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Reading a Target Zone in KeynesŠs Indian Currency and Finance

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Abstract

The gold-exchange standard in India 1893–1913 was characterized by a narrow target zone for the exchange rate, a wide annual range for the international interest-rate differential, and negative (seasonal) autocorrelation in interest rates. These properties are consistent with a standard target-zone model in which fundamentals are negatively autocorrelated on a Markov chain.

Keywords: target zone, Indian currency question, gold exchange standard

JEL Classification Codes: F31, N13, N15

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In *Indian Currency and Finance* (1913) Keynes praised the Indian monetary system for its economizing on precious metals but blamed it for its seasonal inelasticity. As evidence of that inelasticity, he remarked on the regular, seasonal pattern in interest rates from 1900 to 1913. Interest rates reached an annual maximum of approximately 8% in February or March and a minimum of 3% in August or September each year. Keynes contrasted this pattern with that in UK interest rates.

At the same time, India maintained the sterling value of the rupee within a narrow band, under its gold-exchange standard. How could this exchange-rate band have been consistent with the wide range in relative monetary conditions in the two countries? The two main elements of target-zone models – a linear, asset-pricing equation and uncovered interest parity – can link these characteristics.

This paper describes a target zone with fundamentals (relative velocity) on a Markov chain, to keep the analysis as simple as possible. It shows, first, that, given a range for fundamentals, the greater is their negative autocorrelation the *narrower* is the exchange-rate band. Conversely, a given exchange-rate band is consistent with a wider range for fundamentals if those fundamentals are negatively autocorrelated. Second, the greater is the negative autocorrelation in fundamentals the *wider* is the range of the international interest-rate differential relative to the exchange-rate band. Ranges for the exchange rate and the interest-rate differential are observable (unlike fundamentals) and thus can be linked to provide an informal test of the model.

Section I outlines a simple model of a target zone on a Markov chain. Section II applies the results to the operation of the gold-exchange standard in India, as described by Keynes.

I. A Discrete-State Target Zone

Consider the two main economic elements in recent target-zone models: a linear, asset-pricing relationship and uncovered interest parity. First, the asset-pricing relationship relates the log exchange rate e to a fundamental f and the expected rate of change of the exchange rate:

$$e_t = f_t + \alpha E_t(e_{t+1} - e_t), \quad \alpha > 0 \tag{1}$$

where E is the expectations operator. In the application e will be the log of the rupee price of sterling.

Second, the uncovered interest parity (UIP) condition is:

$$\delta_t \equiv r_t - r_t* = E_t(e_{t+1} - e_t), \tag{2}$$

in which r is the domestic (Indian) interest rate and $r*$ the foreign (UK) rate. Combining equations (1) and (2) gives:

$$\delta_t = \frac{e_t - f_t}{\alpha}, \tag{3}$$

which yields the interest differential, once the exchange rate is found as a function of the fundamental.

Target-zone models have f evolve in continuous time and on a continuous state space. That has obvious appeal, but it means that analytical solutions for e and δ can be found only for certain processes. The argument here requires a process for f with negative autocorrelation. The simplest way to obtain that is to use a Markov chain. This characterization makes it very easy to derive some standard properties of target zones as well as isolate novel ones which follow from the negative autocorrelation in fundamentals.

Suppose that a fundamental f_t $(t = 1, 2, 3\ldots)$ can take on one of two values $\overline{f}$ (in summer) and $\underline{f}$ (in winter), with $\overline{f} > \underline{f}$. The fundamental follows a symmetric Markov chain, with 2×2 transition matrix P. From each state there is probability $1-p$ of remaining in that state and probability p of switching, so that

$$P = \begin{pmatrix} 1-p & p \\ p & 1-p \end{pmatrix}.$$

With this parametrization the first-order autocorrelation coefficient of f_t is $\rho = 1 - 2p$, so that $p = 0.5$ gives the iid case and $p > 0.5$ gives negative autocorrelation. With finite support for fundamentals, direct, probabilistic methods can be used to calculate the induced finite support for exchange rates.

One example of a fundamental is the one implied by the monetary model of the exchange rate:

$$f = m - y - (m * - y*), \tag{4}$$

where m is the money supply, y is income, and stars signify foreign variables. This example of a fundamental illustrates a general point: negative autocorrelation could result from economic activity or from intervention or both. Historically the intervention policy (m) seems not to have been seasonal while the underlying activity (y) was. What is random in this example is of course not the change of season but the severity of the monsoon and hence the shock to velocity. However, while the autocorrelation of f matters to the argument here the precise identity of f does not.

