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A PEEK INTO THE GOVERNOR'S CHAMBER: THE ISRAELI CASE

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The paper analyzes the rules used by the Bank of Israel (BoI) to set the interest rate from mid-1993 till the end of 2001, after relative price stability had been achieved. Our approach follows the analytical framework developed since the influential contribution of Taylor (1993). We compare three policy type rules: the classic Taylor type, the interest rate parity type and the domestic real interest rate type. We give a positive answer to the question; can the path of the interest rate in Israel be explained by a well-defined policy rule? And conclude that the BoI followed a strict, forward-looking rule with smoothing based on interest rate parity considerations, including strong reaction to exchange-rate shocks. The success of reducing inflation by applying extremely tight monetary policy is exemplified in the Israeli case although our analysis shows that the disinflation process was not fully completed in the sample period, in the sense that the rate of interest did not return to a steady state level consistent with low inflation and low real rates of interest.

The purpose of this paper is to analyze the rule(s) used by the Bank of Israel (hereafter BoI) to set the interest rate from mid-1993, when the BoI started announcing an official interest rate, till the end of 2001, after relative price stability had been achieved (Figure 1). Our approach follows the analytical framework developed since the influential contribution of Taylor (1993). The central question we ask is: can the path of the interest rate in Israel be explained by a well-defined policy rule? We address two additional issues, the stability of the policy rule and its properties.

The rate of inflation in Israel declined sharply during the period examined. The period started with a persistent step-like annual rate of inflation of 10 percent (Liviatan and Melnick, 1999), and ended with relative price stability illustrated by zero inflation during the year 2000 (Figure 2).

During this period the BoI followed an inflation-targeting type regime. This regime was adopted gradually and started as a necessary by-product of the introduction of a diagonal exchange-rate band at the beginning of 1992. The slope of the exchange-rate band was designed to represent the difference between domestic inflation and inflation abroad, so that the announcement of the exchange-rate band required a parallel announcement of the expected/target domestic inflation rate (Ben-Bassat 1995). Only in July 1993 did the BoI start announcing an official interest rate. It took more than a year, before a distinct shift towards a proper inflation-target regime was observed towards the end of 1994.

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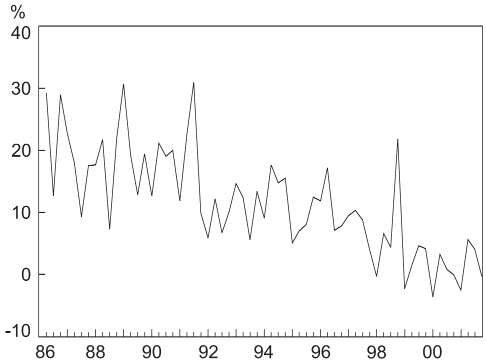
Figure 1
The Bank of Israel Interest Rate, July 1993–December 2001

Figure 2
The Rate of Inflation,[a] 1986–2001



[a] CPI, quarterly rate of change expressed in annual terms.

Prior to 1994, from the stabilization program of 1985, the interest rate in conjunction with direct intervention in the foreign exchange market was used to influence the nominal exchange rate that served as the nominal anchor of the system (Bruno, 1993). The shift to full inflation targeting took place during 1995/6. In 1995 the BoI continued its intervention in the foreign exchange market, controlling the deviation of the nominal exchange rate from the midpoint of the exchange-rate band. Only in 1996 did the BoI adopt a complete nonintervention policy as long as the exchange rate does not reach the limits of the exchange-rate band.

The move towards a more flexible exchange-rate regime after 1996 was continuous (Figure 3 and Table 1). The exchange-rate band was widened and the exchange-rate market was developed, allowing larger fluctuations of the rate of exchange in response to market forces, parallel to liberalization of the foreign exchange market and of the capital account. The slope of the lower limit of the exchange-rate band continued to be set in accordance with the inflation target.

This process was not free of problems regarding the effectiveness of the inflation-targeting regime. Sokoler (2000) illustrates the conflict between the exchange rate and the inflation-targeting regime. As the exchange-rate band widened, the conflict diminished, the exchange-rate regime came closer to a floating one and the inflation-targeting regime improved.

The paper is organized in six sections. In Section 1 we discuss the specification of the policy rules, and define three theoretical specifications; the Taylor type, the interest rate parity type and the domestic real rate type. In Section 2 we present the data and the measurement of the different variables.

Figure 3
The Exchange Rate and the Exchange-Rate Band, July 1993–December 2001

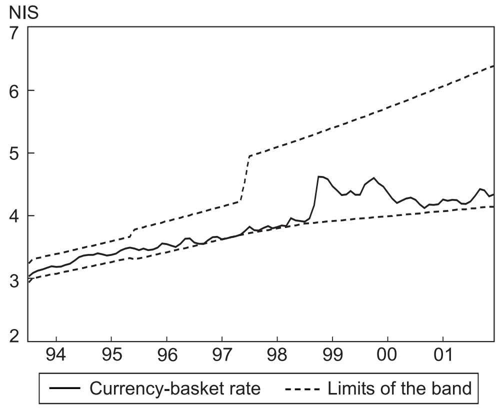


Table 1
Inflation, Inflation Targets and Exchange-Rate Policy (percent)

Year	Rate of inflation[1]	Lower limit of inflation target range	Upper limit of inflation target range	Rate of devaluation[2]	Deviation of exchange rate[3]	Width of the band[4]	Slope of band's lower limit	Slope of band's upper limit
1993	11.2	10	10	8.1	1.3	10	8	8
1994	14.5	8	8	5.4	1.2	10	6	6
1995	8.1	8	11	5.8	1.5	10	6	6
1996	10.6	8	10	3.0	1.3	14	6	6
1997	7.0	7	10	3.7	3.4	14	6	6
1998	8.6	7	10	20.6	6.0	34	4	6
1999	1.3	4	4	–2.5	1.6	38	2	6
2000	0.0	3	4	–6.3	2.3	43	2	6
2001	1.4	2.5	3.5	3.7	1.2	49	2	6

[1] Percent change of the CPI, during the year.
[2] Percent change of the basket exchange rate during the year.
[3] Standard deviation of the monthly basket exchange rate from the midpoint of the exchange-rate band during the year.
[4] Beginning of the year.

In Section 3 we compare the policy rules, evaluate their performance and test their stability. In Section 4 we obtain econometric estimates of the policy rules following the conclusions drawn in Section 3, and select the specification that best fits the actions of the Bank. Section 5 is devoted to discussing the properties of the BoI rule, and Section 6 concludes.

