Monetary Policy Rules and Transmission Mechanisms Under Inflation Targeting in Israel

by

Leonardo Leiderman and Hadas Bar-Or[1]

Research Department

Bank of Israel

January 14, 2000

---

[1] The views expressed in the paper are the sole responsibility of the authors. Leiderman is Senior Director, Research Department, Bank of Israel, and Professor of Economics at the Berglas School of Economics at Tel-Aviv University, and Bar-Or holds the position of economist at the Research Department, Bank of Israel. We thank O. Bar-Efrat, G. Bufman, N. Liviatan, and F. Morande for detailed comments on an earlier draft. For comments and suggestions we also thank seminar participants at the Research Department of the Bank of Israel, Hebrew University, Tel Aviv University, and the central banks of Chile and the Philippines. For any questions or comments please contact the authors at leoleid@bankisrael.gov.il

Abstract

In this paper we analyze Israel's recent inflation targeting policies and their role in the disinflation process in the 1990s. Special features of Israel's economic background underlying inflation targeting are: a high-inflation history which produced various institutions and mechanisms—such as wage and financial indexation—that may produce strong inflation persistence; lack of consensus about the benefits from reducing inflation and thereby lack of full credibility of monetary policy under inflation targeting; the existence of monetary policy overburdening in its attempts to meet the inflation targets, especially when fiscal policy was not compatible with achieving the targets; the coexistence of an exchange rate band together with the inflation targets. Since some of these conditions are not unique to Israel, the analysis is of interest because they may apply to other countries as well. A key finding of the econometric analysis in the paper is that there is a time-varying passthrough from exchange rates to prices, which depends on the state of the business cycle and the size of exchange rate fluctuations. In particular, a higher degree of passthrough was found in booms vs. recessions, and a stronger contemporaneous passthrough emerged under relatively large vs. small exchange rate movements. In the present empirical specifications, monetary conditions are shown to have played a key role in accounting for the various turning points along the disinflation process. Estimates of an analogue of a 'Taylor rule' for the central bank interest rate indicate that in contrast with the monetary accommodation that prevailed in the past, monetary policy in the more recent years has acted as an inflation stabilizer. Moreover, in recent years there has been a growing importance in the role of market-based inflation expectations and a larger degree of interest rate smoothing in the estimated monetary policy rule

I. INTRODUCTION

Disinflation in Israel has been a relatively slow process. It took more than a decade for the rate of inflation to fall from about 18 percent per year in the late 1980s to less than 4 percent per year in the late 1990s. For the years 2000 and 2001 the government has set an inflation target range of 3-4 percent. Whether low inflation is a permanent component of reality in the future remains to be seen. Some important features of the economy—such as the principles guiding monetary policy and asset market's allocations—have adjusted themselves to the new, single-digit, low inflation conditions. Yet many key transmission mechanisms that were introduced previously under double- and triple-digit inflation are still here. Leading examples are the existence of widespread wage- and financial-markets indexation to the consumer price index, as well as a relatively quick passthrough from nominal exchange rates to prices. In spite of these, Israel's experience suggests that it has been possible to disinflate and to conduct monetary policy as in most inflation targeting countries. Underlying these there has been a 'virtuous' circle in the interaction between disinflation and economic institutions. As disinflation became more credible over the years, an increasing number of transmission mechanisms were adapted to these conditions; and, in turn, the latter contributed to make disinflation more credible and to increase the efficacy of monetary policy.

Under these conditions, the conduct of monetary policy faced numerous difficulties. First, there has not been a wide consensus about the need to bring about a convergence of domestic inflation to the rate in the industrial countries. Lack of consensus created ambiguity about the nature and role of inflation targets, about the conduct of monetary policy, and about the fact that fiscal policy has a key role to play in achieving the inflation target. As a matter of fact, in the mid 1990s there was a considerable degree of monetary policy overburdening, as this policy had to offset, at least partially, the potential impacts of fiscal expansion on the rate of inflation; see Bufman and Leiderman (1998). Some politicians have disputed the stance adopted by monetary policy, to the point of proposing legislative changes to effectively reduce the degree of central bank autonomy.[2] There is no doubt that lack of full support from fiscal policy and ambiguity about nominal targets have damaged the credibility of the disinflation process and have raised the difficulties encountered by monetary policy. To effectively reduce the rate of inflation, it has been necessary for the central bank to maintain a more 'conservative' stance than otherwise and to fulfill what has become a partial 'educational' role, explaining to other policymakers and to the public at large the importance of having the rate of inflation in Israel converge gradually to the level prevailing in the leading countries in the globalized economy. Second, most of the time inflation targeting co-existed with nominal-exchange rate targeting, thus further raising ambiguity as to the guiding principles and priorities for monetary policy. Over the years, it has become increasingly clear that the inflation target has become the key objective of monetary policy, and that the nominal exchange rate is seen more and more as an indicator variable primarily set by the market.

[2] See Frenkel (1999) on the role of central bank independence for achieving price stability.

In addition, there has been a need to develop a well-specified forecasting scheme for conducting policy under inflation targeting. It turns out that econometric relations that seemed to work well in the high-inflation period (i.e., before mid 1985) were subject to structural breaks due to frequent regime changes in the post stabilization period. In particular, it is likely that the extent of exchange-rate passthrough to prices will be reduced over time as inflation targets become more credible and as the flexibility of the exchange rate regime is enhanced. Inflation forecast targeting requires the policymaker to continuously monitor comparisons of inflation forecasts against the inflation target, and discrepancies between these two serve as a trigger for monetary policy potential action. Thus, the inflation forecast is a key building block of the policy paradigm under inflation targeting. In the case of Israel, some of the difficulties were overcome by using market-based inflation expectations as one important (yet imperfect) indicator for the market's assessment of the inflation outlook into the future.

The above-mentioned challenges are not unique to Israel. They are shared not only by numerous emerging countries but also by industrial countries.[3] For example, when New Zealand adopted inflation targets in 1989, it did so in the context of wide structural and policy reforms, most of which rendered previously estimated models as quite obsolete. And when the U.K. adopts explicit targets in the fall of 1992, it does so after a period of nominal exchange rate targeting within which the transmission mechanism was quite different from that of inflation targeting coupled with flexible exchange rates. Moreover, in all cases the initial stages of inflation targeting suffered from lack of credibility and from substantial ambiguities, thus resulting in a time path for inflation expectations well above that of the rate of inflation.

In spite of these cross-country similarities, a striking difference with the industrial countries is that in Israel—a country with a relatively recent history of high inflation—the political and public support for inflation targeting and for inflation reduction has been relatively weak. Not a long time ago, inflation targeting was publicly criticized by officials from the finance ministry, and other official entities. Thus, ambiguity and lack of initial credibility, together with a non-supportive role of fiscal policy for disinflation, created at some point in the past conditions less favorable to bringing about satisfactory outcomes of inflation targeting. Yet substantial disinflation has occurred in recent years under inflation targeting and monetary policy is conducted within a framework very similar to that of industrial countries.

In this paper we analyze Israel's inflation targeting policies since 1992, with the eyes toward those characteristics that may well apply to other countries. Section II lays out the main stylized facts about recent disinflation and details about the inflation targeting scheme. Then, section III discusses the transmission mechanism in the inflation process and reports new estimates of equations for the rate of inflation. Special attention is given to the changing nature of the passthrough from exchange rates to prices and its dependence on the sate of the business cycle and

---

[3] See, for example, Leiderman and Svensson (1995) and Morande and Schmidt-Hebbel (1999).

the size of exchange rate fluctuations. Later on, Section IV deals with estimation of a representation for the Bank of Israel's policy rule and section V provides our concluding remarks.

II. Inflation Targeting and the Inflation Process: The Facts

From the beginning of the 1980s, the rate of inflation rose persistently and at an increasing rate, well into triple-digit territory, up until mid 1985 when the Economic Stabilization Program was introduced. Figure 1 depicts the major developments in the inflation process since then. From 1986 to 1991 average inflation was 18 percent per year, not so much as a result of an explicit policy decision (such as an inflation target) but more as a 'residual' consequence of the targeting of other variables, such as the nominal exchange rate and international reserves. The rate of inflation was sharply reduced to an average of 10 percent per year in the period from 1992 to 1996. Lately, there has been a further reduction in the rate of inflation, to 7 percent in 1997, and year-over-year inflation to mid 1998 was a bit below 4 percent. However, the drop in the rate of inflation was interrupted by marked consumer price increases in the last third of 1998, associated with sharp domestic currency depreciation under crises and volatility in world financial markets, mainly related to the financial crisis in Russia and the failure of the large LTCM fund. Yet, because of the tightening of monetary policy and the aiding role of other factors, these price increases were reversed in early 1999, and consequently current forecasts are that the rate of inflation in 1999 will be about less than 1.5 percent, below the official target of 4 percent. See Bank of Israel (1999a, and 1999b).

As far as the policy regime is concerned, an inflation target was first introduced in the context of the shift to a crawling exchange rate band in late 1991. The inflation target came in through 'the back door,' in that it first appeared only as an input in the setting of the exchange rate's rate of crawl, specified in a forward-looking manner as the difference between the inflation target and a forecast of foreign inflation.[4] Both the exchange rate regime and the inflation target are set by the government (mainly following the proposal from the finance minister) upon consultation with the instrument-independent Bank of Israel. As a result of this 'entry through the back door' feature, there has been a considerable degree of ambiguity about the nature and operational meaning of inflation targets as a pre-commitment device for monetary policy and for fiscal policy as well. This ambiguity was especially strong in the initial years of inflation targeting, yet it has decreased substantially over time as the central bank credibly placed the inflation target as the key objective of monetary policy.

