REAL EXCHANGE RATE BEHAVIOUR: A REPLICATION AND ROBUSTNESS CHECK

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Econometrics 871: Time Series Project

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1. Introduction

How do we compare living standards and economic productivity between countries? This is one of the questions that macroeconomics attempts to answers and a number of tools have been developed within the field to this end. One of these tools is the Purchasing Power Parity (PPP) theory, which uses a basket of goods to compare the currencies of different countries. This theory has been widely tested using data, and the results have been divisive and somewhat puzzling.@puz.

In this essay, I replicate[1] the paper "Real Exchange Rate Behaviour: Evidence from Black Markets" by Luintel (2000), which tests the PPP hypothesis. I include some other tests in addition to those in the paper as a robustness check on the results.

This essay[2] is organised as follows. Section 2 contextualises Luintel's paper and discusses the robustness checks. Section 3 discusses the data and reports the results of the Wald-Wolfowitz tests. Section 4 deals with the unit root tests. Section 5 reports the results of the variance ratio test and section 6 presents the structural break tests.

2. Context and Evaluation

provide a brief section that outlines the context and questions of the replicated study: The first part should outline what the authors do, how they motivate the question as of economic interest and/or importance, how they motivate their methods and how they argue that their contribution is novel

The second part can be a critical evaluation of their approach and choices which leads to your choices of robustness checks/extensions

Over the past decade, the purchasing-power parity (PPP) puzzle has taken two forms. Its early form arose from early tests of unit roots in real exchange rates, which failed to reject the null hypothesis, thus casting doubts on the long-term PPP hypothesis of real exchange rates' mean reversion. Following the development of more powerful tests that resulted in rejections of unit roots, the PPP-puzzle re-surfaced in the form of surprisingly slow rates of convergence of real exchange rates to their long-run means.

[1] More accurately, try my best to replicate

[2] This essay was written in R using the package by Katzke (2017)

Rogoff (1996) expressed this puzzle in terms of the estimated "half-life" of real exchange rate shocks being 3 to 5 years. Recent research has attempted to solve that second form of the puzzle by adopting non-linear stochastic models of real exchange rates. Despite this introduction of non-linearities, the literature has continued to focus on the notion of "half-life" as a measure of persistence.

The theory of purchasing power parity (PPP) is one of the most widely tested economics. The overall findings can be summarized as follows. Studies based data wholly reject PPP.1 Rogoff (1996, p. 644) calls this set of evidence 'the abject law of one price. Time-series studies based on aggregate price indices for also largely reject PPP and suggest that the real exchange rate behaves as random walk hypothesis implies that shocks to the real exchange rate are persistent is no tendency for PPP to hold in the short run or in the long run. Rogoff summarizes this set of findings as 'something of an embarrassment' to the argues that every 'reasonable' theoretical model suggests a mean reverting real the long run.3

The behaviour of real exchange rates (relative to the US dollar) is examined using monthly from the black markets for foreign exchange of eight Asian developing countries. The data The black market real exchange rates do not show excess volatility during the recent float contrast to the results reported elsewhere. Unit root tests in heterogeneous panels and variance confirm their stationarity. Thus, we find support for PPP but not for the 'survivorship' Rogoff, 1995). There is little evidence of segmented trends. Issues raised by Rogoff (1996) would hold across countries with differing growth experience- and Lothian and Taylor whether the degree of relative price volatility may bias results in favour of mean reverting rates -are addressed. Copyright © 2000 John Wiley & Sons, Ltd. 1. INTRODUCTION

References are to be made as follows: Fama & French (1997: 33) and Grinold & Kahn (2000) Such authors could also be referenced in brackets (Grinold & Kahn, 2000) and together Grinold & Kahn (2000).

3. Data

The data used for the analysis is a series on black market nominal exchange rates and consumer price indices (CPI) for 8 developing Asian countries, namely: India, Sri Lanka, Myanmar, Malaysia, Pakistan, Philippines, Taiwan and Thailand. I take a subset of these countries by excluding Taiwan[3] from the analysis. Luintel (2000) sources data from various issues of *Pick's Currency Year Book* and *World Currency Year Book*. The data used for Luintel's paper is accessible through the Journal of Applied Econometrics archive, which is where I attained my data. The sample period runs for 31 periods from January 1958 to June 1989. This sample period is split into two parts: Bretton Woods

[3]I excluded Taiwan because there is some data missing from the set and I don't know how to adjust an unbalanced panel. However, it is also interesting to test if the results hold when taking a subset

and after Bretton Woods (also referred to as pre-float period and the float period).

