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The World Bank
October 1991
WPS 791

Measuring Real Exchange Rate Instability in Developing Countries

Empirical Evidence and Implications

Lant Pritchett

The historical evolution of the real exchange rate in most LDCs, with periods of gradual appreciation followed by massive depreciations, implies that the standard variability measures are not valid for comparing real exchange rate uncertainty across countries.

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This paper — a product of the Trade Policy Division, Country Economics Department — is part of a larger effort in PRE to examine the implications of exchange rate policy for economic performance. Copies are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Karla Cabana, room N10-037, extension 37947 (26 pages). October 1991.

Exchange rate policy has received renewed attention because of its prominent role in adjustment programs. Several analysts have examined the impact of real exchange rate uncertainty on the performance of such economic variables as GDP growth, exports, and investment.

Pritchett uses data on the real exchange rate for 56 developing countries with managed exchange rates to make three points:

- The distribution of annual changes in real exchange rates is highly non-normal — both skewness and excess kurtosis (increased probability of tail events).

- This asymmetric non-normality implies that the common practice of using the standard deviation (or coefficient of variation) to compare real exchange rate uncertainty across countries is not justified.

Empirically, the higher order moments (skewness and kurtosis) are at least as important as the standard deviation in explaining cross-country performance.

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by
Lant Pritchett

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Measuring real exchange rate instability in developing countries: Empirical evidence and implications

The real exchange rate (RER) has received increasing attention as a critical relative price. Realignment of an overvalued RER has been one of the critical components of adjustment programs supported by the World Bank (Thomas, et. al., 1990, Conway, 1991). This increased attention has stimulated research into the impact of exchange rate policy on overall economic performance. Several recent papers have shown an empirical association between RER variability and various indicators of economic performance: output growth (Cottani, Cavallo and Khan, 1990, Dollar, 1990, and Lopez, 1991), export performance (Corbo and Caballero, 1990), and investment (Serven and Solimano, 1991, Faine and de Melo, 1990).

This paper contributes to the discussion of the empirical link between the RER and economic performance by providing evidence for three facts about the RER in LDCs. First, for nearly all LDCs with managed exchange rates the historical distribution of annual RER innovations is asymmetric (a pronounced tendency to large RER depreciations) and has very fat tails relative to the normal distribution. Second, because the distribution of RER changes is different across countries, comparing the commonly used RER variability statistics (such as the standard deviation or coefficient of variation) across countries does not convey any reliable information whatsoever. Therefore, finding (or not finding) a statistical association across countries between the variability of the RER and some performance variable by itself can convey no information about the impact of RER "uncertainty." Third, the higher order moments of the distribution of RER changes (skewness and kurtosis) are empirically better correlates of economic performance than the standard variability statistics which suggests that further research is needed into patterns of RER evolution and their consequences for economic performance.

This paper has four sections and a conclusion. The first briefly discusses RER determination in LDCs. The second examines the empirical evidence for the non-normality of exchange rate changes, and illustrates massive skewness towards large depreciations. The third section discusses comparing "variability" across countries and shows that 1) different variability statistics produce substantially different rankings and 2) that countries with the same RER variability may nevertheless have very different RER uncertainty. The fourth reports some simple cross-country regressions that illustrate the surprisingly large empirical importance of the higher order moments (skewness and kurtosis) of the distribution of RER changes in regressions explaining economic performance.

I) The evolution of the RER in developing countries

The developed countries have moved, since the collapse of the Bretton Woods arrangements in 1973, towards a policy of more or less freely floating exchange rates, at least across major currency areas. On the other hand, nearly all developing countries actively control the nominal exchange rate. Exchange rates are generally pegged to a currency, or composite of currencies. The frequency of revision of the exchange rate peg varies, with countries pursuing a managed float revising frequently, while other countries adjust annually or less. Table 1 shows the distribution of developing countries' exchange rate arrangements in 1982.

In the classical discussion the equilibrium real exchange rate was shown to be invariant to the choice of fixed or floating nominal exchange rates. The question was simply whether nominal exchange rates or national price levels, through the money supply, should adjust to reach equilibrium. As a matter of historical practice allowing the domestic price levels to rise more slowly than international prices has not been widely observed in LDCs. In developing countries faced with an appreciated RER the common pattern has been to "defend" overvalued exchange rates and resist nominal devaluations. Governments try to staunch the incipient current account deficit generated by overvaluation imposing increasingly severe restrictions on both the capital and current account payments while simultaneously attempting to mitigate the effects of overvaluation on marginal exporters. This disequilibrium process often ends in a crisis, with a

Table 1: Exchange Rate Arrangements of Developing Countries, March 31, 1982

US dollar	Pegged SDR	French Franc	Composite	Limited Flexibility against single currency	Managed Floating	Independently Floating
Chile	Burma	Benin	Bangladesh	Guyana	Brazil	Argentina[1]
Ecuador	Jordan	Burkina Faso	China	Philippines	Bolivia	Costa Rica[2]
Paraguay	Kenya	Cameroon	Malaysia	Ghana	Colombia	S. Africa
Venezuela	Malawi	GAF	Algeria		Peru	
Dominican Rep	Mauritius	Congo	Tunisia		Uruguay	
El Salvador	Sierra Leone	CIV	Mauritania		Mexico	
Guatemala	Zaire	Madagascar	Tanzania		India	
Haiti	Zambia	Mali	Zimbabwe		Korea	
Honduras		Niger			Pakistan	
Jamaica		Senegal			Sri Lanka	
Panama		Togo			Thailand	
Trinidad and Tobago					Morocco	
Egypt					Turkey	
Syria					Nigeria	
Yemen						
Burundi						
Ethiopia						
Liberia						
Rwanda						
Somalia						
Sudan						

Notes: 1) Floated December 24, 1981 after a period of pre-announced rates.
2) Since January 1981.

massive jump in the nominal rate aimed at reestablishing a manageable RER.[1] Krueger (1978) provides an detailed account of this pattern in the 1970s for a number of LDCs. The excellent empirical analysis of devaluation episodes in Edwards (1989, Ch. 6) and in Kamin (1988) also reveals increasing use of import and foreign exchange payment controls and a sharp fall in imports in the periods preceding large devaluations. This paper examines some empirical implications of this stylized story. To the extent that "resisted devaluation" captures a common experience with exchange rate management in LDCs, RER levels should exhibit infrequent jumps at points where the nominal rate is revalued towards a more sustainable rate and RER innovations should have an asymmetric distribution.