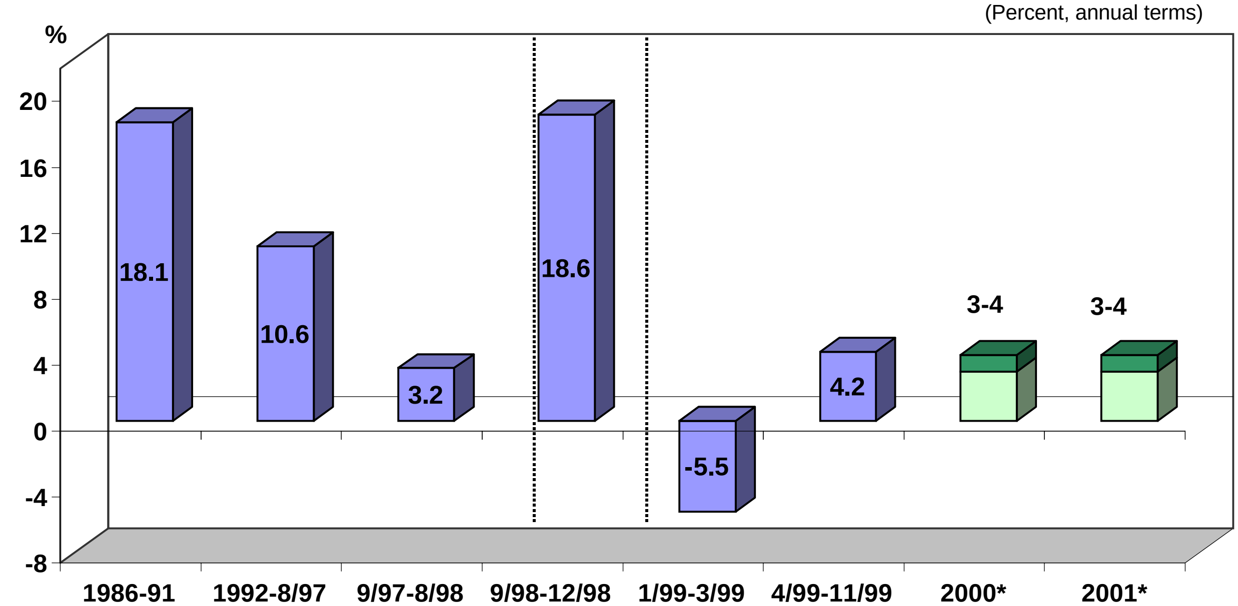
Table 1 provides a summary of inflation targets' history. For some years targets were set as a range and for others as a point target. In all cases the overall CPI (consumer price index) was used in the specification of the target, which seems especially appropriate in an economy subject to a high degree of wage and financial assets indexation to the overall CPI. In general, targets for a

[4] See Bufman, Leiderman, and Sokoler (1995).

given year were set only a few months before the end of the preceding year, and most of the time there have been no explicit multiyear targets. A salient characteristic of the setting of inflation targets in Israel is the generally 'adaptive' behavior by the authorities: the inflation target for the next year was typically set at a rate very close to the observed, year-over-year, rate of inflation at the time of setting the target. Practically, this has meant that advances at disinflation have typically preceded further reductions in the level of the inflation target. It can be seen that the inflation target for 1999 is 4 percent and the target for 2000 and 2001 has been set as the range 3-4 percent. See also Sokoler (1997).

Figure 1
Evolution of the Rate of Inflation in Israel

(Percent, annual terms)



*Inflation target for 2000-2001.

Table 1. Inflation: Targets and Performance, 1992–2001

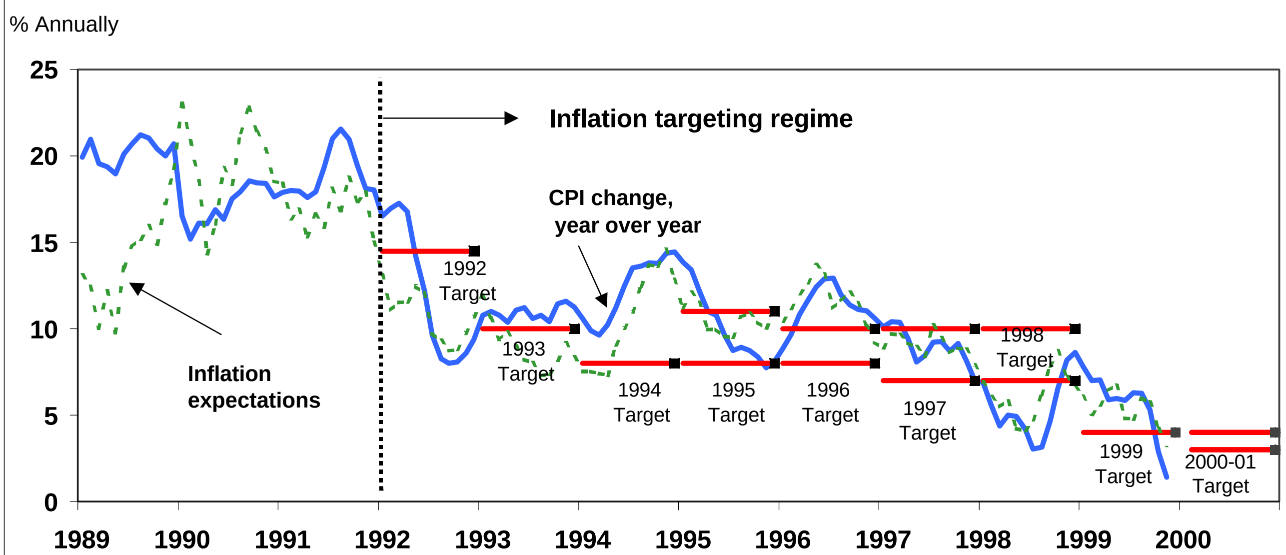
(Annual percent rise in the CPI)

Inflation rate	Inflation target	
9.4	Up to 14-15	1992
11.2	10	1993
14.5	8	1994
8.1	8-11	1995
10.6	8-10	1996
7.0	7-10	1997
8.6	7-10	1998
9.9	9.7	1992 – 98[a]
1.5[b]	4	1999
?	3-4	2000-2001

[a] Average.
[b] Forecast.

The data in Table 1 indicate that although on a yearly basis there have been some deviations of inflation from target, from a multiyear perspective inflation targets have been achieved on average: the average rate of inflation from 1992 to 1998 was 9.9 percent per year, very close to the average of the yearly targets (i.e., 9.7 percent). It can be seen from Figure 2 that there have been several episodes in which there were marked deviations from target within the year of the rate of inflation in the last 12 months and of 12-months ahead expected inflation. Market-based expected inflation in Figure 2 is derived from the yields on indexed and non-indexed bonds traded in the local capital market. Three major episodes of inflation acceleration well above target occurred in 1994, in the first half of 1996 and in the last third of 1998. In all these cases the credibility of the regime was at a very serious test in that inflation expectations escalated to about 15 percent in the first two episodes and to about 10 percent in the last episode. In the reverse direction, the rate of inflation was well under the annual target in the first two-thirds of 1998 and in the last quarter of 1999.

Figure 2
Actual Inflation, Targets and Inflation Expectations

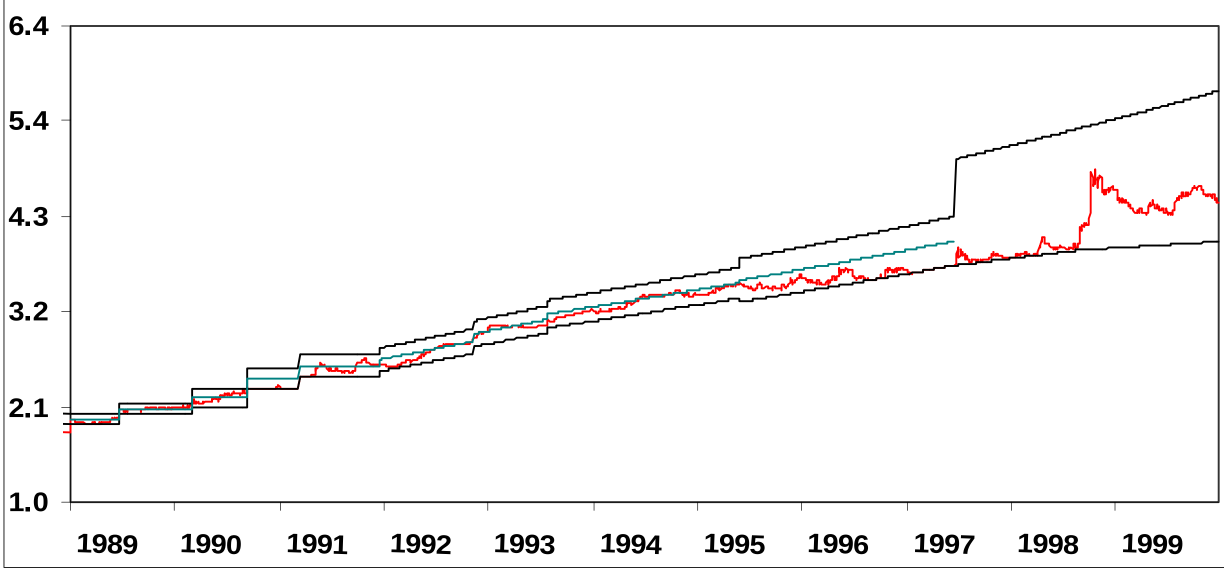


Indicates December of each year.

Note: Inflation expectation are derived from capital market data on indexed and nonindexed bonds.

As discussed, inflation targets in Israel coexist with another nominal policy commitment, namely the crawling exchange rate band for the NIS (new Israeli shekel) against a basket of foreign currencies, depicted in Figure 3. Over the years, there has been a substantial shift toward liberalization of foreign exchange transactions, including capital flows, and together with this there has been a gradual move toward increased flexibility of the nominal exchange rate regime. Less than five years ago there was a relatively narrow exchange rate band and a considerable degree of intramarginal sterilized foreign-exchange market intervention by the authorities. Today, daily exchange rates are primarily set by private market forces with no central bank intervention and in the context of a very wide currency band; see Leiderman and Bufman (1996). In fact, since mid June 1997 there has been a gradual (daily) widening of the currency band, whose width will be about 40 percent by the end of 1999. Israel's experience in the last five years illustrates that under a high degree of capital mobility, the coexistence of an exchange rate band and inflation targeting may make the role of monetary policy more difficult than otherwise, in that with one instrument (the monthly setting of the central bank repo rate) the monetary authority is expected to simultaneously achieve both these targets. In several occasions, e.g. in the first half of 1997, the level of the repo rate required in order to achieve the inflation target was higher than that consistent with lack of pressures on the exchange rate band; this was associated with considerable capital inflows and sizable sterilized intervention in the foreign exchange market to defend the currency band's lower (most appreciated) limit. Over the years the authorities dealt with these policy dilemmas by increasing the emphasis of monetary policy making on inflation targeting, and at the same time increasing the degree of exchange rate flexibility.

