Monetary Policy and Inflation in Israel

by

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ABSTRACT

Monetary policy is the subject of sharp debate in Israel. Establishing a set of basic empirical regularities on these issues is a clear prerequisite for resolving these controversies. The purpose of this paper is to provide a body of empirical evidence on the role of monetary policy measures in the inflation process.

Based on a sample of quarterly data from 1989 to 1997 we find that there is a close association between movements in the rate of inflation and shifts in monetary policy variables. The empirical results show that the impact of monetary policy variables—such as the rate of change of M1 beyond the rate of growth of GDP and the ex-ante real interest rate on Bank of Israel funds—on the rate of inflation works with lags that peak at about two quarters after the change in the monetary variable. Moreover, a relatively simple inflation equation does a relatively satisfactory job at predicting—in a one-step-ahead sense--most recent quarterly movements in the rate of inflation.

The empirical methodology was applied in order to account for the reduction in the rate of inflation from about 16-18 percent in the period before 1991-92 to about 10 percent per year thereafter. The paper quantifies various developments in key variables, such as fiscal, monetary, labor market, and external that combined to produce a decline in the rate of inflation.

I. INTRODUCTION

Monetary policy is the subject of sharp debate in Israel. From a highly accommodative policy in the late 1970s and early 1980s, there have been marked changes in policy over time up to the adoption of explicit inflation targets from 1992 to the present. At the center of the debate are important issues such as: the ability of monetary policy to have an impact on movements in the rate of inflation; the effectiveness of monetary policy in a small open economy operating under a nominal-exchange-rate commitment; the side effects of monetary policy; and the management of policy under inflation targets.

Establishing a set of basic empirical regularities on these issues is a clear prerequisite for resolving these controversies. The purpose of this paper is to provide a body of empirical evidence on the role of monetary policy measures in the inflation process. The main focus of the paper is not on the potential role of monetary policy in a major disinflation program such as the 1985 economic stabilization plan. Instead, we concentrate on a given inflation environment—such as the period from the late 1980s to the present—and explore the explanatory role of monetary policy measures for movements in the rate of inflation. Needless to say, a comprehensive analysis of the inflation process would include a discussion of the role of important non-monetary fundamentals such as fiscal policy, wage policy, and so on. These additional fundamentals are especially important when dealing with sharp changes in the inflation environment.[1] While some of these factors are taken into account in the present paper, the analysis needs to be extended in future work.

The paper is organized as follows. Section II briefly describes recent monetary regimes in Israel, including the present system in which an explicit inflation target co-exists with a crawling exchange rate band. In addition, the section draws on recent work by Lars Svensson to present a basic analytical framework for dealing with forward-looking monetary policy under inflation targets. Section III discusses various transmission mechanisms for the impact of money on inflation and documents some basic empirical regularities on the role of monetary aggregates and interest rates in the inflation process. Section IV presents our main econometric findings on the relation between monetary policy variables, other macroeconomic variables, and the rate of inflation. We report estimates of various econometric specifications for inflation equations and discuss how these estimates

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[1] On the role of fiscal policy in the inflation process in Israel, see e.g. Bruno (1993), Leiderman (1993), and Dahan and Strawczynski (1997).

can be used to forecast inflation in future periods.[2] In Section V we present the main conclusions from this research.

II. MONETARY POLICY UNDER INFLATION TARGETING

Monetary policy in Israel has gone through major changes in recent years. From a highly accommodative policy in the late 1970s and early 1980s, which supported the escalation of inflation to triple-digit figures, the first phase in the aftermath of the remarkable stabilization program of June 1985 featured a policy oriented toward sustaining a fixed-but-adjustable nominal exchange rate, considered as a key nominal anchor in disinflation. Throughout this first phase after the stabilization program, from 1986 to 1991, the rate of inflation stayed in the range of 16-18 percent on average per year. This was followed by a second phase, the period from 1992 to the present, characterized by the modification of the exchange rate regime to a crawling exchange rate band and by the adoption of an explicit inflation target. In this period, the average rate of inflation was reduced to about 10 percent per year.[3] At the same time, during this period there has been **a gradual shift toward increased flexibility of the nominal exchange rate coupled with increased emphasis on inflation targeting.**