II) Evolution of RER asymmetry and non-normality of exchange rate changes

This section examines time series evidence on the evolution of the RER in developing countries. It is shown that the distribution of RER changes is

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[1] As early as 1967, prior to floating rates, Kindleberger characterized the combination of overvalued rates with current and capital account restrictions as a "disequilibrium system."

markedly asymmetric, with a pronounced tendency towards large depreciations. Further, the distribution tends to excess kurtosis, with much fatter tails than the normal (Gaussian) distribution.

A multilateral RER index was constructed for 68 developing countries[2] and 19 OECD and Southern European countries. The 68 developing countries are divided into the primary sample of 56 countries with managed exchange rates, 10 African Franc zone countries, and 2 "dollar" developing countries. The RER index in period t for country j is:

$$1)\quad RER_t^j = \frac{p_t^j}{\left[\prod_{i=1}^{20} \gamma^{ij} p_t^i\right] e_t^j}$$

The CPI of the home country (p_t^j) is used to proxy the price of non-tradables. The price of foreign goods (measured by ep*, where e is the nominal exchange rate, local currency per dollar, γ^{ij} are the shares of country i in country j's trade in 1980, p_t^i are the wholesale prices, in dollars, of country i) is used to proxy the price of tradables. While there are serious objections to this method of measuring the RER, the limitations imposed by multi-country comparability preclude measuring home and traded goods prices directly as would be suggested by the popular definition of the RER as the relative price of non-tradables to tradables. The defense of this RER index is twofold. First, even if it is not theoretically appropriate, this index (or some variant thereof) is what is generally monitored and so is of independent interest. Secondly, nearly all of the empirical work on RER variability has used a RER index of this type.

Empirical work on RER behavior has focussed on the level of the RER (Edwards 1989, 1987). However, evidence strongly suggests that RER levels in most developing countries are not stationary. Only two of 56 countries could reject the standard test for the presence of a unit root and 42 (75%) have a

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[2] The RER index for the was constructed by Francis Ng at the World Bank using exchange rate and price data from the IMF's International Financial Statistics and partner trade weights derived from IMF's Direction of Trade.

statistically significant trend term.[3] Since the variance of a non-stationary times series tends to infinity, the (log) level of the RER was first differenced before analysis and this paper examines the behavior of these unconditional RER innovations:[4]

2) $$\Delta rer_t = \ln(RER_t) - \ln(RER_{t-1}) \; .$$

A) Testing for asymmetry of RER changes

The pattern of "resisted devaluation" described above should produce an asymmetric distribution of RER changes, with a tendency towards larger depreciations than appreciations.[5] In order to examine this hypothesis the empirical distribution of each country's RER changes was tested for left skewness using three statistics. The usual skewness statistic is the scaled third moment of the distribution about the mean scaled by the standard error:

3) $$b_3 = \frac{\mu_3}{\mu_2^{3/2}} \; .$$

This skewness coefficient is zero in any symmetric distribution and is negative in a left skewed distribution, as deviations below the mean are on average larger than those above the mean. Two other skewness statistics are also calculated. The first is the normalized difference of the absolute value of the largest depreciation and the largest appreciation:

4) $$S_1 = \frac{X_n - |X_1|}{\sigma} \; ,$$

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[3] Note that I am not attempting to decide the difficult question whether the series is better represented as a stochastic or a deterministic trend, only to establish non-stationarity.

[4] Given the agnostic stance toward trend stationarity in footnote 3, the deviations from trend could also have been used to establish stationarity. Similar results for the skewness and kurtosis of RER innovations are obtained if the one step ahead forecast errors from a trend are used.

[5] The exchange rate measured used follows the "down is down" convention that a depreciation, or devaluation of the exchange rate is represented as a fall in the RER measure (this is 1/RER as defined in equation 1).

where the RER changes are ordered from smallest (X_1) (i.e., biggest depreciation) to largest (X_n) and σ is the standard deviation. Values less than zero indicate left skewness, as the largest depreciation is larger than the largest appreciation. Finally, the ratio of the largest depreciation to the absolute value of the average change is also computed:

$$5) \qquad S_2 = -\frac{|X_1|}{\left[\sum_{i=1}^{n}|X_i|/n\right]}$$

This indicates how much larger the biggest depreciation is than the "typical" annual change.

Table 2 reports these three skewness statistics for each of the 56 developing countries with managed nominal exchange rates.[6] Impressively, the RER changes of 47 countries (84%) were left skewed by the b_3 statistic and 48 (86%) by S_1. Of the 38 non-Sub-Saharan African countries in the sample only three (Peru, El Salvador and Morocco) failed to show evidence of left skewness. The hypothesis of symmetry ($b_3 = 0$, $S_1 = 0$) was tested using critical regions derived under the assumption of an underlying normal distribution. Symmetry could be rejected in favor of left skewness at the 5% significance level for 34 countries (61%) by the b_3 statistic, and for 29 countries (52%) by S_1. This is strong evidence that the distribution of annual[7] percentage changes in the RER in developing countries with managed nominal exchange rates has been asymmetric, with a marked tendency towards large depreciations.

The magnitude of these deviations from symmetry is significant. The third column of Table 2 reports the ratio of the (absolute value of) largest depreciation to the average of the absolute values. This indicates how much larger the "maxi" depreciation is than the RER change in a "typical" year. The median ratio in the Central America and Caribbean region is 6.0, and in all of the other

[6] Excluded from those normally considered "developing" are the CFA countries and Liberia and Panama.

[7] Of course this skewness and kurtosis is even easier to find in quarterly data. Appendix table A.1 shows the skewness statistics for 20 countries using quarterly data. Only Malaysia fails to reject left skewness at the 1% level.