Figure 3
N.I.S Exchange Rate Against the Currency Basket, 1989-1999



III. On the Monetary Policy Transmission Mechanism

In principle, the channels for potential effects of monetary policy on key macroeconomic variables in a small open economy are well known. A change in the monetary policy stance—as e.g. captured by a change in the central bank overnight rate—may have a short-run impact on the level and composition of aggregate demand, especially through its impact on short- and long-term real interest rates, on the real exchange rate, and on the liquidity available to consumers and investors. Changes in monetary policy can also influence economic agents' forward-looking inflation expectations and the nominal exchange rate, which in turn affect the wage- and price-setting mechanism (e.g. via the domestic pricing of tradable goods and services). Clearly, financial markets and the impact of monetary policy changes on economic agents' balance sheets are key components of the transmission mechanism.

The analysis of these interdependent and simultaneous effects requires the formulation of a model within which each channel of the transmission mechanism and its feedback effects from and to the other channels are specified. Accordingly, relatively small-scale macroeconomic models have been formulated and estimated in various central banks in recent years. These typically consist of an aggregate demand equation, a price-setting equation that e.g. takes into account the impact of the output gap on price pressures, a money demand equation, a wage-setting equation, a real exchange rate equation, a term-structure of interest rates relating short and long rates, an interest rate parity condition, a specification of inflation expectations, and a monetary policy reaction function. Under some conditions, these models can be properly estimated and the resulting parameters can be used to assess the quantitative importance of the various transmission channels as well as to simulate the impact of monetary policy shocks.

In Israel, the specification and estimation of such small-scale macroeconomic models faces the methodological difficulties arising from relatively frequent structural breaks due to numerous regime changes. In spite of this, there are current efforts under way at the Bank of Israel to deal with these issues; see e.g. Azoulay and Elkayam (1997), Djivre and Ribon (1999), Kahn, Kandel, and Sarig (1998), and the research papers by various authors in Leiderman (1999). At the same time, efforts have been devoted to estimating some of the individual components of the overall macroeconomic model, such as money demand and the Phillips curve, with satisfactory results.

We focus here on models for analyzing and forecasting movements in the rate of inflation in Israel, which can play a key role in the inflation targeting scheme. To a large extent, monetary policy consists of what Svensson (1999) has termed ‘inflation forecast targeting;’ see Bufman and Leiderman (1998). That is, monetary policy decisions mainly depend on an assessment of whether in the absence of policy changes it is highly likely that the inflation target will be met. For example, to the extent that the inflation forecast is above the inflation target, this calls for a tightening of monetary conditions. While the existence of market-based data on inflation expectations can be exploited in this forecasting and policy exercise, as implied by the analysis in Bernanke and Woodford (1997), the proper conduct of monetary policy requires the reliance on other indicators and forecasts of the inflation outlook as well.

A. Estimates of a quarterly inflation equation

Most existing quarterly econometric models of the price setting equation in Israel relate quarterly movements in the rate of inflation to a set of explanatory variables that include: measures of monetary conditions—such as the ex-ante central bank real interest rate (which in turn makes use of market-based inflation expectations) and the nominal exchange rate, indicators of ‘imported’ inflation (such as foreign prices), measures of the level of economic activity such as the output gap or the rate of unemployment, and others; for research by various authors, see Leiderman (1999). While estimation of these models yielded reasonable results, within sample simulations suggest that to a large extent these models are not able to economically account for a sizable part of observed key turning points in the disinflation process, such as from the end of 1991 to mid 1992 and from late 1997 up until mid 1998; see Bar-Or (1999). Thus, it has been common to add default dummy values, to capture the fall in the rate of inflation and to enable a more precise estimation of the parameters. It seems plausible that to a large extent these dummies capture the effects of one-time shifts in the stance of fiscal policy on the inflation process. While it has been difficult to detect quarter-to-quarter impacts of fiscal policy variables on the evolution of the rate of inflation, the research by Dahan and Strawczynski (1997) has shown that salient changes in the evolution of inflation in the period 1970–1996 were preceded by substantial and persistent changes in the same direction in the fiscal policy regime, as reflected in changes in the structural public sector deficit and in the public debt.

Our work relies on a reduced-form representation for the quarterly rate of inflation, which mainly differs from most previous work in the specification of the passthrough mechanism from exchange rates to prices. Specifically, in the proposed model the contemporaneous and lagged passthrough is from the nominal exchange rate to prices of all goods, not just tradables. Because of the high-inflation history, there exist—still nowadays, in spite of the reduction in the rate of inflation—various formal and informal indexation mechanisms linking domestic prices and wages to the nominal exchange rate, beyond the impact of the latter on domestic prices of traded goods and services. Hence, nominal exchange rates and foreign prices are entered separately in the inflation equation. In addition, the proposed model of the coefficient of passthrough allows for this coefficient to vary with time, depending on the state of the economy over the business cycle—see Bufman and Leiderman (1996) and Bar-Or (1999)—that is, the extent of passthrough is larger in booms than in downturns. We also examine the extent to which the exchange-rate passthrough coefficients depend on the size of the underlying exchange rate change; that is, whether exchange rate movements beyond a given threshold level give rise to a stronger or quicker passthrough than milder exchange rate changes. Concretely, we estimate an equation of the form:

$$(1)\quad \pi_t = \beta_0 + \beta_1 D2 + \beta_2 DPOIL_t + \beta_3 \pi f_{t-2} + \beta_4 r_t + \beta_5 r_{t-2} + \beta_6 u_t + (\beta_7 + \beta_8 u_t)\varepsilon_t + \beta_9 \varepsilon_{t-1} + \eta_t$$

where π denotes the quarterly rate of change in the consumer price index excluding fruits and vegetables. The fruits and vegetables price index (whose weight in the CPI is only 3.5 percent) is seasonal, extremely volatile, and was strongly affected in the sample period by the existence or lack thereof of a security-induced closure vis-a-vis the territories, that would not enable the entry of Palestinian workers. D2 is a dummy variable for the second quarter of each year. DPOIL is the rate of change of fuel prices in Israel. πf is the rate of change of the price index for imported consumer goods. r denotes the real ex-ante interest rate calculated using the nominal interest rate set by the central bank and market-based inflation expectations. u is the rate of unemployment (seasonally adjusted) and ε is the quarterly rate of change of the NIS/Dollar exchange rate. We will allow for the coefficients on exchange rate depreciation—both contemporaneous and lagged—to depend, through dummy variables, on the size of the exchange rate change; we added to equation (1) β_{10} and β_{11} as the coefficients on these dummies, which correspond to the period 1998:IV-1999:I. Implementing this equation with least squares, correcting for heteroscedasticity, on a sample of data from 1990:I to 1999:III yields the following results:[5]

Table 2. Parameter Estimates

Std. Error	Coefficient	
0.005	0.038	β_0
0.002	0.009	β_1
0.006	0.016	β_2
0.039	0.149	β_3
0.051	-0.263	β_4
0.042	-0.170	β_5
0.041	-0.130	β_6
0.151	0.620	β_7
1.304	-4.325	β_8
0.040	0.205	β_9
0.045	0.093	β_{10}
0.045	-0.229	β_{11}
	0.926	R-squared
	0.896	Adjusted R-squared
	0.005	S.E. of regression
	1.877	Durbin-Watson stat.

For an economy with a considerable degree of volatility such as Israel, the results are quite satisfactory in terms of both the estimated individual coefficients (Table 2) and the overall within-sample fit of the equation (Figure 4). In addition, their broad features conform to those of earlier work. In particular, if we disentangle the nominal interest rate and the ex-ante market-based measure of inflation expectations, the coefficients on both these terms, when entered separately, are quite similar thus providing support to the present specification. An innovative feature of the results is the finding that the passthrough coefficients depend on the state of the business cycle and on the size of the exchange rate change; see below.

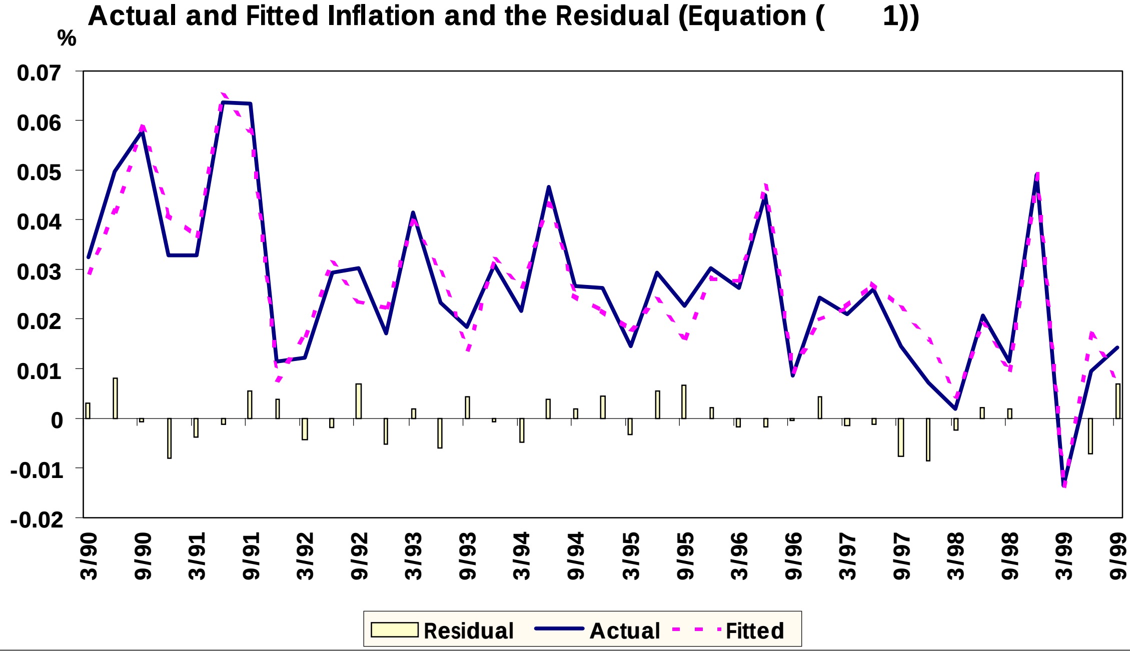
In order to illustrate the meaning of the estimated values of the parameters for the transmission mechanism in the inflation process, we discuss now some of the implied 'partial