1. THE POLICY RULES SPECIFICATION

In the specification of the policy rules we use the following notation:

- i BoI interest rate
- i^* Interest rate abroad
- π Inflation rate
- π^* Inflation rate abroad
- π^T Inflation target
- π^e Expected inflation
- y Output gap
- r Real interest rate

α, β, γ, δ and ρ are parameters

1.1 Taylor-type policy rules

Our first approach follows the classic Taylor (1993) rule where the interest rate is a function of the difference between the rate of inflation and a 2 percent annual target (a state considered as long-run price stability) and the output gap. Applying a Taylor-type rule in Israel requires

that several issues be addressed. a) Should we adopt a backward-looking approach, as in Taylor, or a forward-looking one as required in a non-stationary disinflation process? The forward-looking inflation approach is operationally attractive in Israel given the existence of direct measures of expected inflation. b) How should we define the inflation target? As constant long-run price stability as in Taylor, denoted here the classic approach, or given the fact that Israel was in a disinflation process, should we use the current declared inflation target (Table 1), denoted here as targeting? c) Should we ignore interest-rate smoothing, as in Taylor, or apply it, as indicated by Sack (1998) and Woodford (1999)? d) Should we consider the impact of the output gap as in Taylor, or ignore it, and thus use a strict policy rule? All these issues are addressed here empirically. Formally, the policy rules are:[1]
Classic,

(1) $i = \alpha + \beta(\pi - \pi^T) + \gamma y.$

With smoothing,

(2) $i = (1-\rho)(\alpha + \beta(\pi - \pi^T) + \gamma y) + \rho i_{-1}.$

Strict,

(3) $i = \alpha + \beta(\pi - \pi^T).$

Strict with smoothing,

(4) $i = (1-\rho)(\alpha + \beta(\pi - \pi^T)) + \rho i_{-1}.$

The specification in the classic Taylor rule is: π is backward looking (four quarters moving average of past inflation), $\pi^T = 2$, $\alpha = 4$, $\beta = 1.5$, $\gamma = 0.5$ and $\rho = 0$, i.e., no smoothing. We will consider two variations of the specification: a forward-looking inflation, $\pi = \pi^{e,}$ and a current inflation target,[2] $\pi^T = \pi^T_t$. When applying the current inflation target we allow the constant α to depend on the current expected inflation, π^e. These combinations yield sixteen different Taylor-type policy rules. In the cases with smoothing we set $\rho = 0.75$.

1.2 Interest rate parity type policy rules

The second approach is based on interest rate parity. Given that Israel is a small open economy it is not unreasonable to base the interest rate policy rule on interest rates and inflation rates abroad. When interest rate parity holds, the domestic real rate equals the real rate abroad plus a possible additional differential risk premium. Thus the domestic interest rate converges to the sum of the real rate abroad, the domestic inflation rate and the differential risk premium. Formally, the policy rules are:
Parity,

[1] Two measures of inflation are considered in the inflation gap. A backward - looking inflation during the previous 12 months, and a forward - looking expected inflation for the next 12 months as obtained from the capital market.

[2] See Svensson (1997).

(5) $i = \delta + (i^* + \pi - \pi^*) + (\beta - 1)(\pi - \pi^T) + \gamma y.$

With smoothing,

(6) $i = (1-\rho)(\delta + (i^* + \pi - \pi^*) + (\beta - 1)(\pi - \pi^T) + \gamma y) + \rho i_{-1}.$

Strict,

(7) $i = \delta + (i^* + \pi - \pi^*) + (\beta - 1)(\pi - \pi^T).$

Strict with smoothing,

(8) $i = (1-\rho)[\delta + (i^* + \pi - \pi^*) + (\beta - 1)(\pi - \pi^T)] + \rho i_{-1}.$

The parameter δ represents a differential risk premium. With the same variations on inflation i.e., backward-looking or forward-looking, and on inflation targeting i.e., current or fixed at price stability, we obtain another sixteen policy rules, now of the parity type.

1.3 Domestic real interest rate type policy rules

The third approach is similar to Taylor's but it takes into consideration that the long-term real interest rate may change over time. In the Taylor case the long-term real interest rate is constant, at 2 percent. Here we assume that the domestic interest rate converges to the long term, possibly variable, real interest rate plus the rate of domestic inflation. Formally, the policy rules are:
Domestic real rate,

(9) $i = (r + \pi) + (\beta - 1)(\pi - \pi^T) + \gamma y .$

With smoothing,

(10) $i = (1-\rho)[(r + \pi) + (\beta - 1)(\pi - \pi^T) + \gamma y] + \rho i_{-1}.$

Strict,

(11) $i = (r + \pi) + (\beta - 1)(\pi - \pi^T) .$

Strict with smoothing,

(12) $i = (1-\rho)[(r + \pi) + (\beta - 1)(\pi - \pi^T)] + \rho i_{-1}.$

Again with the same variations on inflation and on inflation targeting, we obtain sixteen additional rules, now of the domestic rate type.

2. THE DATA

Our sample consists of monthly Israeli data from July 1993, when the Bank of Israel started announcing an official interest rate, to November 2001, after three years of relative price stability[3] (Table 1). The relatively high frequency of monthly interest-rate changes requires monthly estimation.

The inflation target in Israel was declared, in most cases, as a range, see Table 1. To use an analytical rule we assume that the BoI used the midpoint of the range as its operational reference target. The target was declared for the rate of change of the CPI during the calendar year. We transformed this discrete target into a continuous one for a year ahead, by constructing an imaginary price-index target that evolves from January to December of each year at a constant monthly rate consistent with the annual target. The inflation target for each month, π^T_t, is computed by calculating the rate of change of the imaginary price index target[4] for one year forward (Figure 4).

In the backward-looking inflation approach we used the rate of inflation in the past twelve months (this is similar to Taylor's four quarters moving average approach). For the forward-looking approach we take advantage of the fact that in Israel the government issues both indexed and unindexed bonds, so their market differential rates of return allow for a measure of inflationary expectations, π^e (Yariv, 1990, 2000).

For the real interest rate we use the real rate of return on long-term (10-year) indexed government bonds. The interest rate abroad, i*, is measured by the federal funds rate, and for inflation abroad, π^*, we use the inflation rate in the USA in the previous twelve months.

Finally, the monthly output gap, y, is calculated using the seasonally adjusted quarterly GDP (Figure 5). To obtain a

Figure 4
The Inflation Target, July 1993–December 2001

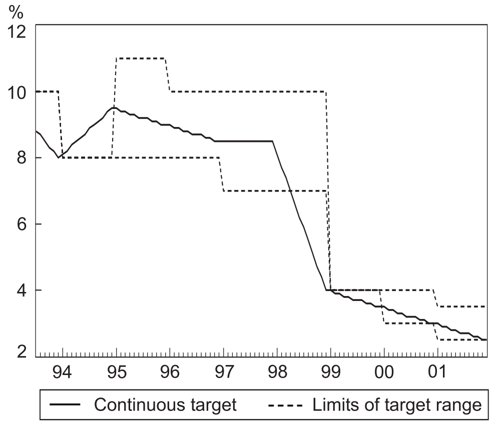


Figure 5
The Output Gap, July 1993–December 2001

[3] In December 2001 the Bank of Israel broke its policy rule in the context of a political package deal with the government.