Table 2: Skewness and kurtosis statistics for annual percentage RER changes, 1966-1988 for 56 developing countries with managed exchange rates.

	b_3 Skewness	S_1 $\frac{\text{max - min}}{\sigma}$	S_2 |min|/avg	b_4 kurtosis	SR std range
Latin America					
Argentina	-1.31**	-1.59**	3.90	1.18*	3.58
Bolivia	-1.31**	-1.12	6.71	6.00**	5.92**
Brazil	-0.24	-0.54	2.99	-0.20	3.98
Chile	-1.09**	-1.77**	5.26	3.44**	5.34**
Colombia	-0.19	-1.04	4.00	1.44**	5.03**
Ecuador	-1.52**	-2.11**	5.46	3.61**	4.98**
Paraguay	-0.80*	-1.28*	3.65	0.75	4.14
Peru	0.59	0.58	2.91	1.04	4.63*
Uruguay	-1.48**	-1.38*	3.65	1.66**	3.77
Venezuela	-1.95**	-2.25**	6.13	4.88**	4.45
Region median	-1.20	-1.33	3.95	1.55	4.72
Central America					
Costa Rica	-2.98**	-2.98**	10.08	11.61**	5.73**
Dominican Rep	-2.32**	-2.48**	8.25	6.61**	5.19**
El Salvador	0.20	0.50	4.46	4.36**	5.91**
Guatemala	-2.08**	-2.31**	7.16	6.82**	5.44**
Guyana	-3.17**	-3.60**	9.33	12.36**	5.27**
Haiti	-1.00**	-0.95	3.61	1.40**	4.45
Honduras	-1.55**	-1.37*	6.80	6.89**	5.95**
Jamaica	-1.43**	-1.93**	4.73	2.19**	4.48
Mexico	-0.91**	-0.86	3.39	0.53	3.88
Trinidad	-1.70**	-1.96**	5.21	5.01**	4.98**
Region median	1.62	-1.95	6.01	5.81	5.23
Asia					
Bangladesh	-0.16	-0.30	4.49	2.10**	5.11**
Burma	-0.03	0.46	1.85	-0.95	3.54
China	-0.57	-1.95**	3.75	0.89	4.78**
India	-1.51**	-2.67**	4.97	2.38**	4.23
Korea	-0.89**	-0.82	3.30	0.30	3.94
Malaysia	-0.13	-0.41	2.95	-0.20	4.15
Pakistan	-2.13**	-2.92**	6.73	5.56**	4.75**
Philippines	-1.11**	-1.77**	4.36	1.35**	4.27
Sri Lanka	-2.62**	-3.65**	7.78	8.67**	4.98**
Thailand	-0.11	-1.08	2.99	-0.59	3.83
Region median	-0.73	-1.42	4.05	1.12	4.25
Middle East & Africa					
Algeria	-1.58**	-1.31*	3.36	2.31**	3.82
Egypt	-2.67**	-2.73**	6.60	9.60**	5.05**
Jordan	-1.92**	-2.49**	5.39	5.09**	4.84**
Morocco	0.45	0.23	2.55	0.28	4.26
Syria	-1.84**	-2.04**	5.75	5.59**	5.14**
Tunisia	-1.31**	-2.06**	5.29	3.57**	5.22**
Turkey	-1.29**	-2.30**	4.31	0.88	3.54
Yemen	-1.46**	-2.09**	4.42	2.50	4.27
Region median	-1.52	2.08	4.85	3.04	4.56

Note: ** (*) significant at the 5% (10%) level.

Table 2: Skewness and kurtosis statistics for annual percentage changes in RER for 53 developing countries with managed exchange rates, 1966-1988 (continued).

	b_3 Skewness	S_1 $\frac{\text{max - min}}{\sigma}$	S_2 $\lvert\text{min}\rvert$/avg	b_4 kurtosis	SR std range
Sub-Saharan Africa					
Burundi	0.62	0.90	1.88	-0.07	3.90
Ethiopia	-0.16	-0.25	3.61	0.95	4.77**
Ghana	-1.88**	-2.16**	6.25	6.48**	5.30**
Kenya	0.52	0.45	1.97	-0.29	3.80
Madagascar	-3.13**	-3.91**	9.41	11.27**	4.98**
Malawi	-0.59	-1.11	3.34	-0.23	3.82
Mauritania	0.96**	1.56**	1.73	1.00	4.25
Mauritius	0.02	-1.00	2.58	-0.79	3.70
Nigeria	-2.57**	-2.82**	7.20	7.90**	4.98**
Rwanda	-1.97**	-2.13**	6.35	5.47**	4.99**
Sierra Leone	0.05	-0.58	3.31	0.27	4.09
Somalia	0.50	0.40	2.75	0.54	4.08
S. Africa	-0.78*	-1.50**	4.39	1.83**	4.78**
Sudan	0.02	0.17	3.33	1.13*	4.78**
Tanzania	-1.89**	-2.24**	5.50	4.84**	4.83**
Zaire	-2.03**	-2.69**	6.10	6.62**	4.89**
Zambia	-1.42**	-1.37*	6.82	6.77**	6.03**
Zimbabwe	-0.54	-0.94	3.31	0.12	4.03
Region median	-0.57	-1.05	3.47	1.07	4.81

regions except SSA the median is near four[8]. The effect on the RER of the delayed depreciations, when they do occur, are larger than a typical "random shock" by a factor of four.

B) Kurtotic distributions

Some phenomena of economic interest have distributions that are more peaked and fatter tailed than the normal, implying a larger relative probability of observations far into the tails. The last two columns of table 2 present two measures of fat tails for our RER innovations series, the excess kurtosis coefficient which is the scaled fourth moment minus three:

[8] In a sample of size 23 from a standard normal sample the average value of this statistic would be 2.5.