[5] Stability tests of equation (1) support the notion that no structural breaks have occurred within the sample.

derivatives' of inflation with respect to various factors, each of which is treated separately from the others. Specifically, our estimates imply that, other things equal, a depreciation of one percent per quarter of the NIS against the dollar in a given year would result in a rise in the rate of inflation of 2.1 percentage points, mostly in the same year. This calculation assumes that there is no output gap; i.e., the rate of unemployment is about 6.5 percent per year. However, should the economy be in a slowdown, with a rate of unemployment close to 9 percent per year, inflation would accelerate by 1.6 percentage points in response to the same exchange rate depreciation shock. That is, the overall (i.e., current and lagged) passthrough from exchange rates to prices is estimated at about 0.5 under full employment and at 0.4 in a downturn. Further, the passthrough was spread almost equally over the current and previous quarter in a slowdown, yet it was faster under full employment (a coefficient of 0.3 on the contemporaneous term and 0.2 on the one-quarter lag).

Figure 4

Actual and Fitted Inflation and the Residual (Equation (1))



To examine whether the size of exchange rate fluctuations matters for the passthrough, we attached, as mentioned, dummy variables to the direct exchange rate passthrough, for the last quarter of 1998 and the first quarter of 1999—a period of sharp exchange rate turbulence. It is found that relative to the earlier sample estimates, all of the passthrough effects have shifted to the contemporanous term. This indicates that when exchange rate shifts are sizable, there is a quicker price response.[6]

Figure 5 depicts the implied within-sample, time-varying, overall passthrough coefficient from the NIS/dollar exchange rate to the consumer price index. The dependence of the passthrough on the state of economic activity is quite evident. In the early 1990s, the overall passthrough plunged from 0.45 to almost 0.25 at the end of 1991 and the beginning of 1992, a time in which there was a surge in unemployment mainly as a result of the influx of immigrants which greatly increased labor supply. On the other hand, the marked recovery in economic activity thereafter got translated into a rise in the passthrough coefficient, which reached a peak of almost 0.55 in mid 1996. The slowdown in the most recent period has led to a decline in the degree of passthrough.

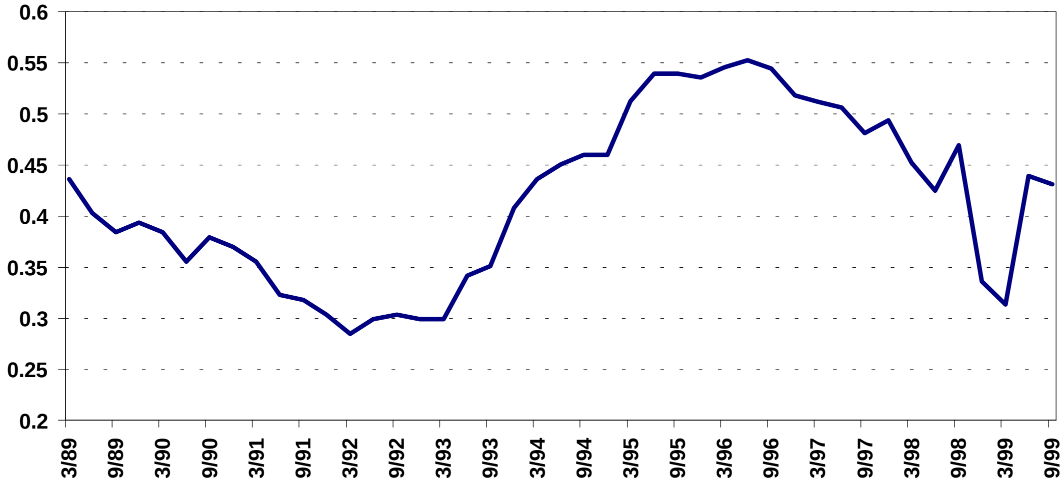
As to the direct effects of monetary policy changes, we find that a rise of one percentage point in the ex-ante real interest rate from the previous year's level is associated with a decrease in the rate of inflation of 1.7 percentage points (about 1.4 in the same year and 0.3 in the subsequent year). A rise in prices abroad of one percent per quarter during the year would lead to a rise of 0.6 percentage points in the rate of inflation, which would be spread evenly over two years. Further, a rise in the rate of unemployment by one percent from the previous year's level would be associated with a reduction of 0.7 percentage points in the rate of inflation in that year—0.52 of which due to the direct effect on inflation, and the rest due to the moderating effect on the passthrough from exchange rates to prices.[7]

---

[6] We have explored additional specifications of equation (1). First, we checked whether the passthrough associated with the foreign-inflation variable varies with the state of the business cycle, as specified for the exchange rate variable. Second, we explored whether the size of fluctuation in the rate of unemployment has an impact, per-se, on the passthrough coefficient. Third, we tested for differential passthrough effects arising from exchange rate depreciations against those from appreciations. Fourth, the effects of the ex-ante real interest rate on the rate of inflation were allowed to depend on the state of the economy. In all of these cases we found no evidence in support of these alternative specifications.

[7] No dummy variable was introduced for the interaction term between the rate of unemployment and exchange rate depreciation because of lack of enough degrees of freedom.

Figure 5
Time-Varying Overall Passthrough Coefficient from the Dollar Exchange Rate to the CPI



Before we move on to further applications of the parameter estimates, it is well to discuss some of their potential limitations and ways to overcome these. While in principle, an equation such as (1) can be subject to simultaneity—i.e., the regressors can be correlated with the error term—more detailed analysis suggests that this issue may not very relevant for the present application. First, when Granger-causality tests are run for the various variables in the sample, in monthly terms for lags of one and two months, we find no evidence for significant causality from the rate of inflation to the rate of depreciation of the domestic currency, and to the real interest rate; for detailed results, see Bar-Or (1999). Yet, we do find significant causality from the real interest rate and the rate of domestic currency depreciation to the rate of inflation.[8] Second, if equation (1) is estimated using 2SLS, the resulting coefficients are very similar to those reported in the Table, yet they are less precisely estimated. Moreover, the following empirical considerations hold: (a) the rate of unemployment is typically a lagging indicator for macroeconomic conditions in Israel and is not related to the contemporaneous rate of inflation; (b) for a large part of the sample there was nominal exchange rate targeting, using foreign exchange market intervention, and thus there was a very limited degree of exchange rate adjustment in response to shocks; that is, the path of the nominal exchange rate was predetermined to a large degree; also in many macro models, financial markets clear

[8] As is well known, it is not possible to determine the direction of contemporaneous causality by means of Granger tests.

faster than goods markets;(c) as far as the real interest rate variable is concerned, central bank setting of nominal interest rates probably reacts more to lagged values of inflation expectations and of inflation shocks than to their present ones, and market based inflation expectations are known to be largely adaptive. The combination of these characteristics reduces the scope for simultaneity.[9]

B. Quantifying the role of various factors in the 1997: IV-1998: III disinflation

As indicated, an important drawback of previous empirical models is that they could not account well for important turning points in the process of inflation as measured by quarterly data. Consequently, they had to rely on dummy variables to avoid that these turning points would result in imprecise parameter estimates. Here we illustrate how the present inflation equation is able to account well within the sample for the marked reduction in the rate of inflation to about 4.2 percent per year in the period from 1997:IV to 1998:III, compared to the higher rate of inflation of 8.8 per year in the earlier period of 1996:IV-1997:III. The basic relevant data for this task are provided in Table 3; see also Bar-Or (1999). The data are organized in the form suggested by taking first differences in equation (1) and measuring by $\Delta\pi$ the drop (of 4.6 percentage points) in the rate of inflation to be accounted for.

From Table 3 it can be learned that—in this ‘inflation-change accounting exercise’--the estimated equation captures quite well the reduction in the rate of inflation.[10] A tightening in monetary conditions, as captured by both a higher ex-ante real central bank interest rate and by a contemporaneous slower rate of domestic currency depreciation vis-a-vis the dollar, was quantitatively the key factor accounting for the reduction in the rate of inflation. In addition to that, the economic slowdown (as captured by a higher rate of unemployment) and the marked fall in fuel prices abroad helped lower inflation in the period under discussion.

---

[9] As far as potential multicollinearity is concerned, contemporaneous cross correlations among the various explanatory variables are quite small, and not statistically significant.

[10] In addition, as shown in Bar-Or (1999), the estimated equation yields satisfactory results also in a out-of-sample forecasts. Using actual values of the right-hand-side variables, estimates of equation (1) up to 1997:III predict a reduction of 4.5 percents in the rate of inflation, to be compared to the actual reduction of 4.6 percents. Also, the contribution of the explanatory variables to the disinflation is very similar to that found within sample; see Table 3.

Table 3. Performance and Contribution of Factors in the 1997: I–1998: III Disinflation

(In percent)

	(1) 1996:IV – 1997:III	(2) 1997:IV – 1998:III	(3) Estimated contribution
Inflation rate	8.8	4.2	4.6
'Explained' inflation rate	9.2	4.6	4.6
Foreign inflation	-5.1	-4.7	-0.1
Oil price change	-9.2	-31.4	0.4
Exchange rate (dollar) depreciation	11.5	5.9	1.7
Ex-ante real interest rate	4.1	5.2	2.0
Unemployment rate	7.6	8.5	0.6

Note: Raw data are the source for columns (1) and (2). Column (3) is derived from applying first differences to equation (1), using the estimated parameter values. 'Explained' inflation is the one corresponding to the basic equation underlying this analysis.