[4] The inflation targets were announced on irregular dates; our measure assumes that the BoI acted as if it knew the following year's target range. This is not unreasonable given that the government set the targets in close consultation with the Bank.

monthly GDP we assume a constant monthly rate of change between the middle months of the respective quarters, which is consistent with the quarterly rate of change. Potential output in this period is assumed to grow at a constant 4.5 percent annual rate (for other measures of the output gap that yield similar results, see Menashe and Yachin, 2002 and Elkayam et al., 2002). We assume that in 1995 there was no output gap (see BoI annual report 1996 p. 30).

3. EVALUATION OF POLICY RULES

In this section we organize a 'horse race' between the forty-eight rules defined in Section 2. In calculating the interest rate for month t in all the different rules, we used information that is available to the decision maker, which is data up to month t-1.[5] The purpose of this race is to obtain a preliminary evaluation of the BoI practice in setting the interest rate.

For each rule we compute the implicit interest rate and calculate the mean, the standard deviation, the correlation with the actual BoI rate, the root mean square error, the mean absolute error, the mean absolute percent error, the Theil inequality coefficient, and we perform a Theil decomposition.

An empirical comparison of the policy rules is presented in Appendix 1. The results for the Taylor-type policy rules are presented in Table 1A, those for the interest rate parity type rules in Table 2A, and those for the domestic real rate type rules in Table 3A.

A number of general conclusions are easily seen:

1. Rules with forward-looking expectation perform better than rules with backward-looking inflation. We conclude that in setting the interest rate the BoI followed a forward-looking rule, using inflationary expectations computed from the capital market.
2. Rules with smoothing perform better than rules without smoothing. Rules without smoothing produce variation in the interest rate that is on average twice the actual variation. We conclude that the BoI applied smoothing in setting the interest rate.
3. Rules that follow the current inflation target perform better than rules defined in terms of long-run price stability. We conclude that the BoI followed the current announced inflation target.
4. Strict rules, i.e., rules that ignore the output gap, perform better than rules that take the output gap into consideration. We conclude that the BoI focused its monetary policy on achieving the inflation target, ignoring the cyclical position of the economy.

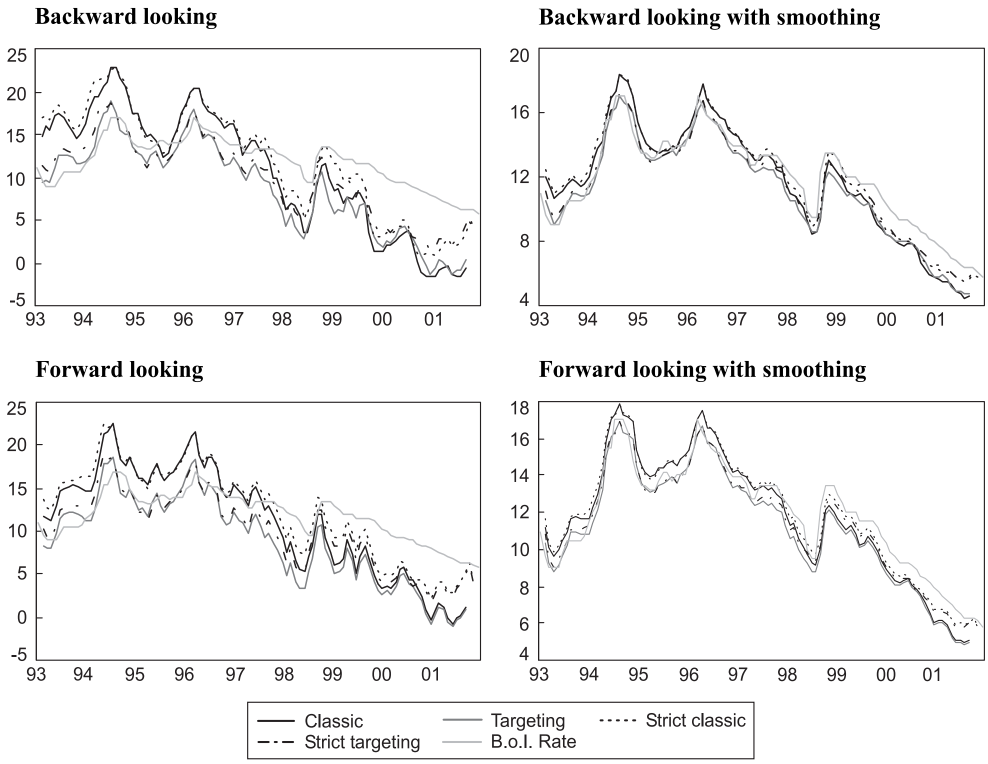
When comparing the different rules we find that the Taylor-type rules perform worse than the parity and domestic-type rules. This result is probably due to the fact that Taylor-type rules are better suited to a large closed economy, while the other two are more appropriate to small open economies (Ball, 1999). The race between the parity-type rules and the domestic rate type rules is very close and does not at this stage result in a clear winner.

The best rules, for the time being, are equations (13), the strict parity-targeting rule with smoothing, and (14), the strict domestic rate targeting rule with smoothing:

(13) $i_t = 0.25*[1.0 + (i^* + \pi^e - \pi^*) + 0.5*(\pi^e - \pi^T_t)] + 0.75*i_{t-1}$.

[5] The BoI announces the rate of interest, for month t, in the last week of month t-1.

Figure 6
The Taylor Type Policy Rules, July 1993–December 2001



(14) $i_t = 0.25*[(r + \pi^e) + 0.5*(\pi^e - \pi^T_t)] + 0.75*i_{t-1}$.

