Assume that b^* is an estimator of b. By definition b^* is an MU estimator of b if the true parameter b is a median of b^* for each b in the parameter space. In other words b^* is a MU estimator if the distance between b^* and the true parameter being estimated is on average the same as that from any other value in the parameter space. Suppose there are two candidates as population parameters b and $b^{'}$ then $E_b \mid b^* - b \mid \leq E_b \mid b^* - b^{'} \mid$ for all b and $b^{'}$ in the parameter space. In this way, the probability that b^* will overestimate the true parameter is the same to that it will underestimate it. Therefore, b_U^*, the exact MU estimator of *b* in (1), is given by:

$$b_U^* = 1 \qquad \text{if } b_{LS} > z(1)$$

$$b_U^* = z^{-1}(b_{LS}) \qquad \text{if } z(-1) < b_{LS} \leq z(1)$$

$$b_U^* = -1 \qquad \text{if } b_{LS} \leq z(-1) \tag{3}$$

where $z(-1) = \lim_{b \to -1} z(b)$ and z^{-1} is the inverse function of $z(.) = z_T(.)$ so that $z^{-1}(z(b)) = b$. In other words, if $b_{LS} = 0.85$, this is not used as the estimate of *b*. Instead, to calculate the MU estimate, we locate the value of *b* that generates the LS estimator to have a median of 0.85.

Appendix 1 shows quantiles of the median function $z(b)$ for different values of $b \in$ {-1,1} and significance levels for our particular sample size obtained by Monte Carlo simulation as in Andrews (1993). The appendix has been constructed using a simple AR(1)[6] model as a DGP and increasing the value of b by 0.01. The number of Monte Carlo replicates was set to 30,000. In what follows, we report a simple example demonstrating how to use the tables in the Appendix 1. Suppose that $z(1) = 0.9772$, then any values of $b_{LS} \geq 0.9772$ corresponds to $b_U^* = 1$. In the same way we calculate b_U^* when $z(-1)$. For example, if $z(-1) = -0.9872$, then, for any values of $b_{LS} \leq -0.9872$, $b_U^* = -1$. Finally if $-0.9872 \leq b_{LS} \leq 0.9772$ one finds b_U^* by looking at the 0.5 quantile column as follows: $b_{LS} = 0.7426$, then $b_U^* = 0.75$. For values of b_{LS} not contained in the 0.5 quantile column, interpolation is required.

Again using the same approach an in Andrews (1993), we can also construct confidence intervals for the median unbiased estimator and for the half-lives of PPP deviations. The $100(1-p)\%$ confidence interval can be constructed as follows:

$$
\begin{aligned}
c_u^L &= 1 && \text{if } b_{LS} > lu(1) \\
c_u^L &= lu^{-1}(b_{LS}) && \text{if } lu(-1) < b_{LS} \leq lu(1) \\
c_u^L &= -1 && \text{if } b_{LS} \leq lu(-1)
\end{aligned} \tag{4}
$$

where c_u^L is the lower confidence interval and $lu(.)$ is the upper quantile. Employing the same approach we can also construct upper confidence interval as follows:

$$
\begin{aligned}
c_u^u &= 1 && \text{if } b_{LS} > ll(1) \\
c_u^u &= ll^{-1}(b_{LS}) && \text{if } ll(-1) < b_{LS} \leq ll(1) \\
c_u^u &= -1 && \text{if } b_{LS} \leq ll(-1)
\end{aligned} \tag{5}
$$

[6] Note that the regression includes an intercept as in Andrews (1993). To check the robustness of our algorithm for the Monte Carlo simulations, we initially reproduced the critical values reported in Andrews (1993), using his T value and for b= 0.90….1.0.

where c_u^u is the upper confidence interval and $ll(.)$ the lower quantile. For example, consider the two-sided 95% confidence interval for b_U^*. Assuming that $b_{LS} = 0.9957$ then, using the 0.975 quantile column, $Il = 0.99$, while $lu = 1$, using the 0.025 quantile column.

2.2 *Approximate median unbiased approach*

The major drawback with the exact median unbiased estimator is that it is only appropriate when the data is well represented by an AR(1) model. When significant serial correlation is present, we need to use higher order AR processes. In this case, model (1) is replaced by the AR(*p*) model:

$$q_t = a + bq_{t-1} + \sum_{j=1}^{p} \theta_j \Delta q_{t-1} + u_t \tag{6}$$

As the true values of the θ_j terms are unknown in practice, the bias correction method in (3) cannot be applied. Instead, Andrews and Chen (1994) posit an iterative procedure that generates an approximately median unbiased[7] (AMU) estimate, b_{AMU}. Firstly, estimate (6) using LS and, treating the estimated values of the θ_i terms as true, compute the MU estimator of *b*, $b_{1,AMU}$, using (3). Secondly, conditional on $b_{1,AMU}$, generate a second set of estimates for the θ_j's and based on these compute second MU estimator of *b*, $b_{2,AMU}$. The final AMU estimate, b_{AMU}, is achieved when convergence is reached. Confidence intervals of the approximate median unbiased estimator and of the half-lives of PPP deviations are obtained in an analogous manner.

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[7] Andrews and Chen (1994) show Monte Carlo evidence demonstrating the accuracy of the AMU estimation method.

It should be noted that half-lives calculated directly from an estimate of b assume shocks to real exchange rates decay monotonically. MP point out that while this is appropriate in the case of an AR(1) model, it is no longer so in the case of an AR(p) model where shocks do not decay at a constant rate. Following Inoue and Kilian (2002), MP suggest obtaining point estimates of half-lives directly from the relevant impulse response function (IRF). The latter is based on the slope coefficients of the levels representation of (6):

$$q_t = a + \sum_{i=1}^{p+1} \phi_i q_{t-i} + u_t \tag{7}$$

where $\phi_1 = b + \theta_1$, $\phi_l = \theta_l - \theta_{l-1}$ for $l = 2,...,p$, and $\phi_{p+1} = -\theta_p$. Since our algorithm generates distributions of the θ_i and ϕ_i coefficients, we can also construct confidence intervals of the AMU estimates of half-lives calculated from the impulse response functions.