C. Inflation forecasting

We now turn to the potential use of equation (1) to forecast inflation. To do so, it is required to formulate forecasts for the right-hand-side variables, such as the rate of currency depreciation, foreign-price inflation, the rate of unemployment, and so on. While external variables' forecasts can be probably taken from foreign sources, a proper derivation of internal variables' forecasts would require working with a fully simultaneous macroeconomic model within which interdependencies among various forecasts could be taken into account. As indicated above, work in developing overall macro models for the Israeli economy is under way at the Bank of Israel, and further research work is needed before we can have a relatively satisfactory small-scale macro model that could be used to derive macro forecasts. Because of this constraint, we focus here on a relatively limited use of equation (1) in forecasting inflation, based on various assumptions about the evolution of the right-hand-side variables.

Consider forecasting inflation for the four quarters from 1997:IV to 1998:III based on the information and other forecasts that were available as of the third quarter of 1997 and based on the parameter estimates of (1) obtained up until 1997:III. Based on IMF forecasts at that time, we assumed that world fuel prices would exhibit the following percentage rates of change in the pertinent four quarters: 0.4, -1.6, -1.6, and –1.6; and that the price of Israel's imports would fall at a rate of –0.375 percent per quarter. In addition, based on a small-scale macroeconomic model of the economy's real side at the Research Department, Bank of Israel, we assumed that the rates of unemployment for the relevant four quarters were (in percents): 7.9, and 8.1 in the next three quarters. It remains to specify the evolution of the exchange rate.

As is well known, typically there are no satisfactory models for predicting exchange rate fluctuations on a monthly or even quarterly basis, both in Israel and in the industrial countries. Much of what appears to move foreign exchange markets are 'news' which by definition are very hard to predict. What we can do at this stage, however, is to derive various forecasts for the rate of inflation based on several alternatives for the rate of currency depreciation in the pertinent future. However, to be specific, consider the forecasts based on what was a relatively plausible assumption at that point in time about the path of the exchange rate, namely appreciations of 0.4 and 0.1 percent in the first two quarters of the forecast horizon, and depreciations of 1.6 percent in each of the two consecutive quarters. Last, there is the forecast of the ex-ante real interest rate on central bank funds. In the very short run, this can be treated as a policy variable, and as such it should be compatible with achieving the inflation target. Using an ex-ante real interest rate of 5 percent, a rate which was in line with those observed since mid 1996, we derived an inflation forecast of 5 percent for the four-quarter horizon; a rate lower than the 7-10 percent inflation target range.

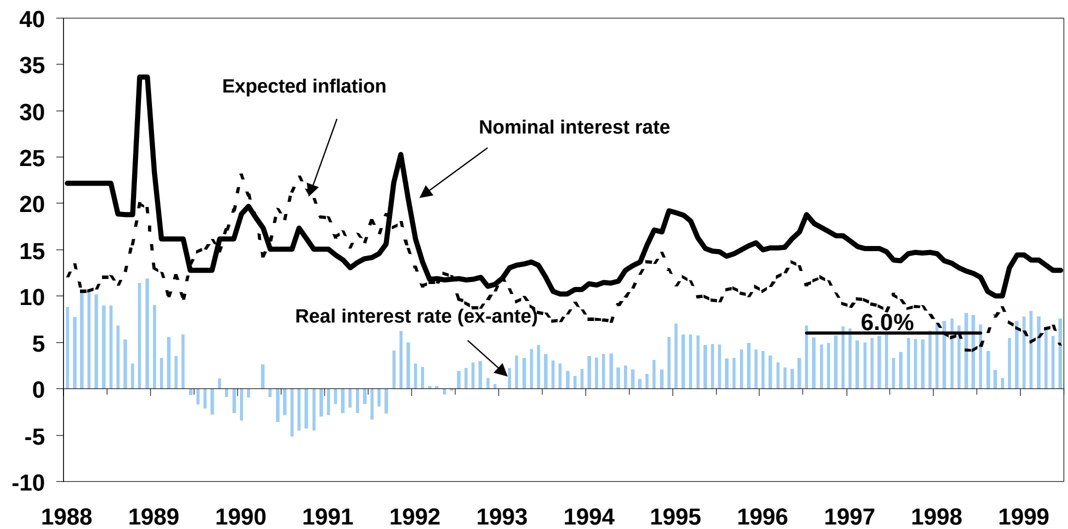
Once again, one could derive alternative forecasts based on differing assumptions about the evolution of the exchange rate and of the ex-ante real interest rate. We believe that more work exploring the forecasting properties of an equation such as (1), and comparing it with the forecasts of other models, is an important avenue for useful research in this area, as is the development of a fully specified, small scale, simultaneous-equation macroeconometric framework.

IV. Assessing Monetary Policy Rules

Here we attempt to formalize some aspects of monetary policy determination. Clearly, no simple mathematical rule can truly describe a process that involves frequent sharp unexpected changes in economic circumstances; as e.g. the impacts of an LTCM type default or of a specific country's crisis. With these caveats in mind, it is still instructive to explore the performance of various monetary policy rules, such as those estimated by Taylor and by Clarida, Gali, and Gertler for monetary policy of the main advanced economies, using data for Israel.

The evolution of the nominal interest rate as well as of market-based inflation expectations and of the implied expected real interest rate for the period from 1988 to the present is displayed in Figure 6. It can be seen that together with the gradual decrease in inflation expectations, especially after 1996, there has been a move toward a more uniform range of ex-ante real interest rates than in the early 1990s, to levels of about 5–7 percent in annual terms. To a large extent, throughout the 1990s monetary policy evolved from main emphasis on nominal exchange rate targeting in the early 1990s, to inflation targeting and enhanced exchange rate flexibility in recent years. It is for these reasons—i.e., possible changes in the monetary policy rule within the sample—that we perform our analysis here on monthly data (which is the periodicity of interest rate decisions) for the relatively more uniform period from 1994 onward.[11]

Figure 6
Effective Nominal[a] and Real Interest Rate and Expected Inflation



[a] On central bank liquid resources.

[11] Interestingly, most of the applied research on monetary policy rules for advanced countries used quarterly data, in spite of the fact that actually monetary policy decisions are made much more frequently.

A. On interest rate changes and the role of inflation expectations

The existence of reliable data on market-based inflation expectations is very useful in an inflation targeting context such as Israel. As a matter of fact, substantial changes in these expectations have typically triggered sharp monetary policy responses. For example, the episodes in late 1994–early 1995, the second half of 1996, and in late 1998 (see Figure 6) illustrate how in the face of sharp increases in inflation expectations there were marked increases in central bank rates. In the first two cases the rise in expected inflation was mainly due to a fiscal expansion together with overheating of the domestic economy, all of which led to a build up of price pressures. In late 1998, the rise in the interest rate was associated with increased inflation risks due to very rapid domestic currency depreciation under world financial crises.

Tables 4, 5, and 6 report statistical and historical information on interest rate changes by the central bank, as well as on the main characteristics of fluctuations in the rate of inflation. The maximal value of the nominal interest rate on central bank funds in the period since 1994 was 17 percent per year, in the middle of 1996. The minimal level was 9.5 percent per year, in August 1998. It can be seen that out of the 67 months in our sample, the average frequency of interest rate changes was almost two months. Moreover, there have been frequent turning points in the trend of interest rates—from increases to decreases, and viceversa—with the average frequency of turning points being every 7.4 months. From Table 5 it can be seen that during the sample period there was a relatively volatile inflation environment; thus it is plausible that the volatility in the inflation process fundamentals prompted frequent interest-rate reactions. Another interesting feature of the results is that in absolute terms of percentage points, increases in interest rates were typically stronger than decreases in rates. This asymmetric pattern would seem quite plausible in an economy in which there are still forces (from the high-inflation periods in the past) toward inflation bias, and where there is a policy objective of gradual disinflation. In that context, there is a stronger interest rate response in the face of rises in inflation than vis-à-vis decreases in inflation.

Table 4. Statistical Characteristics of Bank of Israel's Official Interest Rate

	1/94-7/99	1/94-6/96	7/96-7/99
Average* (percent per year)	13.41	13.72	13.17
Standard deviation	1.82	1.95	1.68
Nomalized standard deviation	0.14	0.14	0.13
Maximum	17.00	17.00	17.00
Minimum	9.50	10.50	9.50
Total months	67	30	37
Frequency of changes	1.60	1.67	1.54
Frequency of turning points	7.44	7.50	7.40
Increases	16	12	4
Decreases	26	6	20
Increases average	0.97	0.78	1.55
Decreases average	-0.54	-0.72	-0.49
Increases standard deviation	0.65	0.46	0.88(0.4**
Decreases standard deviation	0.29	0.42	0.22

*Simple average.