The nominal exchange rates are units currencies per unit of US dollar. There were two mistakes in the nominal exchange rate datasets: for Myanmar November 1974, there was a value of 1.45, which I replaced with 16.5 (based on interpolation). And for the Philippines in September 1975, there was a value of 0.7 with which I replaced with 7.7 (based on interpolation).[4] Luintel sources the CPI figures from issues of International Financial Statistics (which are included in Luintel's dataset available in the JAE data archives).

To calculate the real exchange rates, I follow the lead of Luintel (2000) and apply the following formula to the nominal exchange rates:

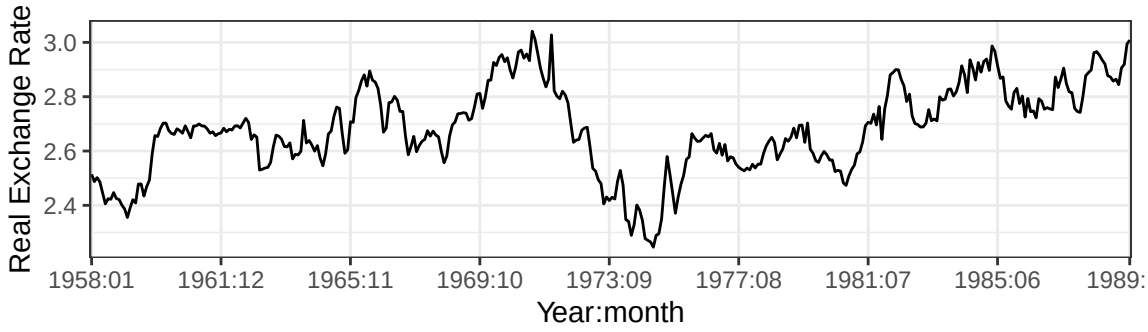
$$rex = log(NominalExchangeRate) - log(CPI) + log(UnitedStatesCPI)$$

I plot the real exchange rate series below in 3.1. The plots below match those of Luintel (2000: 166) and indicate that the real exchange rates are trending. Additionally, the graphs show that the black market exchange rates are somewhat volatile. As expected, we see that after the first oil shock of 1973 the currencies appreciated and then slowly reverted. The plots suggest that the trends are segmented. I test this hypothesis using formal tests, reported below the plots in **??**.

[4] I discovered these mistakes when there was a dramatic difference in my plots of the real exchange rates and Luintel's plots.