Table 3: Skewness statistics for annual percentage change in RER for countries of the OECD and Southern Europe, the Franc Zone and two "dollar" countries, 1966-1988.

	b_3 Skewness	S_1 $\frac{\text{max - min}}{\sigma}$	S_2 $\lvert\text{min}\rvert$/avg	b_4 kurtosis	SR std range
OECD					
Australia	-0.23	-0.03	4.22	-0.33	4.04
Austria	0.00	-0.42	2.81	1.14*	4.47
Belgium	-0.27	-0.28	2.37	-0.83	3.61
Canada	0.03	0.21	2.00	-1.04	3.59
Switzerland	0.15	0.15	3.63	1.75**	5.23**
Denmark	-0.28	-0.54	2.34	-0.97	3.47
France	0.11	0.59	1.48	-1.34**	3.24
Germany	0.15	0.53	1.68	-0.87	3.42
Italy	0.08	0.25	2.55	-0.12	4.35
Japan	0.08	0.50	1.90	-0.92	3.73
Netherlands	1.25**	1.58**	2.37	2.95**	4.78**
Norway	-0.33	-0.60	2.36	-0.92	3.49
Sweden	0.26	0.45	2.50	0.25	4.13
United Kingdom	[illegible] 37	0.55	1.[illegible]7	-0.58	3.52
United States	0.24	0.55	1.[illegible]1	-1.02	3.55
Median	0.08	0.25	2.37	-0.92	3.61
Franc Zone					
Benin	0.62	0.89	2.07	0.02	4.01
Burkina Faso	0.17	-0.13	3.73	1.52**	4.85**
Cameroon	0.66	1.31*	1.87	0.39	4.12
Central Africa	-0.20	0.28	3.04	1.02	4.90**
Congo	0.03	-0.06	3.79	1.81**	5.21**
Cote d'Ivoire	0.36	0.69	1.65	-0.84	3.41
Mali	0.00	0.04	2.61	-0.29	4.06
Niger	-0.87**	-1.37*	3.56	0.64	4.02
Senegal	1.22**	1.51**	2.30	2.16**	4.54*
Togo	0.80*	0.36	2.49	0.56	3.93
Median	0.27	0.32	2.55	0.60	4.09
S. Europe					
Greece	0.24	0.40	2.08	-0.58	3.79
Hungary	-0.34	-0.58	3.00	-0.16	4.09
Portugal	-0.24	0.18	2.19	-0.44	3.59
Yugoslav	-0.40	-0.92	3.14	0.02	4.13
Median	-0.29	-0.75	2.14	-0.30	3.69
Dollar Countries					
Liberia	-0.30	-0.73	2.81	-0.55	3.91
Panama	-0.49	-1.72**	3.53	0.28	4.06
Median	-0.40	-1.23	3.17	-0.14	3.99

Note: ** (*) - significant at the 5 (10)% level.

6) $$b_4 = \frac{\mu_4}{\mu_2^2} - 3$$

The studentized range, which is the maximum less the minimum normalized by the standard error:

$$7) \quad SR = \frac{X_n - X_1}{\sigma}$$

These tests provide additional evidence of the non-normality of RER innovations. Forty eight of the 56 managed exchange rate countries had positive excess kurtosis. The studentized range (SR) was greater than the expected value under normality[9] in all but nine of the countries. Hypothesis tests for the excess kurtosis and studentized range reject the null of normality in 36 and 30 of the 56 countries. For the non-SSA countries 27 (20) of 36 countries could reject the hypothesis by the kurtosis (SR) test.

Table 3 presents the skewness statistics for four other groups of countries for comparison with the managed exchange rate developing countries: fifteen OECD countries, four Southern European countries, ten CFA countries and Liberia and Panama. The skewness evident for the managed developing countries is completely absent. Of the 31 countries only one (Niger) was significantly left skewed by the b_3 statistic. Less than half of the countries were negative by either the b_3 or S_1 measure.

Figures 1 and 2 display the histograms of the standardized annual RER percentage changes for the 56 managed exchange LDCs and the 31 other countries. The bars depict the observed relative frequency and the expected relative frequencies under a standard normal distribution are indicated in the graph by the capped vertical lines. The left asymmetry is visually evident in Figure 1 from the large number of observations more than 3 standard deviations below the mean. Figures 3 and 4 highlight the asymmetry further by displaying the ratio of the observed relative frequency to that of the normal distribution. For the LDCs the excess relative frequency of depreciations is immense. There are three times too many observations 3.5 deviations below the mean, 57 times too many at 4 deviations and 97 times too many 4.5 or more deviations away.

[9] The expected value of the studentized range for a sample of 23 from a normal distribution is 3.85.

Figure 1: Histogram of standardized annual RER percentage changes for 56 LDCs with managed exchange rates, 1966-88.

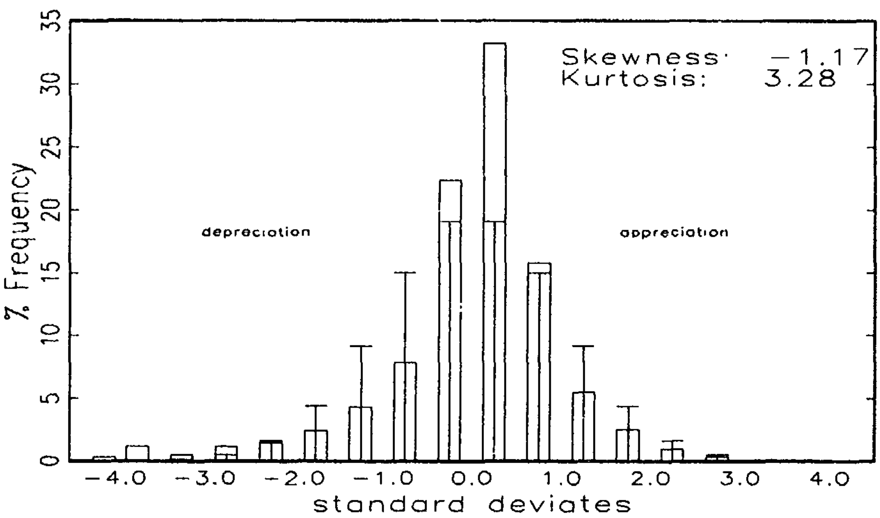


Figure 2: Histogram of standardized annual RER percentage changes for 31 other countries, 1966-88.