****** Excluding November.

Table 5. Statistical Characteristics of the Inflation Rate

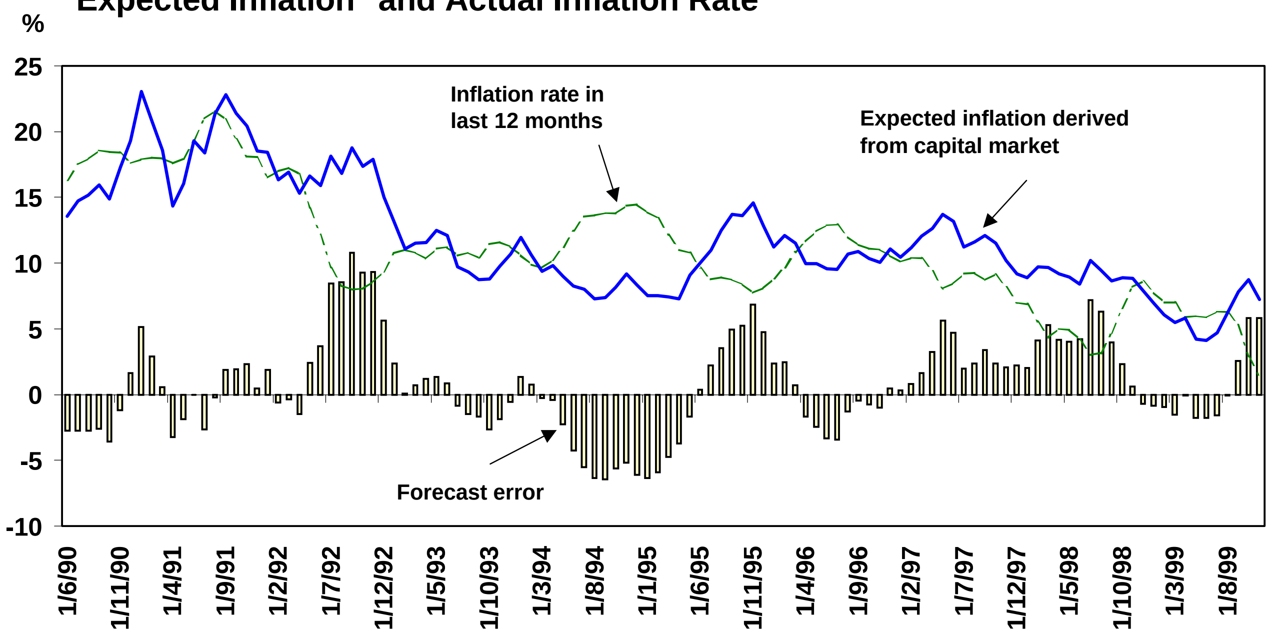
	1/94-7/99	1/94-6/96	7/96-7/99
Average (percent per year)	9.31	11.18	7.79
Standard deviation	2.89	2.09	2.54
Normalized standard deviation	0.31	0.19	0.33
Maximum	14.45	14.45	12.93
Minimum	3.03	7.75	3.03
Total months	67	30	37

Table 6. A Brief History of Bank of Israel Interest Rate Changes

	The Change in the Interest Rate (percentage points)	Date of Announcement
10.50		28/12/93
10.92	0.42	09/05/94
11.52	0.60	23/05/94
12.06	0.54	27/06/94
12.50	0.44	26/07/94
14.00	1.50	29/08/94
15.50	1.50	25/09/94
17.00	1.50	28/11/94
16.30	-0.70	21/02/95
14.80	-1.50	19/03/95
14.00	-0.80	24/04/95
13.50	-0.50	29/05/95
13.20	-0.30	24/07/95
13.70	0.50	21/09/95
14.20	0.50	23/10/95
13.70	-0.50	25/12/95
14.00	0.30	29/01/96
14.80	0.80	21/04/96
15.50	0.70	27/05/96
17.00	1.50	24/06/96
16.30	-0.70	29/07/96
15.80	-0.50	26/08/96
15.50	-0.30	24/09/96
15.20	-0.30	28/10/96
14.70	-0.50	23/12/96
14.20	-0.50	27/01/97
13.90	-0.30	24/02/97
12.70	-1.20	18/06/97
13.40	0.70	25/08/97
12.90	-0.50	26/01/98
12.60	-0.30	23/02/98
12.20	-0.40	23/03/98
11.90	-0.30	27/04/98
11.60	-0.30	25/05/98
11.30	-0.30	22/06/98
11.00	-0.30	27/07/98
9.50	-1.50	06/08/98
11.50	2.00	26/10/98
13.50	2.00	12/11/98
13.00	-0.50	22/02/99
12.50	-0.50	29/03/99
12.00	-0.50	26/04/99
11.50	-0.50	25/07/99
11.20	-0.30	22/11/99
10.70	-0.50	27/12/99

As indicated, market-based inflation expectations are a key variable in the inflation targeting policy regime. That this is the case is quite transparent from central bank official statements and reports—see, e.g. the Bank's **Annual Report** and **Inflation Report—**and from typical analysis in the media. In fact, some newspapers report daily the previous day's market based measure of inflation expectations. The limitations of this indicator are well known and have been taken into account in the policy process. Moreover, as suggested by the analysis of Bernanke and Woodford (1997), proper conduct of inflation targeting requires using not only market-based expectations but also central bank's own forecasts in monetary policymaking. Among the key limitations of market-based inflation expectations are: (a) the fact that conceptually what is measured from market data on yields on indexed and nonindexed bonds is the sum of expected inflation and the risk premium. Only under the assumption of a constant and zero risk premium it is possible to attribute month-to-month changes in these yields' differential to changes in expectations of inflation. (b) to a large extent, as evident in Figure 2, measured inflation expectations are backward-looking and reflect adaptive behavior by the public. It seems that the level and the fluctuations in 12-months-ahead expected inflation are closely correlated with those of inflation in the last 12 months. Hence, a variable that in principle should contain a strong forward-looking element is largely determined by past performance, though it is well known that for some stochastic processes of the rate of inflation 'adaptive' expectations can be 'rational' after all. This means that it would probably be hard to detect expected future turning points in the inflation process solely on the basis of market based expectations. (c) in a regime where the authorities conduct inflation forecast targeting, based on market-based inflation expectations as one of the key indicators, and where there has been a gradual learning about the anti inflation stance of the authorities, it is very difficult to determine the properties of market based inflation expectations. A sudden rise in expected inflation can trigger a strong interest rate response which in turn succeeds in stopping the inflationary pressures so that at the end of the year, say, inflation is back to the target. Under these conditions, a comparison of expected and actual inflation will lead to a sizable forecast error. Figure 7 depicts 12-months ahead expected inflation and actual inflation as recorded 12 months thereafter. It can be seen that there are periods of considerable measured forecast errors and that these errors exhibit a relatively strong degree of serial correlation. Again, whether these observations correspond to 'irrational' expectations or to 'rational' expectations under frequent changes in fundamentals and gradual learning about the authorities' inflation forecast targeting can not be determined on the basis of these data alone. In any case casual observation suggests that as the 1990s advanced indeed there has been a learning process under inflation targeting by both the authorities and the public at large.

Figure 7
Expected Inflation[a] and Actual Inflation Rate



[a]Expected inflation (market-based) is shifted 12 months forward.

B. Estimating a forward-looking analogue of a 'Taylor Rule' for Israel

As stressed above, there is no simple formula that can summarize the complexity of the interest-rate determination process. Having this important caveat in mind, recent influential research by John Taylor (1993) has developed a relatively simple empirical rule which ex-post describes quite well federal funds rate behaviour under the Fed's policies as a function of the output gap and the rate of inflation. Svensson's (1999) research developed the conditions under an inflation targeting regime that will lead to policy rules of the type estimated by Taylor. In both these analyses it was assumed that the central bank makes no use of any available market based measures of inflation expectations. Here we consider estimates of a relatively plausible interest-rate rule for Israel, which exploits the existence of market-based inflation expectations, of the form:

$$(2) \quad i_t = \alpha_0 + \alpha_1[\alpha_2\pi_t^e + (1-\alpha_2)\pi_{t-1}] + \alpha_3(y_{t-1} - y_{t-2}^*) + \alpha_4 i_{t-1} + \alpha_5 \text{trend}_t + \xi_t$$

With y-y* denoting the gap between the last available annual rate of change of the Bank of Israel's economic activity index and a 12 months annual average calculated from the preceding month backward, trend is a time trend variable that in part will capture the gradual move to increased monetary tightening over time, the lagged dependent variable appears to represent the well known case for partial interest rate smoothing, and the variable

$$\alpha_2 \pi_t^e + (1 - \alpha_2)\pi_{t-1}$$

stands for the inflation 'environment,' which reflects a combination of a backward-looking element, last known annual inflation, and a potentially forward-looking one—i.e., last known expected inflation into the future as of the time of reaching the interest rate decision. Lagged inflation is of importance mainly because of the wide use of wage and financial markets indexation to the CPI, which works with a lag, and expected inflation enters as a variable that potentially includes forward looking elements. In this specification, an increase in inflation expectations, and/or an increase in last known annual inflation would trigger a rise in interest rates.[12] Although in principle the equation should actually include the gap between the inflation 'environment' and the inflation target, this has no major practical importance here because the latter was relatively unchanged in the sample period (see Table 1). As is well known, a linear specification such as equation (2) arises e.g. when the central bank's preference function is quadratic in deviations of the inflation 'environment' from target and in the output gap.

In the econometric implementation, we assured that the timing of the right-hand-side variables reflects that of the last available information before the policy decision was taken. In Israel, the consumer price index for a given month is released on the 15th day of the subsequent month. Then, in the last Monday of every month the central bank announces its decision regarding the level of the interest rate on central bank funds for the subsequent month. To illustrate this, the CPI for June 1999 was released on July 15, and the central bank interest rate for August was announced on July 26. Only in rare occasions there have been deviations from this procedure. Thus, the lagged inflation term corresponds to 2 months previous to the present time. Also, the last-known monthly indicator of economic activity is that for a 3-months lag, and the last known market-based inflation expectations correspond to the 5 weeks that precede the interest rate decision. Parameter estimates based on a sample of monthly data from 1994 to the present are given in Table 7.