Current monetary policy in Israel is oriented toward achieving the inflation target set by government while maintaining and supporting, at the same time, the exchange rate's crawling band. When compared to most other countries that adopted explicit inflation targets, Israel's case is unique for at least three reasons. First, it is one of the only cases in which in spite of the attempts to keep inflation relatively low, there are still some institutions and modes of operation left over from the era of triple digit inflation. Second, at variance with other cases there is a considerable degree of ambiguity about the nature and operational meaning of inflation targets as a pre-commitment device not only for monetary policy but for fiscal policy as well. In part this reflects the fact that initially inflation targets were introduced in the somewhat technical context of determining the slope of the crawling exchange-rate band. It was only recently that inflation targets have been

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[2] Some of the specifications that we use are similar to those developed in recent years in important work by Azoulay and Elkayam (see references).

given more fundamental importance, as e.g. indicated by the fact that the target for 1998 has been discussed in detail in several cabinet meetings and has been set jointly--for the first time (in July 1997)--with the setting of the targets for the government budget for that year. Third, Israel is one of the very few cases where inflation targets coexist with another nominal commitment, namely the crawling exchange rate band; other such cases are Chile, Colombia and Poland. Accordingly, under a considerable degree of international capital mobility, concrete dilemmas about policy have emerged as a result of shocks and developments that gave rise to conflicts between the monetary policy measures required to achieve each one of these two targets.[4]

As in other countries [see e.g. Leiderman and Svensson (1995)], the explicit inflation target in Israel has become a key nominal anchor in the economy and as such plays two main roles. First, it provides a transparent guide to monetary policy, the commitment, discipline, and accountability of which can be judged according to whether policy actions were taken to ensure that the target is achieved. Second, if credible it should serve as a coordination device in the wage- and price-setting process and in the formation of the public's inflation expectations. In an economy with a large public sector as Israel, the credibility of the inflation target can be strengthened if the specific target that was chosen serves also as a coordination device in the setting of public-sector wages, of prices of public-sector utilities, and of the price deflator used to translate real government spending into nominal government budget figures.

1. Inflation Targeting: Analytical Basis

Since inflation targeting is a relatively new framework for conducting monetary policy in Israel as well as in other countries it is well to briefly discuss some of the analytical basis underlying such a framework and its policy implications. It is convenient to do so by drawing on the recent important contributions by Lars Svensson (1997a, 1997b). On the motivation for and application of inflation targets in different countries, see e.g. Leiderman and Svensson (1995).

Consider the model in Svensson (1997a):

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[3] For description and analysis of monetary and exchange rate policies in recent years, see, e.g., Bruno (1993), Leiderman (1993), Helpman, Leiderman, and Bufman (1994), Bufman, Leiderman and Sokoler (1995), Leiderman and Bufman (1996), and Sokoler (1997).

[4] See Bufman, Leiderman, and Sokoler (1995) for a more detailed discussion of the history of the adoption of inflation targets in Israel.

$$\pi_{t+1} = \pi_t + \alpha_1 y_t + \alpha_2 x_t + \varepsilon_{t+1} \qquad (2.1)$$

$$y_{t+1} = \beta_1 y_t - \beta_2 (i_t - \pi_t) + \beta_3 x_t + \eta_{t+1} \qquad (2.2)$$

$$x_{t+1} = \gamma x_t + \theta_{t+1} \qquad (2.3)$$

where $\pi_t = p_t - p_{t-1}$ is the inflation rate in year t, p_t is the log price level, y_t is the log of output relative to potential output, x_t is an exogenous variable that represents an impulse to aggregate demand (e.g., fiscal policy), i_t is the monetary policy instrument (say, the interest rate on central bank funds) and $\varepsilon_t, \eta_t, \theta_t$ are i.i.d. random variables with a zero conditional mean. The coefficients α_1 and β_2 are assumed to be positive, the other coefficients are assumed to be nonnegative; β_1 and γ in addition fulfill $\beta_1 < 1$, $\gamma < 1$. The long run natural output level is normalized to equal zero. Although this is a closed-economy formulation, which can be extended to an open economy setting (see below), it helps to illustrate the considerations that affect the conduct of monetary policy under inflation targets in both these cases.