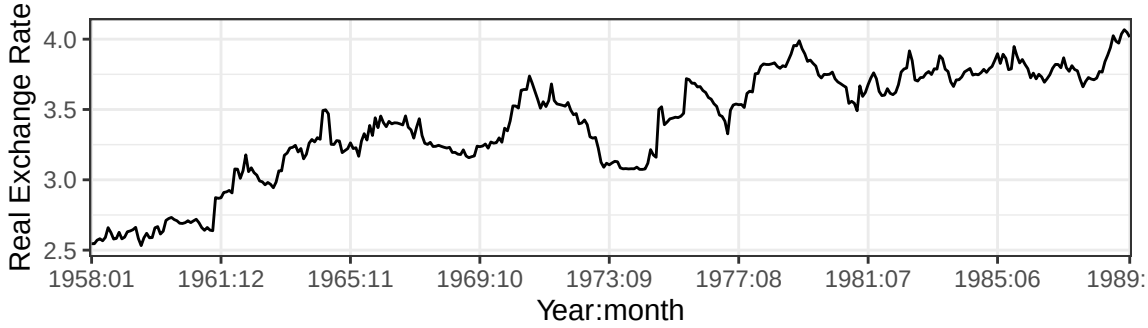
Real Exchange Rates Plot

India



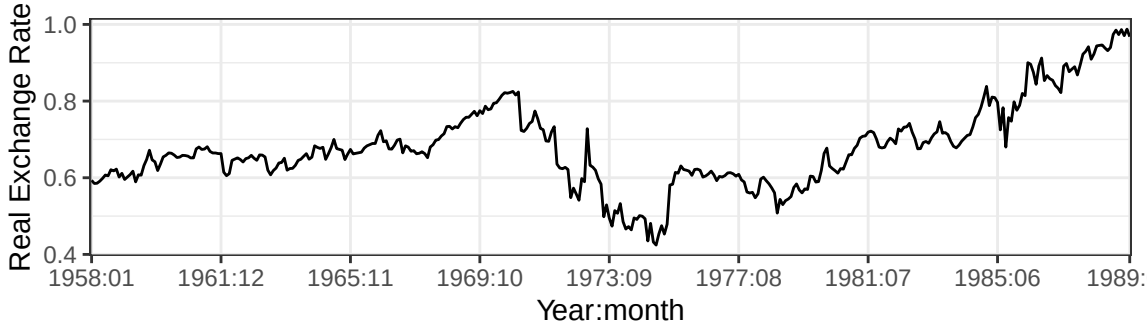
Source: Own Calculations

Sri Lanka



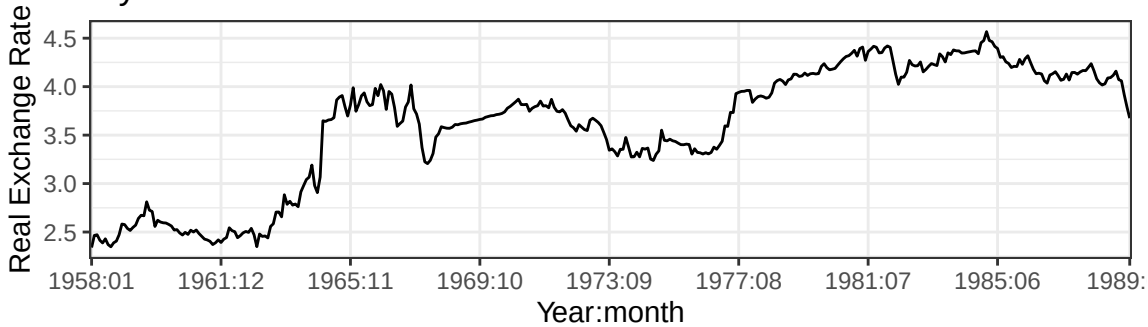
Source: Own Calculations

Malasia



Source: Own Calculations

Myanmar



Source: Own Calculations

Source: Own Calculations

Source: Own Calculations

Source: Own Calculations

Figure 3.1: Plot of Real Exchange Rates over Time

Test/Country	India	SriLanka	Malasia	Myanmar	Pakistan	Philippines	Thailand
Wald-Wolfowitz	-16.065	-18.54	-17.097	-18.231	-16.272	-17.097	-15.962

4. Unit Root Tests

First, I employed the Augmented Dickey-Fuller test for the individual exchange rates to see whether there was a unit root present. The test results show

Countries	Full Sample	Bretton Woods (1958:1-1973:3)	Post-Bretton Woods (1973:4-1989:6)
India (Rupee)	-2.695892	-2.065067	-3.6562004
Sri Lanka (Rupee)	-3.221138	-2.114240	-2.4449256
Malaysia (Ringgit)	-1.469487	-2.160595	-3.7735890
Myanmar (Kyat)	-1.528096	-1.713724	-0.1574589
Pakistan (Rupee)	-3.354481	-2.969905	-5.9078684
Phillipines (Peso)	-3.094185	-2.068390	-3.3811039
Thailand (Baht)	-2.439860	-3.360884	-3.9291658

5. Variance Ratio Test

The following table shows results of the Variance Ratio test for the full sample for up to 20 months. The results of the variance ratio test for the Bretton Woods period and post Bretton Woods period (for up to 20 months[5]) can be found in the Appendix (11)

Table 5.1: Variance Ratio Test for Full Sample Up to month 20

Months	India	SriLanka	Malaysia	Myanmar	Pakistan	Philippines	Thailand
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
2	1.00	0.95	0.79	1.04	0.91	0.91	0.74
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
3	1.02	0.86	0.79	1.05	0.81	0.86	0.68
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
4	1.01	0.87	0.75	1.00	0.71	0.82	0.58
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Continued on next page

[5]The results for 190 months is available upon request; it has been omitted purely to save space

Table 5.1: Variance Ratio Test for Full Sample Up to month 20

Months	India	SriLanka	Malaysia	Myanmar	Pakistan	Philippines	Thailand
5	0.95	0.89	0.73	0.98	0.65	0.80	0.52
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
6	0.91	0.90	0.73	0.95	0.61	0.77	0.48
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
7	0.86	0.91	0.69	0.93	0.58	0.76	0.44
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
8	0.83	0.90	0.69	0.92	0.56	0.77	0.42
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
9	0.81	0.89	0.66	0.90	0.53	0.81	0.40
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
10	0.81	0.88	0.63	0.89	0.50	0.79	0.39
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
11	0.81	0.88	0.61	0.91	0.49	0.79	0.37
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
12	0.83	0.88	0.57	0.95	0.46	0.78	0.37
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
13	0.86	0.87	0.57	0.96	0.47	0.79	0.37
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
14	0.88	0.87	0.57	0.98	0.48	0.79	0.37
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
15	0.90	0.88	0.57	1.00	0.48	0.80	0.37
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
16	0.92	0.88	0.57	1.02	0.49	0.79	0.37
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
17	0.92	0.89	0.58	1.03	0.49	0.78	0.36
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
18	0.92	0.88	0.59	1.04	0.49	0.77	0.36
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
19	0.91	0.88	0.60	1.05	0.50	0.76	0.36
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10
20	0.90	0.87	0.62	1.08	0.52	0.75	0.36
se	0.10	0.10	0.10	0.10	0.10	0.10	0.10