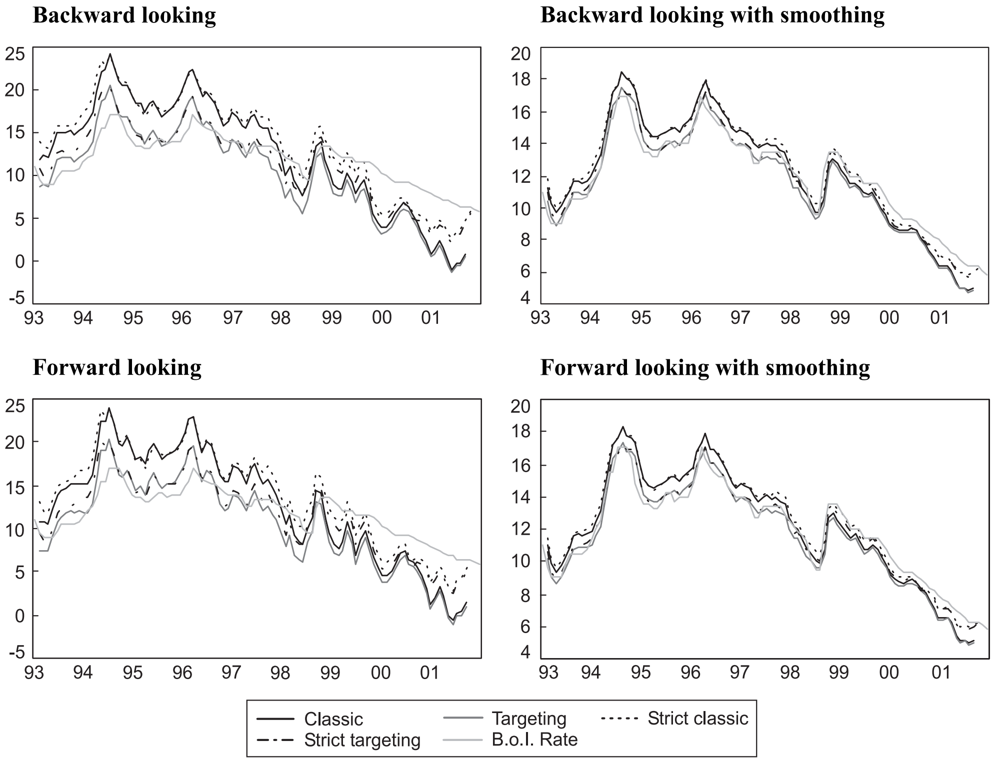
We turn now to the issue of stability. In Figures 6 to 8 we plot the calculated policy rules against the actual BoI interest rate.

A stylized fact is immediately observed; the rules underestimate the rate of interest in the last portion of the sample. In most cases it easy to see that during 1997-98 there was a shift in the way the BoI set its interest rate. To test this hypothesis formally we perform a Chow test for change in the mean of the difference between the BoI interest rate and the rate predicted by each of the rules; the results are presented in Table 2.

To estimate the date of the structural change we perform a search for the month that yields the highest t value; the search yields a maximum likelihood estimate of the date. A similar procedure was used in Liviatan and Melnick (1999) to find structural breaks in the inflation process.

For all the policy rules we find a statistically significant change in the mean. In all cases the difference is positive after the break, i.e., the rules underestimate the interest rate, and

Figure 7
The Interest Rate Parity Policy Rules, July 1993–December 2001



for most of them it is negative before the break, i.e., the rules overestimate the interest rate. The earliest date for which we found a structural break was January 1997 and the latest was March 1998.

We propose four possible explanations for the structural change we discovered in the behavior of the BoI:

1. The BoI failed to discover, in real time, a step-like drop in the rate of inflation that occurred in the last quarter of 1997 (Figure 2). This step-like drop in the rate of inflation was documented in Liviatan and Melnick (1999). It is possible that the BoI waited to see if this was a permanent phenomenon.
2. It is possible that the price shock in the last quarter of 1998, which was due to a large devaluation of the NIS rate, was confused with an inflation shock, leading to a prolonged period of monetary restraint.
3. It is possible that a sharp rise of the interest rate in response to the exchange-rate shock of 1998, together with the relatively large rate of smoothness, led to a prolonged period where the actual interest rate was much higher than the rate required for the long run.

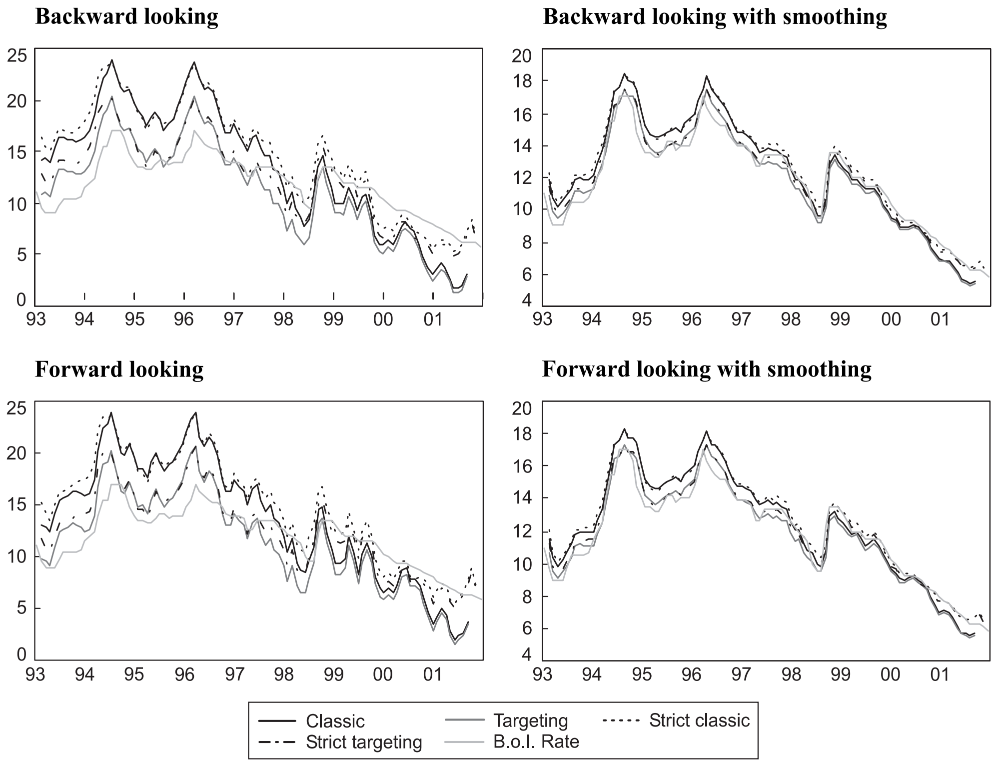
Table 2
Test for Structural Change[1], July 1993–September 2001