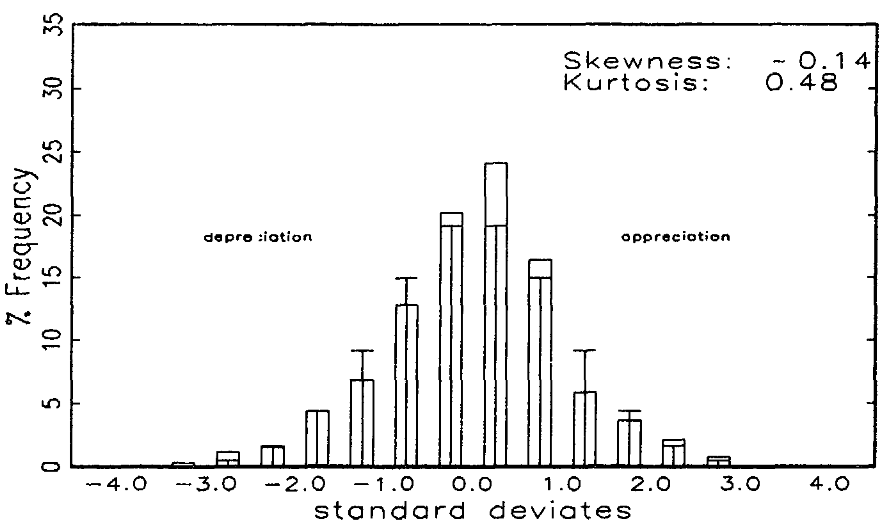


Figure 3: Excess of actual relative frequency to expected frequency from normal distribution for 56 managed exchange rate LDCs.

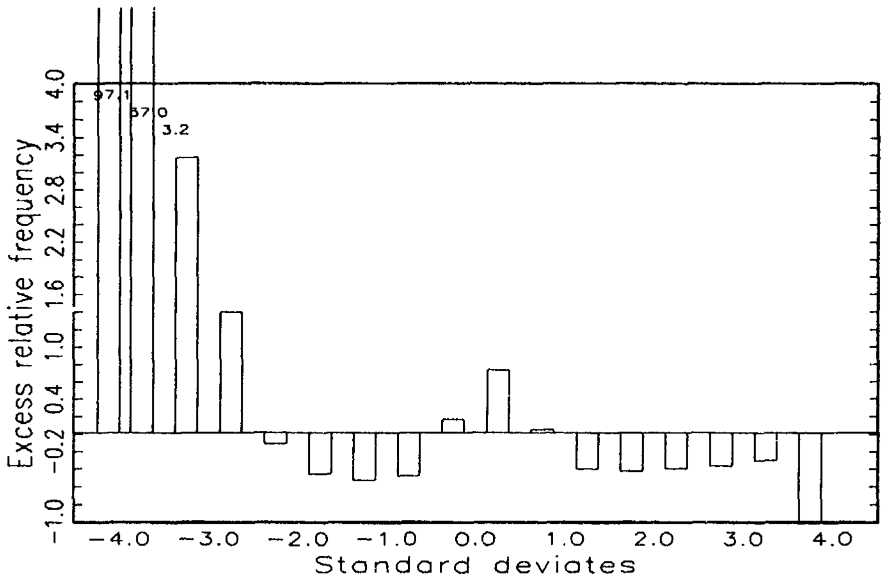
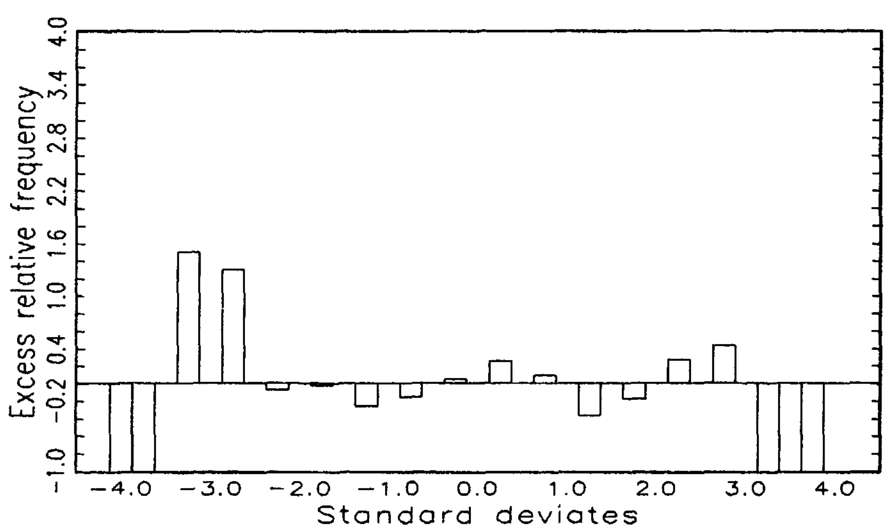


Figure 4: Excess of actual relative frequency to expected frequency from normal distribution, 31 other countries.



C) Testing for asymmetry in kurtotic distributions

Before moving to examine the implications of asymmetry in cross country comparisons a final statistical point needs to be addressed. The critical levels used in the previous sections for the skewness and kurtosis statistics are generated under the null that the parent distribution is normal. However, given that the distribution is kurtotic (thick tailed), the critical levels for the skewness statistic generated under the null of normality will not be correct. In the small samples available it is difficult to statistically distinguish kurtosis (relatively large probabilities of extreme observations) from skewness (tendency for extreme observations in one tail). Deviations from normality due to skewness, implying an asymmetric process, are of greater economic interest than fat tails. To test the hypothesis of skewness independently we need to determine the distribution of the skewness coefficient under the null of a more general symmetric, but kurtotic distribution.

The "student's" t distribution commonly used in hypothesis tests is a symmetric distribution, with a level of kurtosis that decreases with the degrees of freedom (ν):

8) $$b_4 = \frac{6}{\nu - 4}$$

Rejection levels for each of the two skewness statistics were generated using Monte Carlo simulations from t distributions with varying degrees of freedom. The rejections levels are reported in Table 6. For instance, if the parent distribution is assumed to be normal then values of the skewness statistic (b_3) greater (in absolute value) than .84 with a sample size of 23 indicate a rejection of the null of no skewness at the 5% level. However, if the parent distribution is a t(5), with excess kurtosis of 6, then the absolute value of b_3 needs to exceed 1.87 to reject at the same confidence level.