2.3 Panel median unbiased estimation methods

Following Murray and Papell (2005), we consider an *ad hoc* extension of the univariate MU estimation methods to panels. As a preliminary step, we first amend the panel DF regression below for the median bias of b

$$q_{it} = a + bq_{i,t-1} + u_{it} \tag{8}$$

where the number of real exchange rates is indexed from $i = 1, 2,..., N$. Computing b_{MU} for our case, N = 34 and T + 1 = 312, simulated data are generated as AR(1) processes with a common b, zero mean and serially and uncorrelated Gaussian errors. We estimate regression (8) by feasible GLS considering a limited array of b from 1.0, 0.99, 0.98, …, 0.85[8] and the resulting exactly MU estimators, plus 90% and 95% confidence intervals are shown in Appendix 2.

Moving on, to calculate AMU estimates of b in panel ADF regressions we follow an analogous iterative procedure to the univariate case. Firstly, conditional on $\theta_{1i}, \theta_{2i}, ..., \theta_{pi}$, we compute the MU estimator of b, $b_{1,AMU}$. Conditional on $b_{1,AMU}$, new estimates of the θ_{ji}'s are obtained and employed to calculate $b_{2,AMU}$. Again, the final AMU estimate, b_{AMU}, is achieved when convergence is reached[9].

3. Data

We employ monthly data on black market exchange rates for a highly heterogeneous panel of thirty-six emerging market countries over the period 1973M1-1998M12[10]. The US Dollar is used as numeraire currency. The black market exchange rates are obtained from *Pick's World Currency Yearbook (*various publications). The consumer price index (CPI) is used as the price index. We have included only 36 countries because of the lack of consistent data on the CPI for most emerging markets. We have also excluded a number of countries because the time series for the black market exchange rate either have missing observations or display exceptionally large jumps due to the re-denomination or large devaluation of the respective domestic currency against the US dollar. The sample ends in 1998 because of the unavailability of data beyond that year.

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[8] Compared to the univariate case (see Appendix 1), a limited array of b is considered because of the very high computational cost of calculating median unbiased corrections in a panel context.

[9] The estimation methodology allows for serially and contemporaneously correlated errors.

[10] Murray and Papell (2002) employ data for industrial countries over an analogous period. In our sample, it should be noted that data for two countries (Brazil and Poland) commences later. Specifically, Brazil begins in 1979:12 and Poland 1988:01. Thus, to ensure a balanced panel, in the panel estimations only 34 countries are employed.

The countries in our panel are very heterogeneous, varying from poor developing countries (e.g. Nepal, Ghana) to semi-industrial countries (e.g. Korea, Mexico), with different growth experiences and quite diverge levels of per capita income. Thus we address Rogoff's (1996) point whether the PPP hypothesis would hold between countries with different growth experience.

4. Empirical results

The exact median unbiased point estimates are reported in Table 1. The median half-life point estimate is 5.65 years. This is similar to MP, who report a median estimate of 5.69. However, our confidence intervals are slightly narrower than those of MP. For example, our median lower bound is 3.10 years; higher than MP, who report a value of 1.41. And whilst both studies present a median upper bound of $[\infty]$, MP find an infinite upper bound in all OECD countries, whilst our results show a finite upper bound for six emerging market economies.

Table 2 reports point estimates and 95% confidence intervals employing approximate median unbiased estimation that corrects both for the LS small sample bias and serial correlation[11]. The number of lags in the ADF regressions were selected by using the general-to-specific lag selection criterion suggested by Ng and Perron (1995). For comparison purposes, we calculate point estimates and confidence intervals of half-lives of PPP deviations by using two different methods: first, point estimates of b, b_{AMU}; second, the impulse response function (IRF) as in MP.

The median point estimate of half-lives is 5.75 years. In MP the median point estimate for OECD countries is strikingly lower at 1.77. Our median lower bound is

0.93 which is lower than the median lower bound in the case of an AR(1) model. On the other hand the upper bound is still [∞]. In MP, the median lower bound of 0.64 is very close to our estimate, whilst the median upper bound is 3.12 years.

However, these estimates are of little use since they are based on the assumption that shocks to the real exchange rate decay monotonically. But shocks to an AR(*p*) model will not in general decay at a constant rate (MP make the same point). Hence, in what follows we shall use the impulse response functions based on the individual slopes in the levels representation (7) to calculate half-lives and their respective confidence intervals. The median of half-lives calculated from the IRF is 5.96 years, whereas MP report a median estimate of 3.07. Our median lower bound is 0.84 and the upper bound is [∞]. Similarly, MP have a lower bound of 1.24 and an infinite upper bound. Using local to unity asymptotic theory for highly persistent stochastic processes (i.e. with roots very close to one), Rossi (2004) finds a lower bound of 4 to 8 quarters for most currencies and upper bound of infinity for all industrial countries included in her study. Cashin and McDermott (2003) report an average bias-corrected half-life of parity deviations of 5 years for OECD countries, which is higher than that reported by MP and is on the upper end of Rogoff's (1996) consensus range.

There are several points to note here. Firstly, our relatively high average half-life findings overturn those of Cheung and Lai (2000) who discover average half-lives for developing countries less than three years and in many cases in the range 0-2 years[12]. In the aggregate at least, it would appear there is no longer any substantive

[11] The GAUSS programmes employed for the univariate and panel AMU estimation were provided by Murray and Papell, but we had to revise and expand them because of the longer lags in our ADF regressions and different dimension of our data set.
[12] Note that the half-point estimates reported by Cheung and Lai (2000) are based on LS estimates of the ADF regression that is subject to many of the criticisms raised by MP.

evidence that there exists different behaviour in the degree of persistence of the real exchange rate in OECD countries and emerging market economies.

Secondly, the upper bound interval estimates suggest that for 29 countries (i.e. those with an upper bound of [∞]) estimates of half-lives are consistent with anything, even unit root processes[13] where there is no convergence to PPP. Given such uninformative intervals this suggests that no conclusions can be drawn in such cases as to the persistence of PPP. The countries considered by MP, as already mentioned, mainly have infinite upper bounds and thus, in terms of the OECD context they conclude that it cannot even be shown whether the PPP puzzle exists.