From equation (2.1), which is a version of a short term Phillips curve, the acceleration in the rate of inflation is increasing in lagged output and the lagged exogenous variable. Equation (2.2), which can be viewed as an IS relation, posits that output in the current period depends on output in the previous period, on the lagged real interest rate and the lagged exogenous variable[5]. Equation (2.3) gives the evolution of the exogenous variable as a first-order autoregressive process. It can be seen that here the nominal interest rate set by the central bank affects output with a one-year lag and inflation with a two period lag. Hence from the standpoint of influencing the path of inflation, the model embodies a 2 period policy lag. That this is the case can be verified by expressing inflation at t+2 in terms of time t variables:

$$\pi_{t+2} = a_1 \pi_t + a_2 y_t + a_3 x_t - a_4 i_t + (\varepsilon_{t+1} + \alpha_1 \eta_{t+1} + \alpha_2 \theta_{t+1} + \varepsilon_{t+2}), \qquad (2.4)$$

where

$$a_1 = 1 + \alpha_1 \beta_2; a_2 = \alpha_1 (1 + \beta_1); a_3 = \alpha_1 \beta_3 + \alpha_2 (1 + \gamma); a_4 = \alpha_1 \beta_2. \qquad (2.5)$$

Inflation at time t+2 is increasing in the rate of inflation, the output gap, and the exogenous variable at time t, and is decreasing in the nominal interest rate set at time t. Notice that the equation can be rewritten to include the real interest rate on central bank funds in the right hand side:

$$\pi_{t+2} = \pi_t + \alpha_2 y_t + \alpha_2 x_t - \alpha_4 (i_t - \pi_t) + (\varepsilon_{t+1} + \alpha_1 y_{t+1} + \alpha_2 \theta_{t+1} + \varepsilon_{t+2}) \qquad (2.6)$$

How should monetary policy be conducted in this model? Assuming, as in Svensson, that government has set an inflation target of π^* (say, 8.5% per year), that the central bank acts to minimize the expected sum of the discounted losses from current and future deviations of the rate of inflation from the inflation target set by government and that the period loss function is quadratic, the first-order condition for this minimization problem can be expressed as

$$\pi_{t+2|t} = \pi^* \qquad (2.7)$$

where $\pi_{t+2|t}$ is the current (i.e., time t) conditional forecast of the rate of inflation at t+2. Accordingly, the central bank should engage in what Svensson termed "inflation forecast targeting," that is, **to set the interest rate so as to equate its own two-year forecast of the rate of inflation with the inflation target.** This yields the central bank's optimal interest rate rule:

$$i_t = \pi_t + b_1(\pi_t - \pi^*) + b_2 y_t + b_3 x_t, \qquad (2.8)$$

where

$$b_1 = \frac{1}{\alpha_1 \beta_2}; b_2 = \frac{1+\beta_1}{\beta_2}; b_3 = \frac{\alpha_1 \beta_3 + \alpha_2(1+\gamma)}{\alpha_1 \beta_2}, \qquad (2.9)$$

which is a reaction function similar to a Taylor (1993) rule. A central bank equipped with this rule will raise the nominal interest rate on its funds in reaction to any one of the following events: a rise in the rate of inflation (above the inflation target), an increase in output relative to potential, and a rise in the exogenous impulse x_t. As stressed by Svensson, the interest rate depends on current values of inflation, the output gap and the exogenous variable not because current inflation is targeted but because in the model these current variables have persistent effects and predict future inflation. Absent monetary policy change, an increase in current output above potential or a more expansionary fiscal policy (say, an increase in x_t) predict a future deviation of inflation ($\pi_{t+2|t} - \pi^*$) from target. Other things equal, these events call for a rise in the current interest rate in order to

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[5] As shown in Svennson (1997a) the model can be extended to incorporate an LM relation through inclusion of the money market. This would enable to determine a "steady state" value for the rate of inflation, π.

achieve (in a conditional expectation sense) the inflation target.[6] Svensson shows that inflation targeting via an interest rate reaction function is more efficient, in the sense of bringing lower inflation variability, than money growth or exchange rate targeting.

Although this is a relatively simple model of the economy--one that can be extended to an open-economy framework--it captures the essence of forward-looking monetary policy under inflation targets: achieving these targets in the future requires (in the presence of lags) adjusting current monetary conditions in response to current and expected future developments that could lead to deviations of inflation from target. If policy is conducted in this way (i.e., via equation 2.4) the inflation forecast equals the target, and ex-post inflation will differ from the target only because of random shocks whose realization could not be predicted at the time of formulating the policy. Notice that while policy is successful in achieving the target in this case, there will be no simple statistical relation between the interest rate and the rate of inflation: although the inflation rate will be equal, on average, to the target, the interest rate will fluctuate in order to offset potential deviations of inflation from target that may arise due to movements in the output gap (y_t) and in the exogenous variable (x_t, say due to fiscal policy). Hence, the more fundamental link relates a change in the monetary conditions now with the deviation of future inflation from target that would have taken place in the absence of such an adjustment in current monetary conditions. Put differently, the arrival of new information about inflation forecasts which may imply future deviations of inflation from target can trigger interest rate adjustments aimed at avoiding the emergence of such deviations.