The critical values in table 6 can be compared with the skewness statistics in table 2 to check the robustness of the symmetry tests to kurtosis. The values of the skewness statistics are so high that many countries are still able to reject symmetry. Using the critical values generated from a t(6) distribution

Table 4: Critical levels for skewness statistics

		b_3 Skewness 5%	b_3 Skewness 10%	S_1 $\frac{\max - \lvert\min\rvert}{\sigma}$ 5%	S_1 $\frac{\max - \lvert\min\rvert}{\sigma}$ 10%
	Excess kurtosis				
Normal (0,1)	0	.83	.68	1.49	1.23
Student's t degrees of freedom					
5	6	1.87	1.44	2.38	1.95
6	3	1.60	1.25	2.18	1.82
10	1	1.30	1.02	1.88	1.56

17 (12) of the 56 countries could still reject symmetry using the b_3 (S_1) statistic[10]. This is powerful evidence that the asymmetry in RER behavior is not a statistical artifact but reflects asymmetries in the process of RER determination in LDCs with managed exchange rates.

The evidence of this section has shown that, unlike the RER behavior for the more developed countries and for those developing countries with continuously pegged exchange rates, the ex-post distribution of percentage changes in the RER is highly non-normal. Only seven countries (Brazil, Peru, Burma, China, Malaysia, Thailand and Morocco) are not significantly non-normal by either the skewness or the kurtosis tests.[11] The non-normality is especially evidenced by a tendency to extremely large depreciations. This empirical conclusion confirms the belief that the resistance to devaluation leading to exchange rate crises has in fact been a very common pattern among LDCs. To some extent this has been well known, as demonstrated in the immense literature on the peso problem. However,

[10] These are values for two sided tests. Using the 10% (or 5% one sided) significance levels 28 (23) were able to reject.

[11] Some omnibus tests for non-normality are a combination of the skewness (b_3) and excess kurtosis (b_4) statistics. Given that nearly all countries can reject by either test alone the increased power from combining the statistics is not necessary.

the implications for comparing uncertainty of different, non-normal distributions seems to have been ignored as the next two sections will illustrate.

III) Measuring RER variability

Several recent papers have used cross country data to examine the impact of RER variability on economic outcomes. Corbo and Caballero (1990) seek to demonstrate the negative effect of RER uncertainty on exports. Dollar (1990) constructs a unique measure of RER overvaluation and RER variability and examines their impact on economic growth. Lopez (1991) includes a term for RER variability in his equations for capital accumulation and growth. Cottani, Cavallo and Khan (1990) also show negative effects of RER variability on economic growth in a cross country sample. Serven and Solimano (1991) and Faini and de Melo (1990) (or coefficient of variation) show a negative RER variability impact on investment. All of these papers use the standard deviation to measure variability. Section II shows that RER changes are not normally distributed in most countries and that the distribution of RER changes is very different across countries. This implies that comparisons of RER variability across countries are ambiguous, in two ways. First, different variability statistics may produce considerably different country rankings. Second, countries that are ranked as having the same amount of variability may have very different distributions and hence cannot be ranked by uncertainty.

A) Measuring variability

With non-normality many different measures of dispersion are possible which may produce quite distinct rankings of RER variability none of which has any necessary a priori justification as "the" measure of variability. In table 6 the countries were ranked from most to least "variable" by three different dispersion statistics: the standard deviation, the mean absolute deviation (MAD), and the interquartile range (IQR). These variability measures differ the treatment of the deviations. The interquartile range ignores the tails completely while the standard deviation squares the deviations.

The rank correlation between the standard deviation and the interquartile range was only .68 and the average absolute difference in the ranks was 10[12]. A cross country correlation of .68 is quite high for two different variables, but these are presumably measuring the same characteristic (RER variability) and by this standard the correlation must be considered low. Since the interquartile range is insensitive to the tails the rankings of some countries which have generally low dispersion but one or two large depreciations are changed dramatically. Dominican Republic and Costa Rica for example, have a large standard deviation (8th and 21st largest of the 56 countries) yet a very small interquartile range (50th and 55th of 56). The correlation between the standard deviation and the MAD, which puts less weight to extreme observations, was .78 with average absolute rank difference of 8. When the RER is distributed differently in each country then calculating a summary statistic for the dispersion of each will produce a ranking by RER uncertainty, but another equally plausible statistic could (and does) produce a quite different country ranking.

The second dangerous aspect in measuring RER variability by the standard deviation is that countries with roughly the same standard deviation may well have had completely different evolution of the RER. A simple example will illustrate. Imagine two countries which have domestic inflation on average higher than international inflation. One country sets the nominal rate at the beginning of each year equal to the expected inflation differential. Domestic prices are then set equal to the average rate plus a random shock. The ex-post RER will be variable due to the uncertainty of domestic inflation. A second country has no uncertainty about domestic prices but holds the nominal exchange rate fixed for a long period, generating an appreciating RER. At the end of the period the initial period RER is re-established with a maxi-devaluation. The first country's RER is will be on average correctly valued, with only random deviations. The second country's exchange rate will be on average overvalued. However, in Table 6 an example is constructed of the evolution of these RER under

[12] If the rankings were identical the value of the mean absolute difference in the ranks would be zero and if the rankings were uncorrelated the expected value would be 19 in a sample of size 56.