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Taylor type – backward-looking expectations								
Date[2]	Nov–97	Oct–97	Nov–97	Aug–97	Dec–97	Sep–97	Nov–97	Aug–97
Mean before	–3.2	0.3	–0.8	0.1	–3.7	–0.2	–0.9	0.0
Mean after	6.1	6.3	1.4	1.4	4.1	4.2	0.9	0.9
t statistic	19.2	18.4	16.3	15.8	14.7	12.4	12.6	10.7
Panel B: Taylor type – forward-looking expectations								
Date[2]	Dec–97	Oct–97	Dec–97	Aug–97	Dec–97	Jan–97	Feb–98	Aug–97
Mean before	–2.8	0.4	–0.7	0.1	–3.4	–0.5	–0.8	0.0
Mean after	5.0	6.0	1.1	1.4	2.9	3.6	0.6	0.9
t statistic	21.5	17.1	19.5	15.5	17.4	12.2	15.8	10.6
Panel C: Parity type – backward-looking expectations								
Date[2]	Feb–98	Dec–97	Feb–98	Feb–98	Feb–98	Dec–97	Feb–98	Feb–98
Mean before	–4.1	–0.8	–1.0	–0.1	–4.6	–1.4	–1.1	–0.3
Mean after	3.7	4.6	0.8	1.1	1.6	2.5	0.3	0.5
t statistic	20.6	16.4	17.9	13.5	17.7	12.2	15.1	9.7
Panel D: Parity type – forward-looking expectations								
Date[2]	Feb–98	Dec–97	Mar–98	Feb–98	Feb–98	Jan–98	Mar–98	Feb–98
Mean before	–4.0	–0.7	–1.0	–0.1	–4.6	–1.2	–1.1	–0.3
Mean after	3.3	4.2	0.7	1.0	1.2	2.2	0.2	0.4
t statistic	18.5	14.1	16.8	12.2	16.4	10.8	14.7	8.9
Panel E: Domestic rate type – backward-looking expectations								
Date[2]	Oct–97	Sep–97	Aug–97	Aug–97	Oct–97	Jan–97	Aug–97	Aug–97
Mean before	–5.0	–1.6	–1.2	–0.4	–5.5	–2.5	–1.4	–0.5
Mean after	2.2	3.3	0.4	0.7	0.1	1.1	–0.1	0.2
t statistic	22.1	17.7	17.4	13.3	17.5	12.4	13.8	8.5
Panel F: Domestic rate type – forward-looking expectations								
Date[2]	Oct–97	Sep–97	Oct–97	Aug–97	Oct–97	Jan–97	Aug–97	Aug–97
Mean before	–4.9	–1.5	–1.2	–0.4	–5.4	–2.4	–1.3	–0.5
Mean after	1.8	2.9	0.3	0.6	-0.3	0.7	–0.2	0.1
t statistic	20.1	15.3	16.5	12.2	16.8	11.7	13.7	7.8

[1] Test for the mean of the difference between the Bank of Israel interest rate and the interest rate predicted by each of the policy rules. The rules are; (1) Classic, (2) Targeting, (3) Classic smooth, (4) Targeting smooth, (5) Classic strict, (6) Targeting strict, (7) Classic smooth strict and (8) Targeting smooth strict.
[2] The date is identified by an iterative procedure that searches for the maximum value of the *t* statistic; the procedure yields the maximum likelihood of the structural change date.

4. In all cases we assumed that the BoI acted as if it were trying to achieve the midpoint of the inflation target range. It is possible that after 1997-98 the BoI tried to achieve a more ambitious target (Table 1). This would be reflected in a higher path for the required interest rate.

Figure 8
The Domestic Interest Rate Policy Rules, July 1993–December 2001



4. THE ESTIMATION OF POLICY RULES

We now turn to an econometric approach. Bufman and Bar-Efrat (2002) and Leiderman and Bar-Or (2002) estimated interest-rate policy rules for Israel. In their studies the specification is determined on purely statistical grounds, i.e., the statistical significance of the variables and the lags they consider in the estimation. It is thus difficult to interpret their results on a theoretical level. Our approach is different; we follow Sack (1998) and Rudebusch (2001) who specify their estimated policy rule following well-defined theoretical specifications. The specification of our estimated equations closely follows the specifications of the three policy-rule types we are studying, the Taylor type, the interest rate parity type and the domestic real interest rate type.[6] Given the results we discussed in Section 3, we estimate only rules that are forward looking and follow the current inflation target. Equations without smoothing are not presented since they suffer from very high serial correlation. Two lags of the interest rate were needed to eliminate the serial correlation of the residuals. All the equations are

[6] We experimented with the inclusion of the expected output gap as in Clarida, Gali and Gertler (2000) but in no case did this turn out statistically significant.

tested for structural stability by a Chow test at the date estimated by the search procedure discussed in Section 3. We define an exchange-rate shock as an increase in the currency-basket exchange rate larger than two standard deviations of its monthly rate of change; this variable is denoted by 'Shock.' For each equation the variable Dum97 is equal to 1 after the date of structural change identified in Section 3, and 0 before.

The estimation of the Taylor-type rules is presented in Table 3.

Our conclusions are:

1. The output gap is not statistically significant, reinforcing our conclusion that the BoI used a strict policy rule, i.e., itignored the real position of the economy (Equation 2 in Table 3).
2. The equation is not structurally stable (Equations 1 and 2 in Table 3).
3. Introducing the dummy variable (Dum97) solves the instability. This indicates a shift in the policy rule after 1997–98, towards a strengthening of monetary restraint (Equation 3 in Table 3).

Table 3
Estimation of the Taylor-Type Policy Rule, 1993.08–2001.11

	(1)	(2)	(3)	(4)	(5)
Constant	1.10[a]	1.38[a]	0.49	–0.08	0.94[a]
	(0.00)	(0.00)	(0.05)	(0.86)	(0.00)
Shock			1.42[a]	1.32[a]	1.25[a]
			(0.00)	(0.00)	(0.00)
Dum97			0.39[a]	0.41[a]	0.10
			(0.01)	(0.01)	(0.56)
π^e_{t-1}	0.08[a]	0.07[a]	0.15[a]	0.34[a]	–0.04
	(0.00)	(0.01)	(0.00)	(0.02)	(0.58)
$\pi^e_{t-1} - \pi^T_{t-1}$	0.17[a]	0.18[a]	0.08[a]	0.05	0.12[a]
	(0.00)	(0.00)	(0.04)	(0.21)	(0.00)
y_{t-1}		0.02			
		(0.56)			
i_{t-1}	1.03[a]	1.02[a]	1.03[a]	1.00[a]	0.98[a]
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
i_{t-2}	–0.19[a]	–0.19[a]	–0.19[a]	–0.20[a]	–0.20[a]
	(0.02)	(0.01)	(0.01)	(0.00)	(0.00)
$r_{t-1} + \pi^e_{t-1}$				0.14	
				(0.18)	
$i^*_{t-1} + \pi^e_{t-1} - \pi^*_{t-1}$					0.17[a]
					(0.00)
R^2	0.980	0.979	0.987	0.987	0.988
LM	1.75	1.25	0.92	0.80	0.21
	(0.18)	(0.29)	(0.40)	(0.45)	(0.81)
Chow test	3.4[a]	3.0[a]			
	(0.01)	(0.01)			

The dependent variable is the rate of interest for month *t*, all the explanatory variables are known at t-1. p values are given in parentheses. LM is the Breuch-Godfrey serial correlation test.

[a] Significant at five percent.

4. The exchange-rate shocks are statistically significant. This indicates that large increases of the interest rate follow large exchange-rate shocks (Equations 4 and 5 in Table 3).
5. The Taylor specification is rejected since both $r + \pi^e$ and $i^* + \pi^e - \pi^*$ are statistically significant when added to it (Equations 4 and 5 in Table 3).

The estimation of the domestic interest rate type rules is presented in Table 4.
Our conclusions are:

1. The hypothesis that the coefficients of r and π^e are equal is not rejected. This indicates convergence of the nominal rate to $r + \pi^e$ in the long run (Equation 1 in Table 4).
2. Again, the output gap is not statistically significant (Equation 3 in Table 4).
3. The equation is not structurally stable (Equations 1 and 2 in Table 4).