Thirdly, we are left with seven emerging market countries in our sample with finite upper bounds. Thus, and in contrast to MP, we can make some tentative inference as to the nature of the PPP persistence puzzle. To be specific, given that the PPP puzzle concerns the slow speed of adjustment to long-run equilibrium, it makes sense to predicate any conclusions on the PPP persistence puzzle only where this equilibrium is detected[14]. Table 3 isolates these cases from Table 2.

The median point estimate of IRF calculated half-life is 1.34 years, the median lower bound is 0.6 and the upper bound is 3.6. Such results show that if we restrict half-life estimation to those cases where we are statistically sure that long-run PPP holds then reversion to that equilibrium is still not typically confined in the region that can be easily explained by price stickiness. For example, 4 of the 7 countries present upper bounds that range from 3.6 to 6.73 years, which is still *puzzling*.

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[13] This is consistent with the finding by Cerrato and Sarantis (2003). Using the same panel of data and various panel unit root tests, the authors fail to reject the unit root hypothesis for the full panel of emerging market economies.

[14] Chortareas and Kapetanios (2004) make a similar point. Using a panel of 25 OECD countries, they show that when one focuses only on the stationary real exchange rates in the panel the half-lives become shorter (though the authors do not report confidence intervals). Although the PPP puzzle does not disappear, it becomes less pronounced.

To examine whether the results obtained thus far are black market specific[15] we constructed an equivalent official real exchange rate dataset. The results in Table 4 are from the application of the AMU procedure to this new dataset. From the IRF the median half-life is now [∞], with 95% confidence intervals ranging from 1.51 to [∞]. Interestingly, all but one of the official real exchange rates presented an upper bound of [∞]. Therefore, it might be tentatively suggested that official real exchange rates present more persistence than their black market counterparts[16].

The panel results in Table 5 shed further light on our conclusions from the prior univariate regressions[17]. Examination of rows 1 and 3 reveals that both black market and official rate panels produce AMU half-life averages of [∞], the black market panel producing the smaller lower bound of 9.6 years. In contrast to the univariate analysis, these intervals are no longer consistent with persistence explained by nominal rigidities, only with very high *puzzling* persistence or a lack of reversion to PPP even in the long run. Murray and Papell (2005) employ the above panel procedure on the same 20 OECD countries used in MP. Averaging results produced by adopting different lag length selections suggests a 95% confidence interval of 2.48 to 4.09 years[18]. This is more in line with Rogoff's original 3-5 year consensus and much lower than the panel results suggested for emerging market countries in our paper.

Finally, for completeness we applied the AMU panel methodology to the seven black market series identified as having finite upper bounds in the univariate analysis i.e. for the cases where we're statistically sure that long-run PPP holds. The

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[15] We thank an anonymous referee for suggesting this useful exercise.

[16] Since official exchange rates were typically fixed or crawling peg, any persistence predominantly reflects stickiness in relative prices.

[17] Again, we thank an anonymous referee for this constructive suggestion.

AMU half-life is 0.61 with a 95% confidence interval of 0.58 to 0.72. This range is appreciably narrower and lower than that from the comparable univariate results shown in Table 3. This admittedly smaller panel of emerging market countries produces results that are now fully consistent with the 0 to 2 year half-life region that can be explained by nominal rigidities!

5. Conclusions

Most previous studies on the persistence of deviations from PPP have generally obtained half-lives falling within Rogoff's (1996) 'consensus range' of 3 to 5 years for industrial economies. Given that the length of these deviations is considered too long to be explained by nominal rigidities, the so-called PPP puzzle emerges. However, Murray and Papell (2002) have questioned the results of the literature, arguing econometric issues such as small sample bias, serial correlation and confidence intervals have generally been ignored. Employing exact and approximate median unbiased estimation they show that 95% confidence intervals for the persistence of the real exchange rate are very wide. For example, although many lower bounds are less than 2 years, upper bounds commonly equal infinity, a result further supported by Rossi (2004). Hence, Murray and Papell (2002) and Rossi (2004) conclude that such wide confidence intervals provide no information regarding the speed of convergence of PPP deviations.

This paper provides an extensive analysis of PPP persistence by comparing a unique data set of black market real exchange rates for 36 heterogeneous emerging market economies. Notably, previous studies have posited that emerging country

[18] When using a general-to-specific lag length selection procedure, Murray and Papell (2005) find a narrower 95% confidence interval of 2.25 to 2.85 years.

exchange rates may be less persistent than those from industrial countries. We calculate the half-life point estimates by employing both univariate and panel (exact and approximate) median unbiased methodologies.

Firstly, the use of the univariate methodology typically produces confidence intervals that are too wide to be informative regarding the nature of PPP persistence. Moreover, even in the small number of cases where intervals are informative, most countries present upper bounds that fall into the *puzzling* region of greater than 2-3 years. This questions the conclusions of Cheung and Lai (2000) who propose that developing countries have relatively low half-lives. Secondly, as in Murray and Papell (2005), panel regressions are useful in the sense of producing tighter confidence intervals than their univariate equivalents[19]. In full panels such intervals are now informative in the sense that they are no longer consistent with low half-lives that might be explained by price stickiness. However, in a smaller panel it is shown that some real exchange rates present very low half-lives. Thus, from the more powerful panel results a bimodal conclusion emerges. It would appear that in the vast majority of emerging market countries the PPP persistence puzzle is an important feature. However, in a minority of exchange rates, the PPP puzzle is not applicable. The rationale for this dichotomy is clearly an interesting issue.

Recent research points to two potential explanations for the high persistence of real exchange rates. Imbs *et al* (2002) show that the failure to allow for heterogeneity in price adjustment dynamics at the goods and services level induces a positive bias in persistent estimates. Unfortunately the lack of disaggregate data on prices for emerging market economies makes it impossible at this stage to investigate the issue

[19] Murray and Papell (2005) posit two reasons for the tighter confidence intervals in panel regressions. Firstly, that panel regressions utilize both time series and cross-sectional variability. Secondly, that they take advantage of the information contained in the cross correlation of real exchange rates.

of aggregation bias. Other studies emphasize the existence of non-linearities in real exchange rates and argue that half-lives are smaller than the consensus estimates (i.e. Taylor *et al*, 2001)[20]. This is an interesting question and is left for future research.