6. Structural Break Test

To make your graphs look extra nice in latex world, you could use Tikz device. Replace dev - 'png' with 'tikz' in the chunk below. Notice this makes the build time longer and produces extra tex files - so if you are comfortable with this, set your device to Tikz and try it out:

To reference the plot above, add a "\label' ' after the caption in the chunk heading, as done above. Then reference the plot as such: As can be seen, Figures 3.1 and **??** are excellent, with Figure **??** being particularly aesthetically pleasing due to its device setting of Tikz. The nice thing now is that it correctly numbers all your figures (and sections or tables) and will update if it moves. The links are also dynamic.

I very strongly suggest using ggplot2 (ideally in combination with dplyr) using the ggtheme package to change the themes of your figures.

Also note the information that I have placed above the chunks in the code chunks for the figures. You can edit any of these easily - visit the Rmarkdown webpage for more information.

7. Splitting a page

You can also very easily split a page using built-in Pandoc formatting. I comment this out in the code (as this has caused issues building the pdf for some users - which I presume to be a Pandoc issue), but you are welcome to try it out yourself by commenting out the following section in your Rmd file.

8. Math section

$$\beta = \sum_{i=1}^{\infty} \frac{\alpha^2}{\sigma_{t-1}^2} \tag{8.1}$$
$$\int_{x=1}^{\infty} x_i = 1$$

If you would like to see the equations as you type in Rmarkdown, use $ symbols instead (see this for yourself by adjusted the equation):

$$\beta = \sum_{i=1}^{\infty} \frac{\alpha^2}{\sigma_{t-1}^2} \int_{x=1}^{\infty} x_i = 1$$

Note again the reference to equation 8.1. Writing nice math requires practice. Note I used a forward slashes to make a space in the equations. I can also align equations using **&**, and set to numbering only the first line. Now I will have to type "begin equation'' which is a native LaTeXcommand. Here follows a more complicated equation:

9. Results

Tables can be included as follows. Use the *xtable* (or kable) package for tables. Table placement = H implies Latex tries to place the table Here, and not on a new page (there are, however, very many ways to skin this cat. Luckily there are many forums online!).

	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
1	21.00	6.00	160.00	110.00	3.90	2.62	16.46	0.00	1.00	4.00	4.00
2	21.00	6.00	160.00	110.00	3.90	2.88	17.02	0.00	1.00	4.00	4.00
3	22.80	4.00	108.00	93.00	3.85	2.32	18.61	1.00	1.00	4.00	1.00
4	21.40	6.00	258.00	110.00	3.08	3.21	19.44	1.00	0.00	3.00	1.00
5	18.70	8.00	360.00	175.00	3.15	3.44	17.02	0.00	0.00	3.00	2.00

Table 9.1: Short Table Example

To reference calculations **in text**, *do this:* From table 9.1 we see the average value of mpg is 20.98.

Including tables that span across pages, use the following (note that I add below the table: "continue on the next page''). This is a neat way of splitting your table across a page.

Use the following default settings to build your own possibly long tables. Note that the following will fit on one page if it can, but cleanly spreads over multiple pages:

9.1. Huxtable

Table 9.2: Regression Output

	Reg1	Reg2	Reg3
(Intercept)	-2256.361 ***	5763.668 ***	4045.333 ***
	(13.055)	(740.556)	(286.205)
carat	7756.426 ***		7765.141 ***
	(14.067)		(14.009)
depth		-29.650 *	-102.165 ***
		(11.990)	(4.635)
N	53940	53940	53940
R2	0.849	0.000	0.851

*** p $<$ 0.001; ** p $<$ 0.01; * p $<$ 0.05.

10. Lists

To add lists, simply using the following notation

- This is really simple
  - Just note the spaces here - writing in R you have to sometimes be pedantic about spaces...
- Note that Rmarkdown notation removes the pain of defining LaTeXenvironments!