Table 4
Estimation of the Domestic Interest Rate Type Policy Rule, 1993.08–2001.11

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.04 (0.93)	0.60[a] (0.01)	0.76 (0.07)	–0.64 (0.11)	–0.36 (0.33)	1.08 (0.08)
Shock					1.28[a] (0.00)	1.28[a] (0.00)
Dum97				0.56[a] (0.00)	0.37[a] (0.01)	0.12 (0.46)
r_{t-1}	0.26[a] (0.03)					
π^e_{t-1}	0.17[a] (0.00)					
$r_{t-1} + \pi^e_{t-1}$		0.13[a] (0.00)	0.12[a] (0.00)	0.27[a] (0.00)	0.22[a] (0.00)	–0.04 (0.67)
$\pi^e_{t-1} - \pi^T_{t-1}$	0.11[a] (0.01)	0.13[a] (0.00)	0.14[a] (0.00)	0.06 (0.17)	0.05 (0.26)	0.13[a] (0.01)
y_{t-1}			0.01 (0.65)			
i_{t-1}	1.008[a] (0.00)	1.01[a] (0.00)	1.01[a] (0.00)	0.93[a] (0.00)	1.00[a] (0.00)	0.99[a] (0.00)
i_{t-2}	–0.22[a] (0.01)	–0.21[a] (0.01)	–0.21[a] (0.01)	–0.18[a] (0.02)	–0.21[a] (0.00)	–0.20[a] (0.00)
$\pi^a_{t-1} + \pi^e_{t-1} - i^a_{t-1}$						0.17[a] (0.00)
R^2	0.981	0.981	0.981	0.983	0.987	0.988
Restriction test	c(2)=c(3) 1.24 (0.24)					
L.M.	1.22 (0.30)	1.32 (0.27)	1.35 (0.26)	0.04 (0.96)	0.92 (0.40)	0.23 (0.80)
Chow test	2.90[a] (0.01)	3.47[a] (0.01)	3.37[a] (0.00)			

The dependent variable is the rate of interest for month t, all the explanatory variables are known at t-1. p values are given in parentheses. C(i) is the ith coefficient of the regression. LM is the Breuch-Godfrey serial correlation test.

[a] Significant at five percent.

4. Again, introducing the dummy variable solves the instability of the equation (Equation 4 in Table 4).
5. Again, the exchange-rate shocks are statistically significant (Equations 5 and 6 in Table 4).
6. The domestic interest-rate specification is rejected since $r + \pi^e$ becomes not significant statistically when $i^* + \pi^e - \pi^*$ is added to the equation (Equation 6 in Table 4).

The estimation of the interest rate parity type rules is presented in Table 5.

Our conclusions are:

Table 5
Estimation of the Interest Parity Rate Type Policy Rule, 1993.08–2001.11

	(1)	(2)	(3)	(4)	(5)
Constant	1.07[a] (0.00)	1.24[a] (0.00)	1.38[a] (0.00)	1.07[a] (0.00)	1.04[a] (0.00)
Shock				1.26[a] (0.00)	1.37[a] (0.00)
π^a	0.288 (0.00)				
π^e	0.138 (0.00)	0.13[a] (0.00)	0.12[a] (0.00)	0.12[a] (0.00)	
i^a	–0.22[a] (0.00)				
$\pi^* - i^*$		0.25[a] (0.00)	0.25[a] (0.00)	0.19[a] (0.00)	
$\pi^e + \pi^* - i^*$					0.12[a] (0.00)
$\pi^e - \pi^T$	0.19[a] (0.00)	0.19[a] (0.00)	0.20[a] (0.00)	0.13[a] (0.00)	0.11[a] (0.00)
y_{t-1}			0.02 (0.54)		
i_{t-1}	0.92[a] (0.00)	0.92[a] (0.00)	0.92[a] (0.00)	0.99[a] (0.00)	1.02[a] (0.00)
i_{t-2}	–0.19[a] (0.01)	–0.18[a] (0.01)	–0.18[a] (0.01)	–0.21[a] (0.00)	–0.22[a] (0.00)
R^2	0.985	0.985	0.985	0.988	0.987
Restriction test	c(2)=c(3)=c(4) 4.23[a] (0.02)				
Restriction test	c(2)=c(4) 0.76 (0.37)			c(2)=c(4) 2.85 (0.09)	
L.M.	0.20 (0.82)	0.22 (0.80)	0.23 (0.79)	0.20 (0.82)	0.37 (0.69)
Chow test	0.96 (0.47)	0.44 (0.85)	0.64 (0.72)		

The dependent variable is the rate of interest for month *t*, all the explanatory variables are known at t–1. p values are given in parentheses. LM is the Breuch-Godfrey serial correlation test.

[a] Significant at five percent.

1. Again, the output gap is not statistically significant (Equation 3 in Table 5).
2. The equation does not appear to be structurally unstable (Equation 4 in Table 5).
3. Testing the hypothesis that the coefficients of π^e, i* and - π* are equal is rejected. Testing the hypothesis that the coefficients of i* and - π* are equal is not rejected (Equation 1 in Table 5).
4. Exchange-rate shocks are statistically significant (Equation 4 in Table 5).
5. Again, testing the hypothesis that the coefficients of π^e and i* - π* are equal, after including the exchange-rate-shock variable and omitting other irrelevant variables, it is rejected at p=0.05 but cannot be rejected at p=0.09 (Equation 4 in Table 5).

Our econometric analysis leads to the conclusion that the specification that most accurately represents the BoI policy rule is Equation 5 in Table 5. Except for exchange-rate shocks the equation was stable during the sample period. An alternative way of expressing the short - run policy rule of the BoI is:

$$(15)\quad i_t = 0.20*[\underset{(9.22)}{5.16} + \underset{(4.26)}{6.82}*Shock + \underset{(9.35)}{0.59}*(i^*_{t-1} + \pi^e_{t-1} - \pi^*_{t-1})$$

$$+ \underset{(3.19)}{0.54}*(\pi^e_{t-1} - \pi^T_{t-1})] + \underset{(14.74)}{1.02}*i_{t-1} - \underset{(-3.46)}{0.22}*i_{t-2}$$

The values in parentheses are t values.

Ignoring the exchange-rate-shock variable we obtain the long-run policy rule of the BoI during this period:

$$(16)\quad i = 5.16 + 0.59*(i^* + \pi^e - \pi^*) + 0.54*(\pi^e_{t-1} - \pi^T_{t-1})$$

5. THE PROPERTIES OF THE BOI RULE

Our analysis indicates that during this period the BoI applied a relatively stable policy rule that was influenced by interest parity considerations. We shall discuss the short - and long-run properties of the BoI policy rule.

The BoI applied a relatively large rate of smoothness; the sum of the coefficients of the lagged interest rate is 0.8, inducing strong inertia in the path of the interest rate.