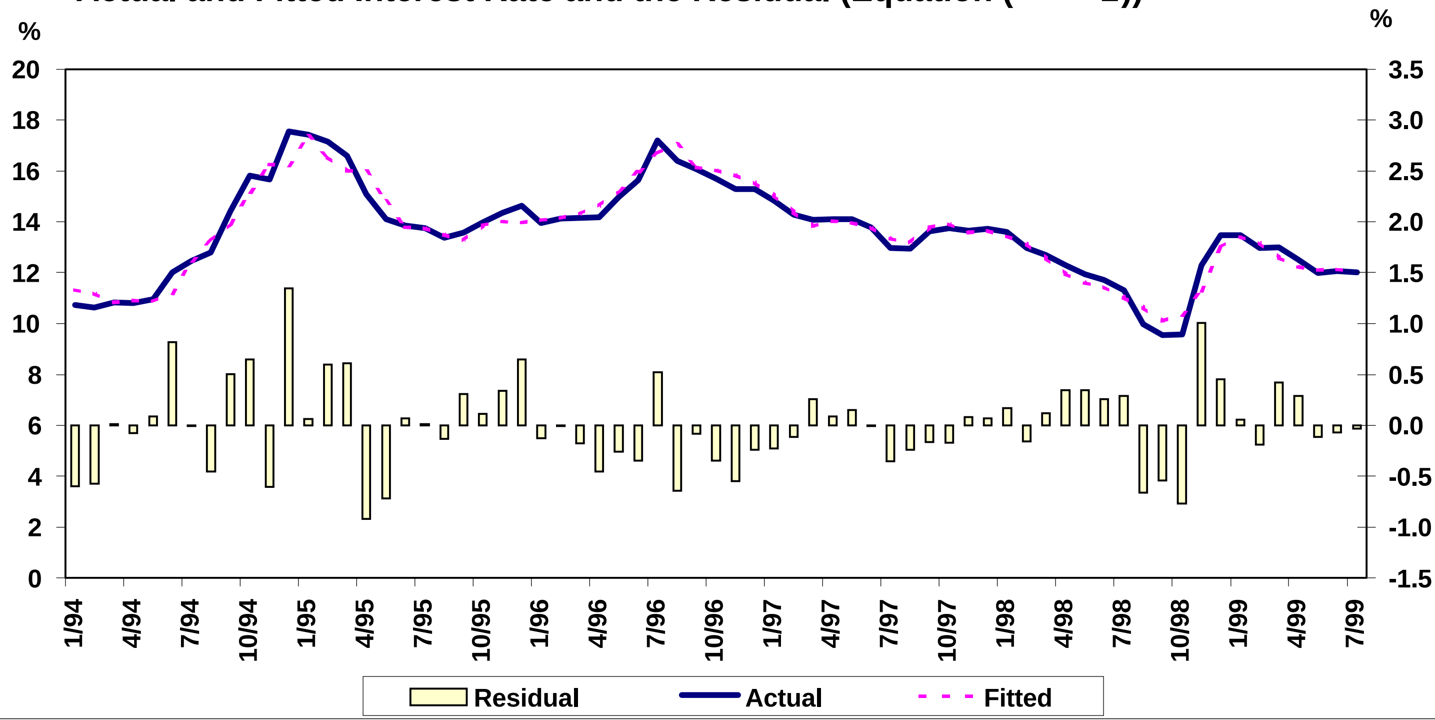
---

[12] Previous work on Bank of Israel's reaction function appears in Gottlieb and Ribon (1997), Djivre and Ribon (1999), Goldberg (1999) and Levanon (1998).

Table 7. Estimates of the Monetary Policy Rule
(1994:01–1999:07)

Std. Error	Coefficient	
0.050	0.013	α_0
0.000	0.500	α_1
0.000	0.747	α_2
0.005	0.079	α_3
0.000	0.497	α_4
0.000	0.0003	α_5
	0.946	R-squared
	0.942	Adjusted R-squared
	1.910	Durbin-Watson stat

Figure 8
Actual and Fitted Interest Rate and the Residual (Equation (2))



It can be seen that on average a rise in the inflation outlook or 'environment' of 1 percentage point in a given month triggers a rise in the central bank rate of 0.5 percentage points. This indicates that in the very short run—say a month—a rise in expected inflation does trigger a rise in the nominal interest rate, yet the impact coefficient is less than unity and the implied ex-ante real rate partially falls in that month. To an important extent, this partial response is consistent with a considerable degree of interest rate smoothing; i.e., when conditions require to change the interest rate, such a change appears to be spread over several months. Accordingly, if the same increase in expected inflation does persist over a whole quarter, the overall response of the nominal interest rate would be close to 1.0, which is line with the estimates obtained by Levanon (1998) and Djivre and Ribon (1999). Within the inflation 'environment' variable, the strongest weight is to market-based inflation expectations, with a weight of 0.75. Figure 8 depicts the actual, fitted, and residual values for equation (2). The equation tracks relatively well the evolution of the central bank interest rate within the sample.[13]

If estimation is conducted for the more recent sample period of 1997:7–1999:7, then the coefficients change in a clear cut pattern (see Table 8): first, there is now a stronger impact of the inflation 'environment' variable on the central bank rate; second, within the inflation 'environment' variable, there is now a stronger effect of forward-looking inflation expectations and lagged inflation is no longer a significant explanatory variable beyond these expectations (we captured this by setting $\alpha_2 = 0$); and third, there is a stronger reaction of contemporaneous interest rates to lagged interest rates, all of which imply that a permanent one percent rise in expected inflation would lead to a rise in the ex-ante central real bank real interest rate, which is consistent with an 'inflation-stabilizing' role of monetary policy; see Clarida, Gali and Gertler.

C. 'Strict' or 'flexible' inflation targeting?

An important issue in characterizing central bank policy under inflation targeting is to determine—in Svensson's (1999) terminology—whether this is a 'strict' or a 'flexible' type of targeting. The first characterization does not allow for countercyclical monetary policy in that the output gap does not enter the interest rate rule beyond its impact on inflation forecasts. The second characterization allows for such a countercyclical monetary policy response. In official statements, Bank of Israel officials have made it clear that their current policy is one of 'strict' inflation targeting, and a common argument has been that in an economy with such a high-inflation history, 'strict' inflation targeting is needed in the first stages of disinflation because of the weak credibility of monetary policy and the need to build reputation for a more effective disinflation. This argument implies that countercyclical policy would be contemplated if and when there is a strong anti-

[13] We have also explored the possible inclusion of foreign interest rates and of the rate of domestic currency depreciation as additional regressors in equation (2). The results did not support the inclusion of these variables. It is plausible that market-based inflation expectations, already included as a regressor in the equation, capture well the potential effects of both these variables on the rate of inflation.

Table 8. Estimates of the Monetary Policy Rule for the Recent Sample (1997:07–1999:07)

Std. Error	Coefficient	
0.052	-0.030	α_0
0.000	0.548	α_1
0.001	0.204	α_3
0.000	0.637	α_4
0.000	0.0007	α_5
	0.932	R-squared
	0.920	Adjusted R-squared
	2.024	Durbin-Watson stat

inflation credibility of monetary policy. However, the fact that there is a nonzero and significant coefficient on the economic activity variable in the interest rate equation would suggest that in practice there is a partial countercyclical element to monetary policy. Yet, whether this is the case or not can not be determined with the present information alone. To the extent that the inflation 'environment' variable is only an imperfect proxy for true expected future inflation, and to the extent that the latter does depend on the level of economic activity, then it is possible for the latter to appear in the equation with a nonzero coefficient, and by itself this need not be interpreted as a deviation from 'strict' inflation targeting. Thus, further work is needed attempting to discriminate empirically strict vs. flexible inflation targeting. These and the other features of the results conform quite well with the findings of Clarida, Gali, and Gertler (1998) for monetary policy in the U.S. and in other industrial countries.

V. Concluding Remarks

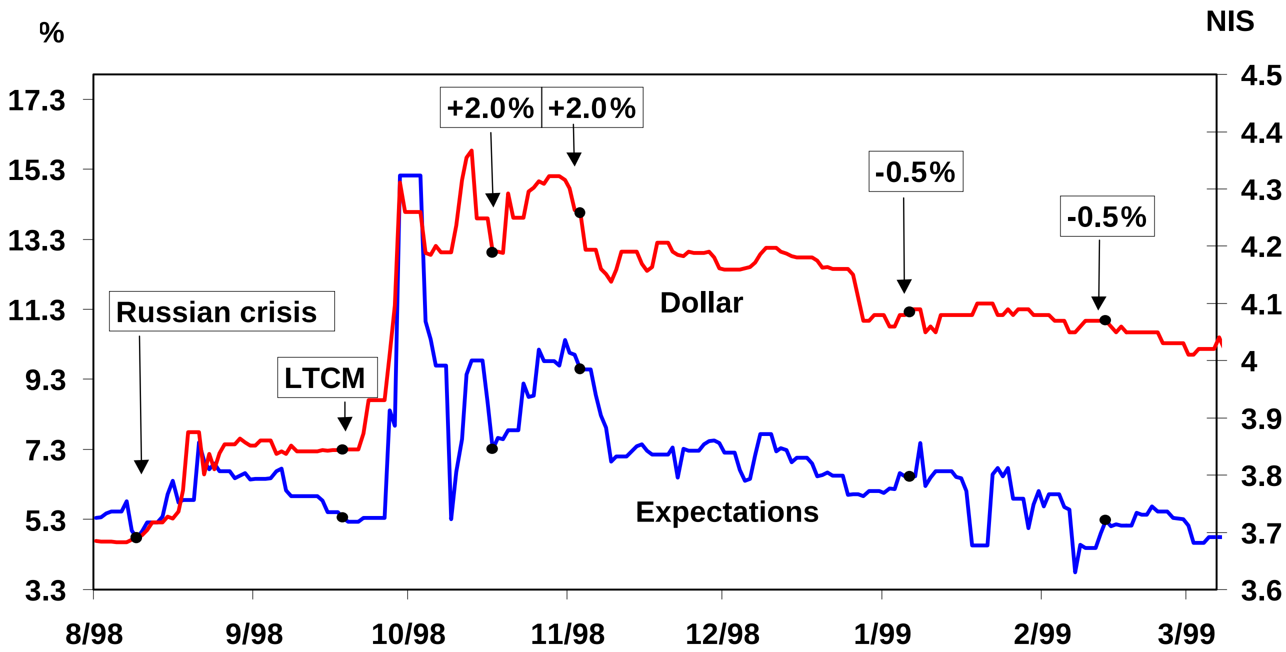
To conclude, it is useful to illustrate the strong interactions between the transmission mechanism in the inflation process and monetary policy rules under inflation targeting with the episode immediately following the Russian crisis and the LTCM failure in the second half of 1998. Because of the increased concern of international investors with their investments in emerging countries, they reduced the size of their position in these countries. Israel was part of this phenomenon, and some foreign positions in the local stock market were liquidated and the funds transferred abroad. These developments led to strong exchange rate depreciation within the very wide currency band. In particular, the depreciation of the NIS against the basket and against the dollar reached about 15 percent on average from August to October 1998. In fact, in three days—from October 6 to 8, 1999—both these exchange rates depreciated by close to 10 percent, a surprising and unusual event in the present Israeli foreign exchange market. See Bank of Israel (1999b).