Table 5: Country rankings for RER uncertainty, by three alternative statistics

	Standard deviation		Means abs deviation		Inter-quartile range	
Latin America	value	rank	value	rank	value	rank
Argentina	32.2	3	14.1	2	33.8	2
Bolivia	36.6	2	6.1	17	19.7	6
Brazil	9.6	33	4.7	28	14.7	12
Chile	20.9	9	10.0	4	23.7	4
Colombia	7.8	42	3.5	45	7.4	44
Ecuador	11.6	30	5.7	19	12.6	20
Paraguay	12.8	22	6.1	16	13.2	18
Peru	13.7	17	7.0	12	15.1	11
Uruguay	19.2	12	8.1	8	14.7	13
Venezuela	12.7	23	3.6	43	8.3	41
Central America						
Costa Rica	12.8	21	3.1	47	4.7	55
Dominican Rep	21.0	8	5.7	18	6.4	50
El Salvador	12.6	25	5.2	25	13.3	17
Guatemala	9.3	36	2.6	51	6.0	52
Guyana	14.5	15	4.2	34	8.4	38
Haiti	6.6	48	4.3	33	8.7	35
Honduras	8.6	38	1.9	55	6.7	47
Jamaica	12.9	19	6.9	13	12.8	19
Mexico	12.6	26	4.6	30	10.9	26
Trinidad	9.5	34	3.8	39	10.1	29
Asia						
Bangladesh	12.7	24	3.6	44	7.9	42
Burma	10.7	31	8.1	7	19.1	7
China	7.0	47	3.8	38	9.1	33
India	5.3	50	2.8	50	4.3	56
Korea Rep	9.3	35	4.6	32	9.8	30
Malaysia	4.5	52	2.4	53	5.1	54
Philippines	8.5	39	5.0	26	9.4	31
Sri Lanka	13.5	18	5.4	24	8.5	37
Thailand	3.5	55	2.8	49	6.4	49
Middle East & Africa						
Algeria	7.3	44	3.8	37	6.9	46
Egypt	15.9	14	5.7	20	14.5	14
Jordan	7.1	46	3.8	40	8.5	36
Morocco	3.9	54	2.0	54	6.7	48
Syria	22.8	7	5.5	22	21.5	5
Tunisia	5.0	51	1.9	56	5.1	53
Turkey	12.8	20	7.5	10	14.2	15
Yemen	14.4	16	7.0	11	17.9	9

these two assumptions over 23 years. The standard deviations of the (log first differenced) series are identical. However, the skewness and kurtosis are obviously completely different, indicating the completely different pattern of RER changes.

One would not expect the response of the economies to the two RER policies would be at all similar even though the standard deviations were equal. While

Table 5: Country rankings for RER uncertainty, by three alternative statistics (continued)

Sub-Saharan Africa	Standard deviation value	Standard deviation rank	Means abs deviation value	Means abs deviation rank	Inter-quartile range value	Inter-quartile range rank
Burundi	7.7	43	5.6	21	11.4	24
Ethiopia	9.3	37	3.7	41	12.0	21
Ghana	51.1	1	22.7	1	48.7	1
Kenya	4.1	53	2.8	48	7.3	45
Madagascar	23.6	6	7.8	9	10.3	28
Malawi	5.8	49	3.7	42	8.3	39
Mauritania	7.8	41	5.5	23	10.8	27
Mauritius	3.2	56	2.6	52	6.1	51
Nigeria	27.9	4	9.6	5	13.9	16
Rwanda	12.5	27	3.3	46	8.3	40
Sierra Leone	12.2	28	4.9	27	11.7	23
Somalia	18.8	13	6.4	15	16.7	10
South Africa	8.4	40	4.0	35	8.7	34
Sudan	12.0	29	4.7	29	11.9	22
Tanzania	20.4	10	9.0	6	18.9	8
Zaire	27.8	5	12.5	3	29.5	3
Zambia	19.6	11	6.5	14	11.3	25
Zimbabwe	7.2	45	4.6	31	9.2	32

the example is deliberately artificial the values for the variance and skewness are within the ranges of those observed in the sample. Clearly the observed range of variation in the sample suggests that the differences in the distribution of RER changes are substantial. For instance, Brazil (9.6) and Costa Rica (12.6) have roughly the same standard deviation and yet Brazil's ΔRER series exhibits neither skewness not excess kurtosis, in contrast to Costa Rica's ΔRER which has both.

Comparing dispersion statistics across countries implicitly assumes that the samples are drawn from a common family of distributions. Only in that case could one infer greater uncertainty, in the usual sense of a mean preserving spread of a distribution (Rothschild and Stiglitz, 1970) from observed standard deviations. If one distribution is symmetric and another skewed, rankings by "uncertainty" in the usual sense are not possible. This creates a serious problem when attempting to compare RER "uncertainty" across countries.

IV) Higher order moments and economic performance

The importance of the non-normal and asymmetric distribution of RER innovations is that RER variability potentially captures two distinct aspects of

Table 6: Empirical example to two RER paths with same σ, but different distribution (moments of Δ rer)

Country type	over-valuation	standard deviation	skewness	kurtosis
"Variable inflation"	0%	.240	0	0
"Resisted devaluation"	53%	.240	-4.2	17.69

$\pi^d = .10$, $\pi^f = .05$, $\sigma_r^d = .1$, 23 years

RER behavior. First, variability increases with general uncertainty. Secondly, variability can be a reflection of the dramatic reversal after the pursuit of unsustainable policies. The statistical significance of a cross country association of RER variability with economic performance is not able to distinguish between the effect of greater general uncertainty and the effects of fact that massive changes in the RER result from the stop-go pursuit of unsustainable macro policies through resisted devaluations. This section illustrates this difficulty by the simple example of adding the higher order moments (b_3 and b_4) to the growth and export performance regressions.

Table 7 reports cross-country regressions with growth rate of export volume and real GDP per worker (least squares growth rates) over the 1966-88 period as the dependent variable and statistics summarizing the higher moments of the distribution of the RER over the same period as regressors.[13] Column A of table 7 gives the results of regressing economic performance indicators on the standard deviation of RER changes.[14] In column B the higher order moments are added.[15] For both measures of economic performance the association is much stronger with the higher order moments (skewness and kurtosis) of RER changes than the standard

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[13] These of course have no interpretation as structural models. Linear regression is used simply to control for the impact of other variables.

[14] This is very highly correlated with the standard deviation of deviations from a trend, which is actually what is commonly used.

[15] Adding the mean of the log first difference of the RER is insignificant and does not affect the other results.

deviation. The $\bar{R}^2$ more than doubles with the inclusion of b_3 and b_4 in the export growth regression. There are two implications. The first is that not finding an important role for RER variability does not mean that RER behavior is unimportant. The second is that finding a significant effect of RER variability does not imply that uncertainty is important.

As an empirical illustration of the first point, I find that, after the inclusion of the higher order moments, the statistical significance of σ in the export volume regression is quite fragile to sample selection. If Ghana is excluded[16] the σ term is not significant even at the 10% level. On the other hand, the higher order terms are still very important. This illustrates a case in which RER variability measured by σ would fail to find an impact of RER variability while the higher order moments are very significant. The conclusion from a regression with no significant coefficient on σ that the pattern of instability of RER behavior had little impact on export performance would be quite wrong.