The rate of interest is not sensitive to the cyclical position of the economy, *ceteris paribus*: it does not decrease in slumps and does not increase in booms.

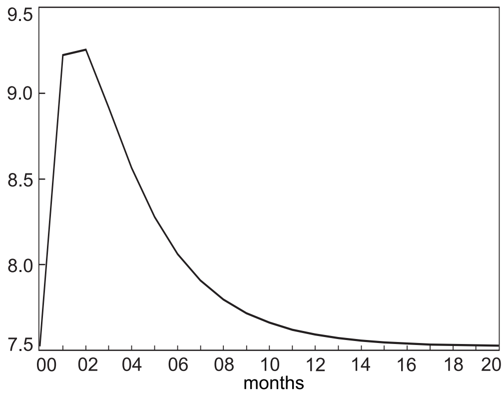
The rate of interest is extremely sensitive to large positive exchange-rate shocks. This property of the reaction function of the BoI should be viewed in the light of the high pass-through coefficient from the exchange rate to the price level; the large degree of openness of the Israeli economy; the high degree of indexation to the exchange rate[7] (Shiffer, 2001), and past traumatic experience from the high-inflation era before the stabilization program of 1985, in which shocks to the level of the exchange rate were translated to higher rates of inflation (Liviatan and Piterman, 1986).

[7] The degree of indexation has declined in the last decade due to the decline in the rate of inflation and devaluation of the NIS.

The combination of these short-run properties of the BoI policy rule led to asymmetric behavior: large positive shocks to the exchange rate were followed by large increases of the interest rate, and due to the high rate of smoothing they led to a prolonged period of high real interest rate. This can be generalized: a temporary, typically positive, shock to the rate of interest is followed by a prolonged period (approximately 18 months) in which the interest rate has an upward bias due, by assumption, to a temporary phenomena (Figure 9). Since high interest rates depress economic activity, it is to be expected that the asymmetry in the BoI behavior aggravate 5 the downturn in the business cycle.

An evaluation of the basic interest-rate levels set by the BoI is obtained by comparing the rate of interest computed using the BoI rule and a classic Taylor rule. In both cases we assume a 2 percent inflation target and zero output gap,[8] see Table 6.

Figure 9
Short-Term Interest Rate Response to a Transitory Exchange-Rate Shock[a]



[a] Calculated using equation 15.
In period 1 the exchange rate rises by more than 2 standard deviations.
Expected inflation rises by 1.5 percent for 1 period.

It easy to see that:

1. The basic interest rate at long-run equilibrium in Israel at a 2 percent rate of inflation is 7.5 percent, compared to 4.0 percent in the Taylor rule. The 3.5 percentage-point difference could be explained as a long-run differential risk premium. This estimate could have an upward bias since it is estimated in a disinflation period that required high interest rates.
2. As the rate of inflation in Israel rises (moving to the right along the rows in the table) the rise in the real interest rate is more moderate than in the Taylor case (see column 2 in Table 6). This is due to a 1.13 coefficient on expected (actual long-run) inflation in the BoI rule, compared to the 1.5 coefficient in the Taylor case. A possible explanation of this result is that the BoI decided to apply a relatively high real rate of interest during the sample period to achieve the desired disinflation. Clearly the coefficients of the rule do not represent steady-state equilibrium and at least the constant should be reduced once a stable low inflation environment is attained.
3. For a one percentage-point rise in the interest rate abroad, the rate in Israel rises by 0.2 percentage points. For a one percentage-point rise in the real rate abroad, the real rate in Israel rises by 0.6 percentage points. This is also due to a more aggressive response to deviations from the inflation target in the Taylor case than in the Israeli response. It is possible that this is due, again, to the basic higher real rate in Israel during this disinflation episode.

[8] The latest assumption is relevant for the classic Taylor rule only since the output gap does not appear in the BoI rule.

Table 6
The Interest Rate in Israel:[a] Applying the Bank of Israel Rule[b]

(Annual rates, percent)

Inflation abroad	The rate of interest[c] abroad	Domestic Inflation 0	2	5	10
0	1.0 (1.0)	4.7 (4.7)	6.9 (4.9)	10.3 (5.3)	16.0 (6.0)
2	4.0 (2.0)	5.3 (5.3)	7.5[d] (5.5)	10.9 (5.9)	16.6 (6.6)
5	8.5 (3.5)	6.1 (6.1)	8.4 (6.4)	11.8 (6.8)	17.4 (7.4)
10	16 (6.0)	7.6 (7.6)	9.9 (7.9)	13.3 (8.3)	18.9 (8.9)

[a] Approximate real interest rates are given in parentheses.
[b] Calculated using Equation (16), assuming a 2 percent domestic inflation target.
[c] Assuming the interest rate abroad is set by a classic Taylor rule with a zero output gap, i.e., full employment.
[d] Long-run equilibrium interest rate when the rate of inflation equals the 2 percent target in both markets.

6. CONCLUSIONS

Peeking into the BoI Governor's chamber allows us to identify a relatively simple monetary policy rule that was used during a successful disinflation episode in Israel. Our econometric analysis showed that the rule was based on interest rate parity considerations, including strong reaction to large exchange-rate shocks.

The success of reducing inflation by applying an extremely tight monetary policy cannot be disputed. Our analysis also showed that the disinflation process was not fully completed in the sense that the rate of interest did not come back to a steady state level consistent with low inflation and low real rates of interest.[9] It remains to be seen from future developments whether, given the structure of the Israeli economy,[10] disinflation in the current monetary regime can reach such a steady state without causing monetary and exchange-rate instability as a result of reducing the interest rate to world market levels.

An interesting and important question is whether Israel could have achieved similar results on the inflation front paying a lower price in terms of output loss. An important question for future research is that the very high real interest rates may have played an important role in the decline of economic activity in Israel, reflected in the loss of output, the rise of unemployment and the poor growth performance. An attempt to address this question requires a complete model; this remains a challenge for future study.

[9] A sharp reduction of 2 percentage points of the BoI interest rate in the last week of 2001 that violated the policy rule led to a large devaluation of the NIS. This resulted in a sharp rise of the CPI (7 percent from December 2001 to July 2002) and a sharp upward violation of the inflation target.

[10] In particular the degree of openness, with a floating exchange-rate regime, in a world of globalization characterized by very large and volatile capital movements.