To solve for the exchange rate, note that, without bubbles, equation (1) implies:

$$e_t = \frac{1}{1+\alpha} \sum_{i=0}^{\infty} E_t \left(\frac{\alpha}{1+\alpha}\right)^i f_{t+i}. \tag{5}$$

The exchange rate can take on two values, one for each initial state. Denote them $\bar{e}$ and $\underline{e}$. Tracing the possible paths for the fundamental, and weighting each path by its probability to calculate the expectation in equation (5) gives:

$$\begin{aligned} (\bar{e} \quad \underline{e})' &= \frac{1}{1+\alpha}\left[(\bar{f} \quad \underline{f})' + \left(\frac{\alpha}{1+\alpha}\right)P(\bar{f} \quad \underline{f})' + \left(\frac{\alpha}{1+\alpha}\right)^2 P^2(\bar{f} \quad \underline{f})' + \ldots\right] \\ &= \frac{1}{1+\alpha}\left[I_2 - \frac{\alpha}{1+\alpha}P\right]^{-1} (\bar{f} \quad \underline{f})', \end{aligned} \tag{6}$$

in which I_2 is a 2×2 identity matrix. Then the range of values for the exchange rate is:

$$\bar{e} - \underline{e} = \frac{\bar{f} - \underline{f}}{1 + 2\alpha p}. \tag{7}$$

The expected change in the exchange rate also can be found in each state. At $\bar{e}$, for example, the change may be zero, with probability $1-p$, or may be $\underline{e} - \bar{e}$ with probability p. Combining this with UIP (2) gives

$$\begin{aligned} \bar{\delta} &= p(\underline{e} - \bar{e}) \\ \underline{\delta} &= p(\bar{e} - \underline{e}) \end{aligned} \tag{8}$$

Note that $\bar{\delta} < \underline{\delta}$ so that the differential is smallest in the summer. If the exchange rate is high it is expected to fall (appreciate) so that the interest rate is low relative to the foreign rate.

From the values in equations (7) and (8) the range for the interest-rate differential is:

$$\underline{\delta} - \overline{\delta} = 2p(\overline{e} - \underline{e}) = \frac{2p}{1 + 2\alpha p}(\overline{f} - \underline{f}). \tag{9}$$

An alternative expression for the interest differential can be found by substituting the exchange-rate solution (6) in equation (3). That method gives:

$$(\overline{\delta} \ \ \underline{\delta})' = \frac{1}{\alpha}\left[\frac{1}{1+\alpha}[I_2 - \frac{\alpha}{1+\alpha}P]^{-1} - I_2\right](\overline{f} \ \ \underline{f})'. \tag{10}$$

The interest-rate range can be calculated from this expression as a check on equation (9).

This target zone has many of the standard properties, described by Bertola (1991), Svensson (1991a, 1992), and contributors to Krugman and Miller (1991). For example, the band on f implies bands on e and δ, the exchange-rate band is narrower than the fundamental band (from equation (7)), and there is a negative relation between δ and e.

The Markov chain for fundamentals is an approximation, which can be made richer for empirical work by adding states and allowing asymmetric transitions (see Cox and Miller, 1965). The qualitative properties of the e and δ ranges apply with these generalisations, while the expressions in equations (7) and (9) are specific to the symmetric, two-state example. That example (in which we are always at an edge of the band) does not give interesting distributions for e and δ, but it is the simplest model in which to study the effect of autocorrelation in the fundamental. Moreover, it yields testable predictions which do not require observation of the fundamental f or knowledge of the parameter α.

For a given range of fundamentals increasing p – inducing negative autocorrelation in fundamentals – *narrows* the range of the exchange rate (equation (7)). The reasoning is the same as that in the finding that mean reversion in fundamentals narrows exchange-rate bands, whether it is induced by intervention as in Flood and Garber (1991) or inherent in economic activity as in Froot and Obstfeld (1991), Delgado and Dumas (1991), and Lindberg and Söderlind (1992).

There are two effects on δ of increasing p. First, negative autocorrelation leads to larger expected changes up or down (seen in equation (8)) in e within a given band (because $1 - p$, the probability of no change, is small), which leads to a wider range for δ. Second, though, negative autocorrelation tends to narrow the e-band. Equation (9) shows that the first effect dominates: negative autocorrelation *widens* the range for the interest-rate differential. Adding states or asymmetries will not affect these properties.

All three variables (f, e, and δ) have the same Markov transitions. Thus the transition matrix could be estimated from any one of them. But a simpler way to examine evidence is to use the link between the observed ranges for the exchange rate and the interest-rate differential. The ratio of the δ-range to the e-range is $2p$. The band for the interest differential can be wider than the band for the exchange rate only if $p > 0.5$ so that there is negative autocorrelation. The next section examines these variables for the case of India and the U.K., 1893–1913.