[20] It should be noted, however, that these studies employ the least squares methodology for the estimation of the nonlinear models, so the econometric problems raised in Section 1 still apply.

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Table 1: Exact median unbiased half-lives in DF regression (Black market rates)

Country	b_{MU}	95% CI	HL_{MU}	95% CI
Algeria	0.995	[0.990 1.000]	11.52	[5.75 ∞]
Argentina	0.976	[0.960 1.000]	2.38	[1.41 ∞]
Bolivia	0.925	[0.890 0.980]	0.74	[0.50 2.86]
Brazil	0.961	[0.940 1.000]	1.45	[0.93 ∞]
Chile	0.979	[0.960 1.000]	2.72	[1.41 ∞]
Colombia	1.000	[0.990 1.000]	∞	[5.75 ∞]
C.Rica	0.995	[0.990 1.000]	11.52	[5.75 ∞]
D.Republic	0.995	[0.985 1.000]	11.52	[3.82 ∞]
Ecuador	1.000	[0.997 1.000]	∞	[19.23 ∞]
Egypt	0.946	[0.920 0.996]	1.04	[0.69 14.41]
El Salvador	0.994	[0.985 1.000]	9.60	[3.82 ∞]
Ethiopia	0.976	[0.956 1.000]	2.38	[1.28 ∞]
Hungary	0.986	[0.976 1.000]	4.10	[2.38 ∞]
Ghana	0.825	[0.770 0.898]	0.30	[0.22 0.54]
India	1.000	[0.997 1.000]	∞	[19.23 ∞]
Indonesia	1.000	[0.997 1.000]	∞	[19.23 ∞]
Kenya	0.976	[0.956 1.000]	2.38	[1.28 ∞]
Korea	0.480	[0.395 0.590]	0.08	[0.06 0.11]
Kuwait	0.986	[0.976 1.000]	4.10	[2.38 ∞]
Malaysia	1.000	[0.997 1.000]	∞	[19.23 ∞]
Mexico	0.946	[0.900 0.984]	1.04	[0.55 3.58]
Morocco	0.996	[0.986 1.000]	14.41	[4.10 ∞]
Nepal	0.995	[0.986 1.000]	11.52	[4.10 ∞]
Nigeria	0.995	[0.986 1.000]	11.52	[4.10 ∞]
Pakistan	1.000	[0.997 1.000]	∞	[19.23 ∞]
Paraguay	1.000	[0.997 1.000]	∞	[19.23 ∞]
Philippines	0.961	[0.936 1.000]	1.45	[0.87 ∞]
Poland	0.985	[0.976 1.000]	3.82	[2.38 ∞]
Singapore	0.985	[0.976 1.000]	3.82	[2.38 ∞]
S.Africa	0.932	[0.897 0.980]	0.82	[0.53 2.86]
S.Lanka	0.996	[0.996 1.000]	14.41	[14.41 ∞]
Thailand	0.976	[0.956 1.000]	2.38	[1.28 ∞]
Tunisia	1.000	[0.997 1.000]	∞	[19.23 ∞]
Turkey	0.976	[0.956 1.000]	2.38	[1.28 ∞]
Uruguay	0.992	[0.985 1.000]	7.19	[3.82 ∞]
Venezuela	1.000	[0.997 1.000]	∞	[19.23 ∞]

Table 2: Approximately median unbiased half-lives in ADF regressions (Black market rates)

Country	k	b_{AMU}	95% CI	HL_{AMU}	95% CI	HL_{IRF}	95% CI
Algeria	11	1.00	[0.95 1.00]	∞	[1.13 ∞]	∞	[0.38 ∞]
Argentina	9	0.99	[0.92 1.00]	5.75	[0.69 ∞]	3.51	[0.30 ∞]
Bolivia	11	0.95	[0.90 0.99]	1.13	[0.55 5.75]	1.97	[0.60 5.00]
Brazil	3	0.96	[0.87 1.00]	1.41	[0.41 ∞]	1.30	[0.25 ∞]
Chile	12	1.00	[0.95 1.00]	∞	[1.13 ∞]	∞	[1.37 ∞]
Colombia	12	1.00	[0.96 1.00]	∞	[1.41 ∞]	∞	[1.97 ∞]
C.Rica	11	0.99	[0.95 1.00]	5.75	[1.13 ∞]	6.73	[1.67 ∞]
D.Republic	6	0.99	[0.95 1.00]	5.75	[1.13 ∞]	6.15	[1.35 ∞]
Ecuador	4	1.00	[0.97 1.00]	∞	[1.90 ∞]	∞	[2.12 ∞]
Egypt	5	0.92	[0.86 0.95]	0.69	[0.38 1.13]	0.81	[0.49 1.35]
El Salvador	11	1.00	[0.94 1.00]	∞	[0.93 ∞]	∞	[0.76 ∞]
Ethiopia	11	1.00	[0.95 1.00]	∞	[1.13 ∞]	∞	[0.71 ∞]
Hungary	12	1.00	[0.94 1.00]	∞	[0.93 ∞]	∞	[0.39 ∞]
Ghana	10	0.77	[0.75 0.82]	0.22	[0.20 0.29]	0.41	[0.34 0.46]
India	0	1.00	[0.99 1.00]	∞	19.2 ∞]	1.00	[19.2 ∞]
Indonesia	9	1.00	[0.95 1.00]	∞	[1.13 ∞]	∞	[1.08 ∞]
Kenya	9	0.96	[0.92 0.99]	1.41	[0.69 5.75]	2.16	[1.08 6.73]
Korea	12	0.94	[0.89 0.98]	0.93	[0.50 2.86]	0.12	[0.11 0.13]
Kuwait	4	0.99	[0.94 1.00]	5.75	[0.93 ∞]	5.58	[0.88 ∞]
Malaysia	7	1.00	[0.96 1.00]	∞	[1.41 ∞]	∞	[1.54 ∞]
Mexico	1	0.97	[0.90 1.00]	1.90	[0.55 ∞]	1.62	[0.48 ∞]
Morocco	9	1.00	[0.94 1.00]	∞	[0.93 ∞]	∞	[0.43 ∞]
Nepal	5	1.00	[0.94 1.00]	∞	[0.93 ∞]	∞	[0.88 ∞]
Nigeria	1	1.00	[0.95 1.00]	∞	[1.13 ∞]	∞	[0.85 ∞]
Pakistan	12	1.00	[0.94 1.00]	∞	[0.93 ∞]	∞	[1.03 ∞]
Paraguay	0	1.00	[0.99 1.00]	∞	19.2 ∞]	∞	[19.2 ∞]
Philippines	9	0.96	[0.88 0.99]	1.41	[0.45 5.75]	1.52	[0.73 4.47]
Poland	11	0.96	[0.87 1.00]	1.41	[0.41 ∞]	2.00	[0.16 ∞]
Singapore	7	0.99	[0.93 1.00]	5.75	[0.80 ∞]	4.88	[0.64 ∞]
S.Africa	12	0.94	[0.87 0.98]	0.93	[0.41 2.86]	1.34	[1.01 3.60]
S.Lanka	3	0.99	[0.94 1.00]	5.75	[0.93 ∞]	5.77	[1.04 ∞]
Thailand	1	0.98	[0.93 1.00]	2.86	[0.80 ∞]	2.78	[0.73 ∞]
Tunisia	10	1.00	[0.97 1.00]	∞	[1.90 ∞]	∞	[1.25 ∞]
Turkey	4	0.99	[0.92 1.00]	5.75	[0.69 ∞]	4.35	[0.28 ∞]
Uruguay	1	0.99	[0.94 1.00]	5.75	[0.93 ∞]	5.62	[0.82 ∞]
Venezuela	10	1.00	[0.96 1.00]	∞	[1.41 ∞]	∞	[1.80 ∞]