APPENDIX

Empirical Comparison of the Policy Rules

Table 1
Taylor-Type Policy Rule Comparisons,[1] July 1993 – September 2001

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Backward-looking expectations								
Mean	10.9	8.8	11.8	11.2	12.1	10.1	12.1	11.6
Standard deviation	7.2	5.4	3.5	3.2	6.5	4.7	3.4	3
Correlation with BoI rate	0.805	0.846	0.952	0.974	0.783	0.828	0.953	0.976
Root mean square error	5.3	4.7	1.3	1.1	4.6	3.5	1.1	0.8
Mean absolute error	4.7	3.8	1.1	0.9	3.9	2.9	0.9	0.7
Mean absolute % error	0.45	0.37	0.11	0.09	0.37	0.28	0.09	0.06
Theil inequality coefficient	0.074	0.081	0.06	0.06	0.07	0.074	0.058	0.056
Bias proportion	0.04	0.46	0.04	0.47	0	0.32	0	0.31
Variance proportion	0.69	0.33	0.42	0.16	0.65	0.32	0.33	0.1
Covariance proportion	0.26	0.2	0.55	0.36	0.35	0.36	0.67	0.58
Panel B: Forward-looking expectations								
Mean	11.3	8.9	11.9	11.3	12.5	10.2	12.2	11.6
Standard Deviation	6.3	5.2	3.4	3.1	5.5	4.4	3.2	2.9
Correlation with BoI rate	0.844	0.854	0.969	0.977	0.837	0.842	0.973	0.981
Root mean square error	4.3	4.4	1	1	3.6	3.2	0.8	0.7
Mean absolute error	3.8	3.6	0.9	0.9	3.2	2.6	0.7	0.6
Mean absolute % error	0.36	0.35	0.08	0.08	0.29	0.25	0.07	0.06
Theil inequality coefficient	0.072	0.08	0.058	0.059	0.067	0.073	0.055	0.055
Bias proportion	0.03	0.48	0.02	0.5	0.02	0.33	0.04	0.34
Variance proportion	0.69	0.31	0.43	0.15	0.61	0.29	0.31	0.09
Covariance proportion	0.28	0.21	0.55	0.35	0.37	0.37	0.65	0.57

[1] The mean and standard deviation of the BoI rate of interest for this period are 12.0 and 2.7 respectively. The rules are; (1) Classic, (2) Targeting, (3) Classic smooth, (4) Targeting smooth, (5) Classic strict, (6) Targeting strict, (7) Classic smooth strict and (8) Targeting smooth strict.

Table 2
Interest Rate Parity Type Policy Rule Comparisons,[1] July 1993–September 2001

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Backward-looking expectations								
Mean	12.7	10.3	12.2	11.6	13.9	11.6	12.5	11.9
Standard deviation	6.5	5.4	3.5	3.2	5.7	4.6	3.3	3
Correlation with BoI rate	0.886	0.904	0.974	0.982	0.885	0.902	0.978	0.985
Root mean square error	4.3	3.6	1	0.8	4	2.5	1	0.6
Mean absolute error	4	2.8	0.9	0.7	3.6	2	0.9	0.5
Mean absolute % error	0.36	0.28	0.08	0.07	0.31	0.2	0.07	0.04
Theil inequality coefficient	0.068	0.073	0.057	0.056	0.065	0.066	0.056	0.053
Bias proportion	0.02	0.22	0.04	0.21	0.22	0.03	0.27	0.01

Table 2 (continued)

Variance proportion	0.77	0.56	0.52	0.35	0.56	0.58	0.33	0.28
Covariance proportion	0.21	0.22	0.44	0.44	0.22	0.39	0.4	0.71
Panel B: Forward-looking expectations								
Mean	12.8	10.5	12.2	11.7	14	11.7	12.6	12
Standard deviation	6.3	5.2	3.4	3.2	5.5	4.4	3.2	3
Correlation with BoI rate	0.888	0.905	0.976	0.984	0.891	0.907	0.981	0.987
Root mean square error	4.2	3.4	1	0.8	3.9	2.3	0.9	0.5
Mean absolute error	3.8	2.7	0.9	0.6	3.5	1.9	0.8	0.4
Mean absolute % error	0.34	0.27	0.08	0.06	0.29	0.18	0.07	0.04
Theil inequality coefficient	0.067	0.072	0.057	0.056	0.064	0.065	0.055	0.051
Bias proportion	0.03	0.21	0.05	0.2	0.27	0.02	0.32	0.01
Variance proportion	0.75	0.55	0.51	0.34	0.52	0.56	0.3	0.26
Covariance proportion	0.22	0.24	0.44	0.45	0.21	0.42	0.37	0.73

[1] The mean and standard deviation of the BoI rate of interest for this period are 12.0 and 2.7 respectively. The rules are; (1) Classic, (2) Targeting, (3) Classic smooth, (4) Targeting smooth, (5) Classic strict, (6) Targeting strict, (7) Classic smooth strict and (8) Targeting smooth strict.

Table 3
Domestic Real Interest Rate Type Policy Rule Comparisons,[1] July 1993–September 2001

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Backward-looking expectations								
Mean	13.6	11.2	12.4	11.9	14.8	12.5	12.7	12.2
Standard deviation	6.1	4.9	3.3	3.1	5.3	4.2	3.2	2.9
Correlation with BoI rate	0.872	0.884	0.973	0.98	0.867	0.874	0.976	0.983
Root mean square error	4.2	2.9	1	0.7	4.2	2.3	1.1	0.6
Mean absolute error	3.7	2.5	0.9	0.6	3.5	1.9	0.9	0.4
Mean absolute % error	0.33	0.24	0.07	0.06	0.29	0.17	0.07	0.04
Theil inequality coefficient	0.066	0.069	0.056	0.054	0.064	0.064	0.056	0.052
Bias proportion	0.13	0.07	0.17	0.05	0.43	0.04	0.47	0.07
Variance proportion	0.63	0.57	0.38	0.28	0.36	0.41	0.17	0.11
Covariance proportion	0.24	0.36	0.46	0.66	0.21	0.54	0.35	0.82
Panel B: Forward-looking expectations								
Mean	13.7	11.4	12.5	11.9	14.9	12.6	12.8	12.2
Standard deviation	5.9	4.8	3.3	3	5	4	3.1	2.9
Correlation with BoI rate	0.877	0.888	0.976	0.983	0.878	0.885	0.98	0.986
Root mean square error	4.1	2.7	1	0.6	4.1	2.1	1	0.5
Mean absolute error	3.6	2.3	0.8	0.5	3.4	1.8	0.8	0.4
Mean absolute % error	0.3	0.22	0.07	0.05	0.27	0.15	0.07	0.03
Theil inequality coefficient	0.065	0.068	0.056	0.053	0.063	0.063	0.056	0.051
Bias proportion	0.17	0.06	0.21	0.04	0.49	0.08	0.54	0.12
Variance proportion	0.6	0.56	0.35	0.27	0.31	0.36	0.14	0.08
Covariance proportion	0.23	0.38	0.44	0.69	0.19	0.56	0.31	0.8

[1] The mean and standard deviation of the BoI rate of interest for this period are 12.0 and 2.7 respectively. The rules are; (1) Classic, (2) Targeting, (3) Classic smooth, (4) Targeting smooth, (5) Classic strict, (6) Targeting strict, (7) Classic smooth strict and (8) Targeting smooth strict.

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