II. Indian Currency

By 1893 a decline in the price of silver had made the Indian government's gold obligations in London (the 'Home Charges') very expensive. The government stopped the free mintage of silver and the silver rupee, legal tender and the principal medium of exchange, became inconvertible. By 1899 the rupee had appreciated to 1*s* 4*d* (16 old pence, with 12 pence, denoted *d*, in a shilling, denoted *s*) and the government was operating an unofficial gold exchange standard at that rate. The government maintained the value of the rupee in a narrow range around this rate through several types of transactions, including sales of Council Bills (described by Malhotra (1960)) in London, direct conversion of rupees into gold sovereigns (at a rate of 15 rupees = 1 £ sovereign = 20 *s*), and occasionally new rupee coinage.

Section I showed that a narrow exchange-rate band may be consistent with a wide range of fluctuation in fundamentals if the fluctuations are negatively autocorrelated. That possibility is of historical interest because such fluctuations were highlighted by Keynes. In the Indian rate of discount, for example,

> annual variations, while perfectly noticeable, are relatively small in comparison with the seasonal changes, which are very great and very regular, and which afford the most clear ground of differentiation between the Indian market and those with which we are familiar in Europe (1913, pp 170-171).

The interest differential thus also was highly seasonal.

One way of removing the seasonality in Indian interest rates might have been to fix the exchange rate.

> Let us suppose that the exchange between London and Calcutta were fixed at 1s 4d, in the sense that the government were always prepared to provide telegraphic remittance *in either direction* at this rate. Under such circumstances, the London and Indian money markets would become practically one market, and the large differences which can now exist between rates current in the two centres for loans on similar security would become impossible (p 174).

But Keynes argued against this possibility because of the very large reserves he estimated would be required. Indeed in *A Treatise on Money* (1930, volume II, chapter 36, part iii) Keynes later argued in favour of widening gold points to enhance national interest-rate autonomy. His solution therefore was for the Indian government (through the presidency banks) to make loans during harvest seasons and hence make the money supply seasonally elastic.

The aim of this section is informally to guage the consistency of the historical ranges for δ and e with the target-zone model, given the negative (seasonal) autocorrelation in the interest differential. As to the exchange-rate band, Keynes (1913, p 5) noted the monetary arrangements meant "in practice that the extreme limits of variation of the sterling value of the rupee are 1s $4\frac{1}{8}d$ and 1s $3\frac{29}{32}d$." Decimalizing, inverting, and taking logarithms gives $\overline{e} = -2.7667$ and $\underline{e} = -2.7804$ so that $\overline{e} - \underline{e} = 0.0137$. Thus the width of the band was 1.37 percent of the level of the exchange rate. For this exchange-rate band, Table 1 gives the predicted range for the interest-rate differential for various values of ρ (the autocorrelation) and hence p (the transition probability parameter). The last column is the predicted range for the interest-rate differential under the symmetic, two-state example. Different numerical ranges would result from alternative transition matrices, though the ranges still would increase as ρ decreased.

To compare these predicted ranges with actual ranges for δ one ideally would measure r and $r*$ in the same place on assets of the same maturity and with the same issuer. Fisher (1930, pp 403-407) did this for Indian government bonds in London, and found evidence of UIP, but his data are at annual frequency. Market bill rates on rupee-denominated debt are difficult to collect on a consistent basis at high frequency.

An alternative way to provide some evidence on the within-year range for δ is to compare interest rates set by the authorities in each country. Table 2 lists each country's discount rate for the last week in February and the last week in August for 1893–1913. These are the months in which, Keynes noted, the Indian discount rate reached its annual maximum and minimum respectively, and so these measurements should give the maximum range for the differential, given the lesser seasonality in the UK Bank rate. The two discount rates applied to infrequent advances of approximately two weeks, whereas one can think of t as counting six-month periods from summer to winter and so on. As an approximation, one may think of the rates as six-month rates and then divide their difference by two to measure δ, because the rates are quoted on an annual basis. The average season-to-season range for δ is 2.00 percent.

As a test, one may see whether this average range and the autocorrelation in the differential are jointly consistent with the range for e noted by Keynes. For differentials sampled in February and August the first-order autocorrelation coefficient is $\rho = -.6$ which implies $p = 0.8$ and an interest-differential range of 2.19. This predicted range is close to the historical average range, and is shown in bold type in Table 1. The results are virtually the same with data for 1898–1913, which exclude the transition to the gold exchange standard. Compared to six-month rates, short-term discount rates may overstate the range for the differential, but also may overstate the negative autocorrelation; thus more accurate measurements might lie slightly further up in Table 1.