Note: HL_{AMU} and HL_{IRF} represent, respectively, point estimates of half-lives (in years) from approximate median unbiased estimates of b and from the impulse response function. Their respective 95% bootstrap confidence intervals are presented in columns six and eight.

Table 3: Selected approximately median unbiased half-lives in ADF regressions

(Black market rates)

Country	k	b_{AMU}	95% CI	HL_{AMU}	95% CI	HL_{IRF}	95% CI
Bolivia	11	0.95	[0.90 0.99]	1.13	[0.55 5.75]	1.97	[0.60 5.00]
Egypt	5	0.92	[0.86 0.95]	0.69	[0.38 1.13]	0.81	[0.49 1.35]
Ghana	10	0.77	[0.75 0.82]	0.22	[0.20 0.29]	0.41	[0.34 0.46]
Kenya	9	0.96	[0.92 0.99]	1.41	[0.69 5.75]	2.16	[1.08 6.73]
Korea	12	0.94	[0.89 0.98]	0.93	[0.50 2.86]	0.12	[0.11 0.13]
Philippines	9	0.96	[0.88 0.99]	1.41	[0.45 5.75]	1.52	[0.73 4.47]
S.Africa	12	0.94	[0.87 0.98]	0.93	[0.41 2.86]	1.34	[1.01 3.60]

Note: HL_{AMU} and HL_{IRF} represent, respectively, point estimates of half-lives (in years) from approximate median unbiased estimates of b and from the impulse response function. Their respective 95% bootstrap confidence intervals are presented in columns six and eight.

Table 4: Approximately median unbiased half-lives in ADF regressions (official rates)

Country	k	b_{AMU}	95% CI	HL_{AMU}	95% CI	HL_{IRF}	95% CI
Algeria	12	1.00	[0.96 1.00]	∞	[1.41 ∞]	∞	[1.82 ∞]
Argentina	8	0.96	[0.91 0.99]	1.41	[0.61 5.75]	1.93	[0.86 6.36]
Bolivia	11	0.94	[0.84 1.00]	0.93	[0.33 ∞]	0.24	[0.17 ∞]
Brazil	12	0.99	[0.95 1.00]	5.75	[1.13 ∞]	7.41	[1.67 ∞]
Chile	12	1.00	[0.95 1.00]	∞	[1.13 ∞]	∞	[0.96 ∞]
Colombia	11	1.00	[0.98 1.00]	∞	[2.86 ∞]	∞	[2.92 ∞]
C.Rica	9	0.99	[0.95 1.00]	5.75	[1.13 ∞]	7.78	[1.69 ∞]
D.Republic	0	0.98	[0.97 1.00]	2.9	[1.9 ∞]	2.9	[1.9 ∞]
Ecuador	5	1.00	[0.94 1.00]	∞	[0.93 ∞]	∞	[0.68 ∞]
Egypt	11	0.98	[0.95 1.00]	2.86	[1.13 ∞]	4.01	[1.64 ∞]
El Salvador	2	1.00	[0.96 1.00]	∞	[1.41 ∞]	∞	[1.52 ∞]
Ethiopia	0	1.00	[0.99 1.00]	∞	[3.82 ∞]	∞	[3.82 ∞]
Hungary	12	1.00	[0.95 1.00]	∞	[1.13 ∞]	∞	[1.41 ∞]
Ghana	1	1.00	[0.96 1.00]	∞	[1.41 ∞]	∞	[1.49 ∞]
India	1	1.00	[0.97 1.00]	∞	[1.90 ∞]	∞	[2.01 ∞]
Indonesia	10	1.00	[0.96 1.00]	∞	[1.41 ∞]	∞	[1.52 ∞]
Kenya	12	1.00	[0.95 1.00]	∞	[1.13 ∞]	∞	[0.98 ∞]
Korea	8	0.99	[0.95 1.00]	5.75	[1.13 ∞]	5.77	[1.28 ∞]
Kuwait	12	1.00	[0.94 1.00]	∞	[0.93 ∞]	∞	[0.59 ∞]
Malaysia	7	1.00	[0.97 1.00]	∞	[1.90 ∞]	∞	[1.97 ∞]
Mexico	5	0.97	[0.93 1.00]	1.90	[0.80 ∞]	2.02	[0.78 ∞]
Morocco	10	1.00	[0.98 1.00]	∞	[2.86 ∞]	∞	[2.86 ∞]
Nepal	11	1.00	[0.96 1.00]	∞	[1.41 ∞]	∞	[0.58 ∞]
Nigeria	3	1.00	[0.96 1.00]	∞	[1.41 ∞]	∞	[1.51 ∞]
Pakistan	12	1.00	[0.94 1.00]	∞	[0.93 ∞]	∞	[0.59 ∞]
Paraguay	0	1.00	[0.99 1.00]	∞	[2.9 ∞]	∞	[2.9 ∞]
Philippines	8	0.98	[0.95 1.00]	2.86	[1.13 ∞]	3.38	[1.57 ∞]
Poland	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Singapore	12	0.99	[0.95 1.00]	5.75	[1.13 ∞]	6.49	[1.67 ∞]
S.Africa	12	0.99	[0.95 1.00]	5.75	[1.13 ∞]	5.20	[1.38 ∞]
S.Lanka	7	1.00	[0.96 1.00]	∞	[1.41 ∞]	∞	[1.49 ∞]
Thailand	7	0.99	[0.95 1.00]	5.75	[1.13 ∞]	6.09	[1.22 ∞]
Tunisia	7	1.00	[0.95 1.00]	∞	[1.13 ∞]	∞	[1.16 ∞]
Turkey	12	1.00	[0.92 1.00]	∞	[0.69 ∞]	∞	[0.45 ∞]
Uruguay	12	0.99	[0.96 1.00]	5.75	[1.41 ∞]	7.03	[2.00 ∞]
Venezuela	0	0.98	[0.97 1.00]	2.9	[1.7 ∞]	2.9	[1.7 ∞]