Conversely, finding a role for RER variability need not imply a role for uncertainty. Both the skewness (b_3) and excess kurtosis statistics are normalized by the standard deviation, implying that these measures are invariant to transformations that increase the standard deviation without altering the underlying shape of the distribution. Nevertheless the rank correlation between the skewness and the standard deviation is -.46. The rank correlation between excess kurtosis and the standard deviation is .55. In other words, the departure of the higher order moments from normality is associated with higher measured standard deviations. This raises the possibility that RER variability effects attributed to uncertainty are actually independent effects of the higher order moments, which may represent other features of RER behavior.

Based on this evidence there is no question that more careful attention to what is meant by "uncertainty" and why it affects real variables like export growth is needed.

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[16] Ghana's σ of 51.1 (see table 6) is nearly 60% larger than that of the next highest country (Argentina at 32.2).

Table 7: Export performance and distribution of RER changes, 1966-88 for 49 non-oil exporting LDCs with managed exchange rates.

	Export Volume growth A	Export Volume growth B	GDP per Worker growth A	GDP per Worker growth B
Standard deviation (σ)	-163 (.055)**	-.153 (.058)**	-.095 (.024)**	-.084 (.025)*
Skewness (b_3)		-.026 (.008)**		-.011 (.003)**
Kurtosis (b_4)		-.008 (.002)**		-.004 (.001)**
$\bar{R}^2$	.144	.287	.246	.38
N	46	46	46	46

Standard errors in parenthesis
Note - *(**), significant at the 5(1)% level.

Conclusion

This paper firmly establishes one stylized fact and examines two practical implications of this fact. The recent historical process of exchange rate management in many LDCs had produced a distinctive pattern of changes in the RER. Changes tend to be skewed, with large depreciations of the real exchange rate much more likely than equal sized appreciations. This fact implies that theoretical and empirical discussions of the impact of RER uncertainty need to be much more careful as the term "RER variability" is ambiguous in two senses. Different dispersion measures produce distinct (although not completely dissimilar) rankings of variability across countries. Second, countries with the same variability (as measured, for instance, by the standard deviation) may have had widely different evolution of the RER. Finally an empirical example demonstrates that differences in the distribution of exchange rate changes beyond the variability are quite strongly associated with economic performance as measured by average export growth or GDP per worker. In particular, for a given standard deviation, an increase in kurtosis (increased probability of tail events) has a strong negative association with economic performance. Further, a result that is more of a puzzle, is that increased left skewness was associated with better economic performance, for given levels of the standard deviation and kurtosis. This implies that attributing the impact of a higher standard deviation to greater uncertainty is quite naive.

I conclude with a discussion of the limitations of the current research and some speculations. The major limitation of this present paper is that only unconditional RER innovations were examined. A model of RER fundamentals along the lines of Edwards, 1989, or El Badawi, 1991, would allow the decomposition of RER changes into parts due to changes in fundamentals and conditional innovations. This also would allow the distinction between persistent misalignment with infrequent corrections and pure variability especially due to fundamentals as opposed to policy to be more clearly drawn (Edwards, 1987). Given the apparent importance of misalignment demonstrated previously, and the importance of the distribution of uncertainty evidenced in this paper, this seems like a promising line of research. Also recent theoretical work by Serven, 1991, has suggested that anticipated devaluations may inhibit private investment, which makes the decomposition into conditional and unconditional innovations even more interesting.

Of course recommendations for exchange rate policy are impossible to draw from simple cross country associations. Nevertheless this paper adds to a growing literature that suggests that countries that have dramatically mis-managed their external policies have had inferior economic performance. Further I would suggest that the importance of the higher order moments suggests that while policy that produces a more variable exchange rate is bad, this may be capturing an effect of unsustainable policies that have an independent and additional harmful effect. Infrequent large changes in the RER appear to be more strongly associated with poor economic performance that increases in "uncertainty" in the commonly used sense of higher variance.

Appendix Table A.1: Skewness and kurtosis statistics on quarterly percentage changes in RER for 20 developing countries, 1963II-1988IV.

Country	skewness (b_3)	test statistic on b_3	S_1 min-max/σ	S_2 min/avg
Argentina	-3.149	-14.322	-4.067	11.072
Bolivia	-1.684	-7.564	-1.765	10.606
Brazil	-0.567	-2.591	-0.429	4.595
Colombia	-0.775	-3.538	-1.795	7.659
Ecuador	-1.740	-7.913	-2.434	6.987
Paraguay	-2.204	-9.944	-2.298	7.909
Dominican Rep	-8.092	-36.357	-8.437	28.531
Guatemala	-4.961	-22.382	-5.651	18.262
Honduras	-0.504	-2.304	-1.168	4.519
India	-1.800	-8.186	-3.212	8.351
Korea	-1.130	-4.258	-1.333	5.327
Malaysia	0.136	0.619	-0.346	5.100
Pakistan	-5.617	-25.548	-6.555	19.599
Philippines	-4.286	-19.571	-5.407	16.231
Sri Lanka	-4.853	-22.162	-6.041	17.252
Thailand	-1.713	-7.138	-2.520	7.185
Tunisia	-0.668	-3.052	-1.649	6.064
Turkey	-2.554	-9.735	-3.545	8.338
Kenya	-0.589	-2.677	-0.926	4.937
Zambia	-3.362	-15.293	-2.920	16.543

Kurtosis results

Country	kurtosis b_4	test statistic on b_4	SR std. range
Argentina	15.207	35.918	8.377
Bolivia	10.403	24.298	8.206
Brazil	1.457	3.454	6.022
Colombia	6.121	14.510	8.252
Ecuador	4.551	10.750	6.160
Paraguay	7.757	18.185	6.551
Dominican Rep	78.081	182.361	11.179
Guatemala	35.906	84.176	10.095
Honduras	1.159	2.747	5.726
India	8.070	19.061	8.074
Korea	3.129	6.236	6.203
Malaysia	2.011	4.749	6.938
Pakistan	40.566	95.815	9.846
Philippines	28.829	68.343	10.006
Sri Lanka	36.193	85.801	10.585
Thailand	6.162	13.434	6.889
Tunisia	3.777	8.954	6.748
Turkey	10.637	21.420	6.944
Kenya	1.880	4.440	5.891
Zambia	26.654	62.955	11.191

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