Table 2 also lists telegraph exchange rates between Calcutta and London. These rates must be viewed sceptically, for most foreign exchange transactions were in bills of exchange rather than in cable transfers. This distinction is well-known in research on the pre-war dollar-sterling exchange (see for example Officer (1986)). Nevertheless, the exchange rate generally was lower (the rupee more valuable) in February than in August, so that $\overline{e} > \underline{e}$, as one would expect from UIP.

However, some characteristics of the telegraph rates are inconsistent with the simple target-zone model here. For example, the rates are mildly positively autocorrelated. And the exchange rates and interest differentials allow one to reject credibility of the zone using Svensson's (1991b) UIP-based test. Adding the interest differential to the current exchange rate gives an expected future exchange rate which often lies outside the band, when the differential is assumed to apply over a horizon of six months. An even simpler test, similar to one used by Morgenstern (1959), is to compare δ to 1.37 percent which was the width of the band, and hence the maximum depreciation, according to Keynes. The February differential in the discount rates, viewed (perhaps problematically) as six-month rates, often exceeded 2 percent.

More frequent and accurate measurements of δ (using market interest rates with six-month horizon) and e (using bills of exchange) would allow further tests of this approach. For example, one could see whether the weekly exchange rate was in the band described by Keynes, guage the correlation between e and δ, and study the seasonal patterns in detail. But the evidence so far on the range for δ and its autocorrelation seems roughly consistent with the theory given the historical range for e.

As usual in target-zone models, misspecification could arise if investors believed that the Indian authorities might suspend or limit convertibility of the rupee. For example, the credibility of the 1893–1913 arrangements may have been affected by frequent investigations into the Indian currency question, such as that of the Fowler Commission of 1898, which recommended a gold standard.

III. Conclusion

A simple target-zone model can explain the conjunction of wide, seasonal variation in an international interest-rate differential and a narrow exchange-rate band. Both features were characteristic of Indian monetary arrangements during 1893–1913. The idea that negative autocorrelation may make narrow exchange-rate bands consistent with large interest-rate differentials may be relevant also to contemporary exchange-rate policy. For example, Williamson (1992) argued that the ERM could be preserved, despite the shock of German reunification, by applying this principle. He suggested a one-time DM appreciation outside the band with a commitment to a subsequent, gradual depreciation. This saw-tooth pattern for the exchange rate might have been consistent (by UIP) with interest rates in other countries remaining below those in Germany or at least lower than otherwise.

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Table 1: Predicted Interest-Differential Range (%)

$$\underline{\delta} - \overline{\delta} = 2p(\overline{e} - \underline{e})$$

$$\overline{e} - \underline{e} = 0.0137$$

ρ	p	$\underline{\delta} - \overline{\delta}$ (%)
0.9	0.05	0.14
0.6	0.20	0.55
0.3	0.35	0.96
0.0	0.50	1.37
-0.3	0.65	1.78
-0.6	**0.8**	**2.19**
-0.9	0.95	2.60

Notes: ρ is the first-order autocorrelation of the interest differential δ, p is the corresponding parameter of the transition matrix, and the last column gives the predicted range for δ given p and the range for the exchange rate.

Table 2: February and August Discount Rates and Exchange Rate

	February			August		
	r	$r*$	v	r	$r*$	v
1893	5	2.5	14.6875	4	4	14.6875
1894	9	2.5	13.5625	4	2	13.6875
1895	7	2	12.84375	3	2	13.375
1896	7	2	14.46875	3	2	14.09375
1897	10	3	15.15625	5	2	15.8125
1898	12	3	16	4	2.5	15.875
1899	7	3	16.03125	4	3.5	15.96875
1900	8	4	16.09375	4	4	15.96875
1901	9	4.5	16	4	3	15.96875
1902	8	3	16.09375	3	3	15.90625
1903	8	4	16.09375	3	3	16
1904	7	4	16.09375	3	3	16
1905	7	3	16.03125	4	2.5	16.0625
1906	9	4	16.09375	5	3.5	16.0625
1907	9	5	16.15625	3	4.5	16
1908	9	4	15.90625	3	2.5	15.84375
1909	8	3	15.90625	3	2.5	15.875
1910	6	3	16.0625	3	3	16.03125
1911	8	3.5	16.09375	3	3	16
1912	8	3.5	16.125	3	3	16.03125
1913	7	5	16.03125	5	4.5	16.03125

Notes: r is the discount rate at Calcutta, $r*$ is Bank rate, and v is the value of the rupee in pence. The exchange rate is $e{=}ln(1/v)$. Observations are for the last week of the month. Source: *The Economist.*