Note: HL_{AMU} and HL_{IRF} represent, respectively, point estimates of half-lives (in years) from approximate median unbiased estimates of b and from the impulse response function. Their respective 95% bootstrap confidence intervals are presented in columns six and eight.

Table 5: Half-lives from panel regressions

Currency type	b_{LS}	HL_{LS}	b_{AMU}	95% CI	HL_{AMU}	95% CI
Black market	0.993	8.22	1.00	[0.994, 1.000]	∞	[9.60, ∞]
Selected Black Market	0.912	0.63	0.914	[0.905, 0.923]	0.61	[0.58, 0.72]
Official Market	0.996	14.41	1.00	[0.998, 1.000]	∞	[28.85, ∞]

Note: 95% bootstrap confidence intervals are not presented for the LS panel estimations. Murray and Papell (2005) stress the bias is so severe that bootstrapping LS half-life estimates in panel regressions should be avoided.

Appendix 1

Quantiles of the Median Function $z(b)$ for T+1=312

b/Quantile	**0.025**	**0.05**	**0.5**	**0.95**	**0.975**
-0.99	-0.9988	-0.9975	-0.9872	-0.9599	-0.9519
-0.98	-0.9929	-0.9912	-0.977	-0.9455	-0.9367
-0.97	-0.9931	-0.9913	-0.9771	-0.9454	-0.9364
-0.96	-0.9809	-0.978	-0.9574	-0.9207	-0.9108
-0.95	-0.9739	-0.9707	-0.9468	-0.9072	-0.8976
-0.94	-0.9665	-0.9632	-0.9369	-0.8938	-0.8845
-0.93	-0.9596	-0.9559	-0.927	-0.8832	-0.8719
-0.92	-0.9521	-0.9478	-0.9167	-0.8709	-0.8594
-0.91	-0.9452	-0.9395	-0.907	-0.8597	-0.8474
-0.9	-0.9373	-0.9322	-0.8977	-0.8486	-0.8367
-0.89	-0.9297	-0.9243	-0.8871	-0.8357	-0.8256
-0.88	-0.9222	-0.9161	-0.8779	-0.8254	-0.813
-0.87	-0.9138	-0.9078	-0.8674	-0.8141	-0.8018
-0.86	-0.9054	-0.899	-0.8579	-0.8011	-0.7888
-0.85	-0.8972	-0.8902	-0.848	-0.7905	-0.7798
-0.84	-0.8897	-0.8824	-0.8377	-0.7785	-0.7649
-0.83	-0.8814	-0.8745	-0.8275	-0.7665	-0.7534
-0.82	-0.8728	-0.8654	-0.818	-0.7589	-0.7451
-0.81	-0.8646	-0.857	-0.8081	-0.7461	-0.7326
-0.8	-0.856	-0.8478	-0.7978	-0.7333	-0.7205
-0.79	-0.8465	-0.8385	-0.787	-0.7228	-0.709
-0.78	-0.8392	-0.8308	-0.778	-0.714	-0.6994
-0.77	-0.8286	-0.8201	-0.768	-0.702	-0.6887
-0.76	-0.8215	-0.8129	-0.7581	-0.6898	-0.6751
-0.75	-0.8135	-0.8048	-0.7479	-0.6786	-0.6632
-0.74	-0.8049	-0.7957	-0.7391	-0.6697	-0.6571
-0.73	-0.7961	-0.7865	-0.7285	-0.6566	-0.6426
-0.72	-0.7884	-0.7776	-0.7187	-0.6457	-0.6305
-0.71	-0.78	-0.7696	-0.7087	-0.6357	-0.6214
-0.7	-0.7716	-0.761	-0.699	-0.6271	-0.6135
-0.69	-0.7618	-0.7502	-0.6886	-0.6163	-0.6008
-0.68	-0.7513	-0.7409	-0.6787	-0.6043	-0.5881
-0.67	-0.7437	-0.733	-0.6687	-0.5921	-0.5746
-0.66	-0.7342	-0.7232	-0.6586	-0.5827	-0.5686
-0.65	-0.7258	-0.7149	-0.6499	-0.5747	-0.5583
-0.64	-0.7159	-0.7047	-0.6386	-0.5639	-0.5488
-0.63	-0.7073	-0.6954	-0.628	-0.5527	-0.5363
-0.62	-0.6985	-0.6865	-0.618	-0.539	-0.523
-0.61	-0.6905	-0.6782	-0.609	-0.5281	-0.5124
-0.6	-0.681	-0.6687	-0.5994	-0.52	-0.5032
-0.59	-0.672	-0.659	-0.5889	-0.5079	-0.4923
-0.58	-0.6631	-0.6497	-0.5798	-0.4996	-0.4817
-0.57	-0.6538	-0.6406	-0.5697	-0.487	-0.4703
-0.56	-0.6446	-0.631	-0.5596	-0.4757	-0.4588
-0.55	-0.635	-0.622	-0.549	-0.467	-0.448
-0.54	-0.6244	-0.6127	-0.5396	-0.455	-0.4394
-0.53	-0.6173	-0.6053	-0.529	-0.4466	-0.4303
-0.52	-0.6085	-0.5948	-0.5199	-0.4372	-0.4187