Following these dramatic events, which occurred under orderly functioning of the foreign exchange market that was not used to this magnitude of shocks, the next policy concern was about their potential implications for inflation acceleration. In the high-inflation past, currency devaluations were typically one-time events that had a strong and permanent impact on prices and on inflation expectations. In an economy with advanced methods of wage and financial markets indexation, there was a very quick passthrough from changes in the exchange rate to actual and expected changes in the rate of inflation. However, this time one could have expected a relatively weaker passthrough because of the increased flexibility in the exchange rate regime, of the weaker state of economic activity, and of the stronger credibility of anti-inflation policy by the central bank. In other words, there were good reasons to believe that there had been some degree of exchange rate overshooting and that eventually some currency appreciation would offset the previous developments.

Figure 9 depicts the daily behavior of the U.S. dollar/NIS exchange rate and of 12-months ahead inflation expectations during this volatile period. Remarkably, the rapid exchange rate depreciation was accompanied by a sharp upward shift in inflation expectations. Along with these developments, there were very high consumer price increases in September, October, and November of 1998. In particular, consumer prices rose by 3 percent only in one month, October 1998; see Figure 10. Given the substantial risk of acceleration in the rate of inflation well beyond the official target, the monetary policy question was how and when to react to these events, while allowing room for the possibility that these events may represent a one-time jump in the price level and not necessarily an increase in the rate of inflation (as was the case in the high-inflation past).

A first element in the policy dilemma was whether to intervene in the foreign exchange market to smooth out exchange rate fluctuations. In spite of many calls for intervention in policy and public discussions, the central bank opted for not to intervene in the foreign exchange market, especially given that such intervention may well create additional incentives for capital outflows and for speculation against the central bank actions. In the Bank's view, this was seen as an opportunity to allow for private market forces to fully determine the exchange rate, while internalizing the true extent of exchange rate risk in the new, more flexible regime. As far as interest rate policy is concerned, the central bank did not increase interest rates in September and October, because it was assessed that this episode may represent more of a price level jump than of a permanent increase in the rate of inflation. It was only toward late October, when there was substantial turbulence in domestic financial markets that the Bank of Israel raised its interest rate by 2 percentage points. However, since this change was not followed by stabilizing trends in the foreign exchange market and in inflation expectations, this prompted a 'surprise' additional interest rate rise of 2 percentage points in early November.

Figure 9
Dollar Exchange Rate and 12 Month Inflation Expectations

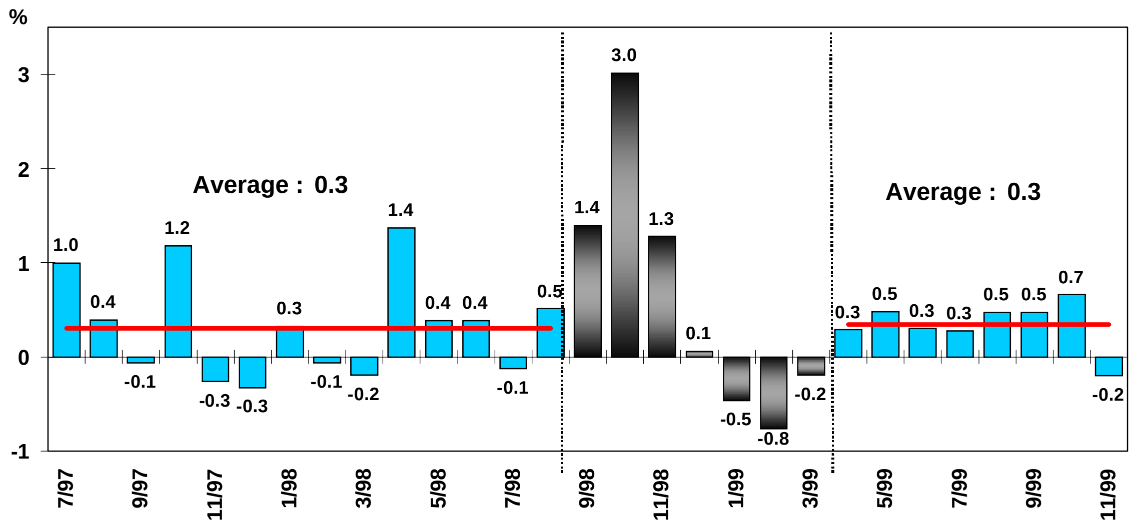


X% Indicates a change in BoI interest rate by X%.

This policy move contributed to generate a reversal in the previous trend of the nominal exchange rate and in inflation expectations. As shown in Figure 10, pretty soon the rate of inflation moved back to its pre-shocks level along with an important degree of domestic currency appreciation (of about 5 percent from December 1998 to March 1999), inflation expectations adjusted downward, and this opened some room for interest rate reductions effected in 1999. As to the passthrough associated with the wide fluctuations in the NIS exchange rate to inflation over this period, our estimates indicate that although the overall passthrough may have remained unchanged in this episode, there has been an increase in the contemporaneous exchange rate coefficient, and a decrease in the lagged one. One possible explanation for this finding is that the size of the exchange rate shifts was so large that it prompted quicker price responses that before.

In sum, we believe these developments provide support to the policy strategy of focusing on achieving the inflation target and allowing for market determination of the nominal exchange rate, with no intervention in the foreign exchange market (unless this market is not operating in an orderly fashion). Four months after the dramatic rise in the central bank rate by 4 percentage points it was possible for the central bank to begin reducing interest rates without jeopardizing the inflation target. By mid 1999, there was a common assessment that inflation had returned to about 4 percent per year—though the rate of inflation for 1999 itself was forecasted to be well below that figure—and this was internalized by the government's decision to set the inflation target for the years 2000 and 2001 as the range 3-4 percent.

Figure 10
Monthly* Rates of Change of CPI



*Month-on-month rate of change.

It would be desirable in future work to explore analytically and empirically various aspects of inflation targeting that emerged from Israel's experience, such as: (a) possible asymmetries in monetary policy actions in the course of a disinflation process, whereby the policy response to deviations of inflation above target are stronger than those when inflation is lower than target; (b) the evolution of the exchange rate passthrough mechanism as related to the process of disinflation, the increased flexibility in the exchange rate regime, the changing credibility of monetary policy and of the inflation target, and the effective degree of openness of the economy vis-à-vis the global economy; and (c) the role of inflation target's, and monetary policy's, credibility in the choice of the degree of fixed vs. flexible inflation targeting.

References

Azoulay, E., and D. Elkayam, 1997, "A Model of the Effect of Monetary Policy on Economic Activity and Inflation in Israel, 1988–1996," Occasional Paper No. 1, Monetary Department, Bank of Israel, (Hebrew).

Bank of Israel, 1999a, *Annual Report 1998*, Jerusalem: Bank of Israel.

Bank of Israel, 1999b, *Inflation Report*, First Half of 1999, Jerusalem: Bank of Israel.

Bar-Or, H., 1997, "On the Passthrough from Exchange Rates to Prices," M.A. thesis, Tel-Aviv University, July.

Bar-Or, H., 1999, "The Inflation Process and the Passthrough from Exchange Rates to Prices in Israel in the 1990's," Internal working paper, Research Department, Bank of Israel, June.

Bernanke, B.S., and M. Woodford, 1997, "Inflation Forecasts and Monetary Policy," *Journal of Money, Credit and Banking* 29, pp. 653–684.

Bufman, G., L. Leiderman, and M. Sokoler, 1995, "Israel's Experience with Explicit Inflation Targets: a First Assessment", In Leiderman and Svensson.

Bufman, G., and L. Leiderman, 1999, "Monetary Policy and Inflation in Israel," Discussion Paper 98.04, Research Department, Bank of Israel. Also in Leiderman (1999).

Clarida, R., J. Gali, and M. Gertler, 1998, "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory," Discussion Paper No. 1908, CEPR, June.

Dahan, M., and M. Strawczynski, 1997, "Fiscal Policy and Inflation in Israel," Manuscript, Research Department, Bank of Israel. Also in Leiderman (1999).

Djivre, J., and S. Ribon, 1999, "Monetary Policy, the Output Gap and Inflation—The Case of Israel," unpublished manuscript, Research Department, Bank of Israel, April.

Frenkel, J.A., "Central Bank Independence and Monetary Policy for Price Stability," in Leiderman (1999).

Goldberg, D., 1999, "Interest Rate Smoothing in Inflation Targeting Models," M.A. thesis, Tel Aviv University, June.

Gottlieb, D., and S. Ribon, 1997, "Private International Capital Movements and Monetary Policy in Israel—October 1988 to March 1997," Discussion Paper No. 97.09, December, Research Department, Bank of Israel.

Kahn, M., S. Kandel, and O. Sarig, 1998, "Real and Nominal Effects of Central Bank Monetary Policy," Unpublished manuscript, Monetary Department, Bank of Israel (May).

Leiderman, L. (ed.), 1999, *Inflation and Disinflation in Israel*, Jerusalem, Bank of Israel.

Leiderman, L., and L.E.O. Svensson (eds.), 1995, *Inflation Targets*, London: CEPR.

Leiderman, L. and G. Bufman, 1996, "Searching for Nominal Anchors in Shock-Prone Economies in the 1990s: Inflation Targets and Exchange Rates Bands," in *Securing Stability and Growth in Latin America: Policy Issues and Prospects for Shock-Prone Economies*, ed. by R. Hausmann and H. Reisen (Paris: OECD).

Levanon, G., 1998, "On the Bank of Israel's Reaction Function," M.A. thesis, Tel Aviv University.

Morande, F., and K. Schmidt-Hebbel, 1999, "The Scope for Inflation Targeting in Emerging Market Economies," unpublished manuscript, Central Bank of Chile.

Sokoler, Meir, 1997, "Credibility Half-Won in an Ongoing Battle: An Analysis of Inflation Targets and Monetary Policy in Israel," Working Paper, Monetary Department, Bank of Israel. Also in Leiderman (1999).

Svensson, L.E.O., 1999, "Inflation Targeting as a Monetary Policy Rule," *Journal of Monetary Economics* 43, pp. 607–654.

Taylor, J.B., "Discretion versus Policy Rules in Practice," *Carnegie-Rochester Series on Public Policy* 39, pp. 195–214.