11. Conclusion

References

10 Fama, E.F. & French, K.R. 1997. Industry costs of equity. *Journal of financial economics*. 43(2):153–193.

Grinold, R.C. & Kahn, R.N. 2000. Active portfolio management.

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Appendix

Appendix A:

Table 11.1: Variance Ratio Test for Bretton Woods period up to month 20

Months	India	SriLanka	Malaysia	Myanmar	Pakistan	Philippines	Thailand
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
2	1.06	0.88	0.80	1.03	1.01	1.02	0.79
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
3	1.03	0.80	0.73	1.01	0.92	0.90	0.72
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
4	0.99	0.77	0.66	0.95	0.76	0.84	0.61
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
5	0.92	0.79	0.59	0.93	0.61	0.81	0.50
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
6	0.88	0.80	0.56	0.91	0.55	0.79	0.47
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
7	0.84	0.80	0.53	0.90	0.50	0.79	0.39
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
8	0.82	0.80	0.55	0.89	0.49	0.81	0.36
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
9	0.80	0.80	0.55	0.88	0.44	0.83	0.36
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
10	0.80	0.78	0.56	0.87	0.39	0.82	0.36
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
11	0.79	0.78	0.56	0.90	0.36	0.81	0.37
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
12	0.80	0.78	0.53	0.96	0.34	0.82	0.35
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
13	0.83	0.76	0.53	0.98	0.35	0.84	0.35
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
14	0.86	0.74	0.55	1.00	0.36	0.85	0.34
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
15	0.90	0.74	0.56	1.04	0.35	0.87	0.32
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
16	0.88	0.72	0.56	1.07	0.34	0.87	0.31
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
17	0.89	0.71	0.56	1.09	0.33	0.87	0.30

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Table 11.1: Variance Ratio Test for Bretton Woods period up to month 20

Months	India	SriLanka	Malaysia	Myanmar	Pakistan	Philippines	Thailand
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
18	0.89	0.71	0.56	1.10	0.34	0.88	0.31
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
19	0.87	0.70	0.57	1.11	0.35	0.88	0.31
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
20	0.84	0.69	0.58	1.15	0.36	0.89	0.32
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Table 11.2: Variance Ratio Test for post Bretton Woods period up to 20 months

Months	India	SriLanka	Malaysia	Myanmar	Pakistan	Philippines	Thailand
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00
se	0.14	0.14	0.14	0.14	0.14	0.14	0.14
2	0.95	1.01	0.78	1.05	0.78	0.85	0.71
se	0.14	0.14	0.14	0.14	0.14	0.14	0.14
3	0.99	0.91	0.80	1.14	0.68	0.84	0.66
se	0.14	0.14	0.14	0.14	0.14	0.14	0.14
4	0.98	0.93	0.75	1.14	0.61	0.82	0.58
se	0.14	0.14	0.14	0.14	0.14	0.14	0.14
5	0.93	0.94	0.76	1.12	0.60	0.81	0.53
se	0.14	0.14	0.14	0.14	0.14	0.14	0.14
6	0.88	0.94	0.73	1.06	0.54	0.78	0.49
se	0.14	0.14	0.14	0.14	0.14	0.14	0.14
7	0.82	0.94	0.69	1.02	0.50	0.76	0.45
se	0.14	0.14	0.14	0.14	0.14	0.14	0.14
8	0.77	0.92	0.68	1.00	0.45	0.76	0.44
se	0.14	0.14	0.14	0.14	0.14	0.14	0.14
9	0.75	0.89	0.62	0.98	0.40	0.81	0.40
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
10	0.75	0.86	0.60	0.98	0.39	0.79	0.38
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
11	0.75	0.85	0.55	0.98	0.38	0.79	0.34
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
12	0.76	0.84	0.51	0.99	0.37	0.78	0.33
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
13	0.76	0.82	0.47	1.00	0.39	0.78	0.32

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Table 11.2: Variance Ratio Test for post Bretton Woods period up to 20 months

Months	India	SriLanka	Malaysia	Myanmar	Pakistan	Philippines	Thailand
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
14	0.75	0.83	0.45	0.99	0.40	0.77	0.32
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
15	0.73	0.83	0.43	0.98	0.39	0.77	0.31
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
16	0.72	0.83	0.42	0.99	0.39	0.75	0.31
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
17	0.72	0.83	0.42	0.98	0.38	0.74	0.30
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
18	0.71	0.81	0.42	0.98	0.38	0.72	0.28
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
19	0.68	0.80	0.42	0.99	0.38	0.70	0.27
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15
20	0.64	0.78	0.41	0.99	0.39	0.68	0.25
se	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Appendix B