-0.51	-0.5979	-0.5847	-0.5106	-0.425	-0.4071
b/Quantile	**0.025**	**0.05**	**0.5**	**0.95**	**0.975**
-0.5	-0.5914	-0.5775	-0.5008	-0.4183	-0.3999
-0.49	-0.5802	-0.5652	-0.4895	-0.4038	-0.3885
-0.48	-0.5695	-0.5565	-0.4802	-0.3948	-0.3768
-0.47	-0.5625	-0.548	-0.4703	-0.3866	-0.3708
-0.46	-0.5543	-0.5387	-0.4599	0.3748	-0.3589
-0.45	-0.5426	-0.5281	-0.4513	-0.3658	-0.3491
-0.44	-0.5356	-0.5222	-0.4401	-0.3534	-0.337
-0.43	-0.5243	-0.5102	-0.431	-0.3426	-0.3234
-0.42	-0.5155	-0.5012	-0.4206	-0.3327	-0.3161
-0.41	-0.508	-0.4915	-0.4113	-0.3219	-0.3048
-0.4	-0.4969	-0.4814	-0.4006	-0.3129	-0.2958
-0.39	-0.4853	-0.4712	-0.3888	-0.3024	-0.285
-0.38	-0.4793	-0.4625	-0.3802	-0.29	-0.273
-0.37	-0.469	-0.4535	-0.3709	-0.2813	-0.2643
-0.36	-0.4599	-0.4437	-0.362	-0.2708	-0.253
-0.35	-0.4501	-0.4338	-0.3505	-0.2593	-0.241
-0.34	-0.4419	-0.4246	-0.3406	-0.2495	-0.2325
-0.33	-0.4325	-0.4161	-0.3314	-0.2397	-0.2233
-0.32	-0.4214	-0.4067	-0.3213	-0.2312	-0.2128
-0.31	-0.415	-0.3979	-0.3101	-0.2197	-0.2037
-0.3	-0.4034	-0.388	-0.3012	-0.2106	-0.1917
-0.29	-0.3952	-0.3782	-0.2915	-0.2007	-0.1821
-0.28	-0.3846	-0.3698	-0.2819	-0.1901	-0.1719
-0.27	-0.375	-0.3585	-0.2712	-0.1786	-0.1606
-0.26	-0.3647	-0.3492	-0.2619	-0.1685	-0.1492
-0.25	-0.3547	-0.3397	-0.251	-0.1584	-0.1419
-0.24	-0.3474	-0.3309	-0.2424	-0.1518	-0.1329
-0.23	-0.3374	-0.3212	-0.2325	-0.1405	-0.1231
-0.22	-0.3264	-0.3104	-0.2217	-0.1274	-0.1089
-0.21	-0.3179	-0.3013	-0.2119	-0.1212	-0.1047
-0.2	-0.3072	-0.291	-0.2005	-0.1094	-0.0916
-0.19	-0.3001	-0.2818	-0.1923	-0.1012	-0.0839
-0.18	-0.2875	-0.2725	-0.1816	-0.0886	-0.0727
-0.17	-0.2811	-0.2637	-0.1717	-0.079	-0.0611
-0.16	-0.2692	-0.2523	-0.1624	-0.0694	-0.0515
-0.15	-0.2601	-0.2415	-0.1524	-0.0608	-0.044
-0.14	-0.2515	-0.235	-0.143	-0.0478	-0.0286
-0.13	-0.2403	-0.2233	-0.1321	-0.0386	-0.0212
-0.12	-0.2305	-0.2156	-0.1225	-0.0306	-0.0143
-0.11	-0.2197	-0.2029	-0.1124	-0.0187	-0.0012
-0.1	-0.2136	-0.193	-0.1029	-0.0119	0.0076

b/Quantile	**0.025**	**0.05**	**0.5**	**0.95**	**0.975**
0.1	-0.0135	0.0025	0.0962	0.188	0.2071
0.11	-0.0048	0.0137	0.1057	0.1977	0.2156
0.12	0.0048	0.0225	0.1151	0.2048	0.2212
0.13	0.0351	0.0351	0.1265	0.2165	0.2328
0.14	0.0256	0.0436	0.1366	0.2268	0.243
0.15	0.0357	0.0536	0.1478	0.2387	0.2555
0.16	0.043	0.0629	0.156	0.2446	0.2623
0.17	0.0539	0.0721	0.1655	0.2553	0.2723
0.18	0.0636	0.0837	0.1759	0.2665	0.2827
0.19	0.0756	0.0923	0.185	0.2754	0.2911
0.2	0.0848	0.1021	0.1955	0.2865	0.3018
0.21	0.0954	0.1126	0.2063	0.2936	0.3118
0.22	0.1044	0.125	0.2155	0.3045	0.3199
0.23	0.1149	0.1319	0.2254	0.3143	0.3303
0.24	0.1251	0.1429	0.2358	0.3236	0.3394
0.25	0.1325	0.1507	0.2447	0.3311	0.3465
0.26	0.1434	0.1623	0.2543	0.3419	0.358
0.27	0.1547	0.172	0.2638	0.3521	0.3686
0.28	0.1636	0.1817	0.3623	0.3623	0.3783
0.29	0.1759	0.1932	0.2861	0.3725	0.3912
0.3	0.1856	0.202	0.2936	0.3787	0.3949
0.31	0.1968	0.2158	0.3052	0.3912	0.4069
0.32	0.2063	0.2242	0.3152	0.4004	0.4151
0.33	0.2172	0.2337	0.32	0.411	0.4251
0.34	0.226	0.2435	0.3347	0.4186	0.4352
0.35	0.2357	0.2533	0.3447	0.4288	0.4457
0.36	0.2466	0.2645	0.3542	0.4389	0.4534
0.37	0.2545	0.2722	0.3638	0.4463	0.4621
0.38	0.269	0.2872	0.3742	0.457	0.4704
0.39	0.2759	0.2944	0.3827	0.4681	0.4832
0.4	0.2864	0.3063	0.394	0.4754	0.4916
0.41	0.2953	0.3134	0.4046	0.4873	0.5018
0.42	0.3063	0.326	0.414	0.4954	0.5095
0.43	0.3201	0.336	0.4237	0.5033	0.5187
0.44	0.3302	0.3473	0.4345	0.5145	0.5298
0.45	0.3383	0.3547	0.4444	0.5224	0.5368
0.46	0.3494	0.3656	0.4539	0.5332	0.5468
0.47	0.3597	0.3766	0.4627	0.5417	0.5581
0.48	0.3699	0.387	0.4733	0.5511	0.5655
0.49	0.3796	0.3978	0.4838	0.5609	0.5729
0.5	0.3899	0.406	0.4928	0.5687	0.5839
0.51	0.3987	0.4188	0.5042	0.5794	0.5928
0.52	0.4102	0.4279	0.5132	0.5889	0.6039
0.53	0.4213	0.4387	0.5235	0.5982	0.6135
0.54	0.4337	0.45	0.5332	0.6084	0.6229
0.55	0.4429	0.4599	0.5423	0.6178	0.6314
0.56	0.4539	0.4708	0.5535	0.6259	0.6393
0.57	0.4656	0.4816	0.5633	0.6364	0.6506
0.58	0.4719	0.4888	0.572	0.6443	0.6567
0.59	0.4841	0.5025	0.5835	0.6541	0.6663

b/Quantile	**0.025**	**0.05**	**0.5**	**0.95**	**0.975**
0.6	0.4946	0.5116	0.5925	0.6638	0.6763
0.61	0.5077	0.5239	0.6038	0.6727	0.6851
0.62	0.5173	0.534	0.6124	0.6814	0.6932
0.63	0.5273	0.5446	0.6229	0.6908	0.7025
0.64	0.5375	0.555	0.6318	0.6994	0.7113
0.65	0.549	0.5647	0.6436	0.7104	0.721
0.66	0.5607	0.575	0.6527	0.7181	0.7281
0.67	0.5735	0.5889	0.6621	0.7256	0.7372
0.68	0.581	0.5962	0.6722	0.7349	0.7451
0.69	0.5918	0.6071	0.682	0.7452	0.7572
0.7	0.6033	0.6191	0.6924	0.7542	0.7656
0.71	0.612	0.6287	0.7025	0.7633	0.7744
0.72	0.6256	0.6398	0.7128	0.7721	0.783
0.73	0.6337	0.6506	0.7216	0.7809	0.7897
0.74	0.6462	0.6612	0.7321	0.7902	0.8001
0.75	0.6587	0.6727	0.7426	0.7998	0.8096
0.76	0.6682	0.6818	0.7517	0.8078	0.8182
0.77	0.6769	0.6911	0.7614	0.816	0.8244
0.78	0.69	0.7041	0.7719	0.8252	0.8348
0.79	0.702	0.7157	0.7813	0.834	0.8421
0.8	0.7113	0.7254	0.7916	0.8421	0.8509
0.81	0.7242	0.7368	0.8011	0.8515	0.8594
0.82	0.7356	0.7491	0.8107	0.8602	0.8678
0.83	0.7458	0.7598	0.8213	0.8683	0.8755
0.84	0.759	0.7712	0.8315	0.8768	0.8842
0.85	0.7673	0.7819	0.841	0.8861	0.8928
0.86	0.7796	0.7946	0.8513	0.8944	0.9013
0.87	0.7887	0.8032	0.8608	0.9021	0.9084
0.88	0.8032	0.8154	0.871	0.9101	0.9161
0.89	0.814	0.827	0.8801	0.9188	0.9248
0.9	0.8262	0.839	0.8901	0.9267	0.9323
0.91	0.8369	0.8485	0.9003	0.9352	0.9406
0.92	0.8505	0.8617	0.9107	0.9431	0.9482
0.93	0.8628	0.8738	0.9204	0.9511	0.9552
0.94	0.8726	0.8836	0.9297	0.9585	0.9624
0.95	0.8842	0.8954	0.9398	0.9663	0.9697
0.96	0.8981	0.9083	0.9493	0.9736	0.9768
0.97	0.9104	0.9202	0.9591	0.9805	0.9837
0.98	0.9217	0.9315	0.9684	0.9873	0.9896
0.99	0.9327	0.9419	0.9772	0.9936	0.9957
1	0.9462	0.9556	0.9863	0.9995	1.0014

Appendix 2

Panel median unbiased estimator: N=34, T+1=312

b/Quantile	**0.025**	**0.05**	**0.5**	**0.95**	**0.975**
1.00	0.98589	0.98634	0.98970	0.99247	0.99279
0.99	0.97511	0.97572	0.98007	0.98333	0.98405
0.98	0.96546	0.96663	0.97131	0.97509	0.97573
0.97	0.95518	0.95638	0.96179	0.96647	0.96708
0.96	0.94598	0.94649	0.95215	0.95688	0.95774
0.95	0.93456	0.93563	0.94240	0.94775	0.94872
0.94	0.92407	0.92586	0.93231	0.93894	0.93986
0.93	0.91365	0.91519	0.92223	0.92897	0.93054
0.92	0.90398	0.90488	0.91235	0.91944	0.92055
0.91	0.89361	0.89506	0.90242	0.90962	0.91125
0.90	0.88189	0.88457	0.89221	0.89993	0.90095
0.89	0.87222	0.87318	0.88292	0.89078	0.89142
0.88	0.86309	0.86455	0.87324	0.88052	0.88222
0.87	0.85335	0.85470	0.86298	0.87161	0.87260
0.86	0.84180	0.84400	0.85292	0.86216	0.86380
0.85	0.83181	0.83350	0.84305	0.85180	0.85373