2. Recent Inflation Performance

That recent developments featured severe challenges to official inflation targets is evident from Figure 1.[7] This figure depicts the evolution of the rate of inflation, inflation targets, and market-based expected inflation in Israel from 1992 to the present. As common in Israel, expected inflation is derived from the yields on indexed and non-indexed

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[6] As shown by Svensson, to the extent that the loss function of the central bank includes also deviations of output from potential output, the optimal interest rate rule is of the same from as equation (2.8), yet the absolute value of the b_1 coefficient is smaller, and the absolute value of the b_2 coefficient is larger, than for the loss function in the text. Extending the basic model to a small open economy would introduce additional transmission mechanisms for monetary policy, especially through its impact on nominal and real exchange rates.

[7] For more detailed discussion of these and related developments, see Bank of Israel, Annual Report, issues from recent years.

bonds traded in the local capital market. It can be seen that there have been several periods in which the rate of inflation deviated from target. Measured from December of a given year to December of the previous year, as in the specification of the target, the largest deviation of inflation from target occurred in 1994, when annual inflation reached 14.5 percent against a target of 8 percent. However, in the following years of 1995 and 1996 the targets were achieved (and any deviations that occurred were quite minimal). Overall, with a multiyear perspective it can be argued that **inflation targets have been achieved on average**: the average annual rate of inflation from 1992 to 1996 was 10.2 percent which is very close to the average upper-limit annual inflation target of 10.8 percent.
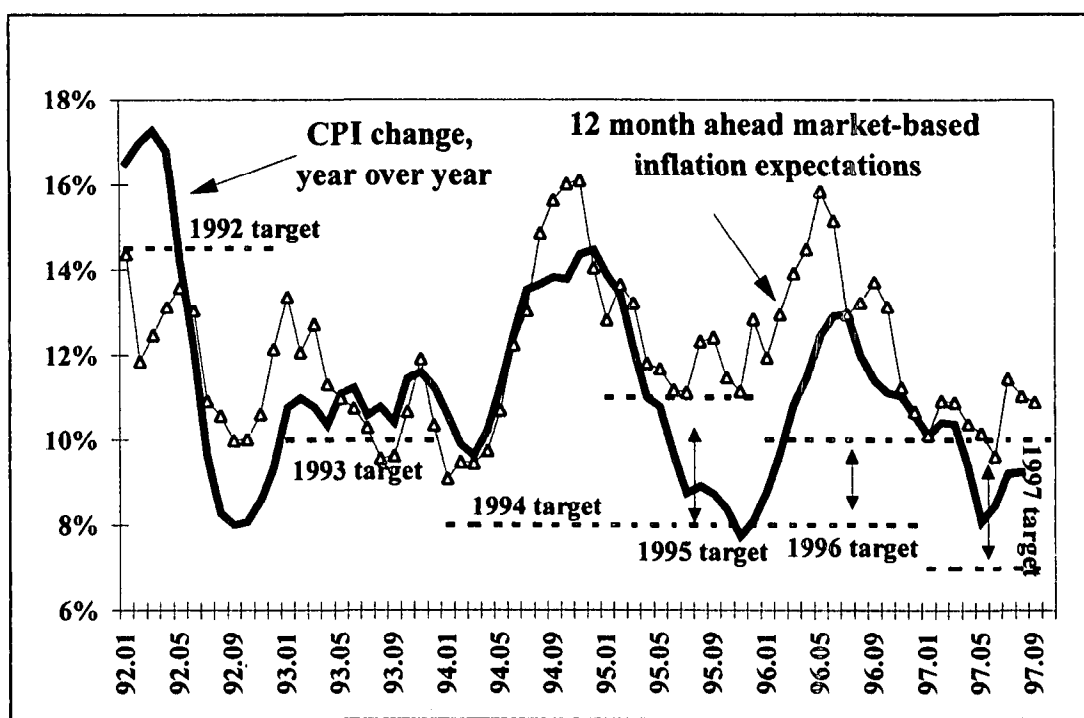
Figure 1: Inflation in Israel – actual, expected and targets.

Having established that annual inflation targets were achieved on average in the past five years, it is well to stress that there were two major episodes of acceleration of the rate of inflation <u>within</u> the years well above the target: these occurred in late 1994 and in the first half of 1996; see Figure 1. In both these cases the regime was challenged and its credibility was endangered, as captured by the escalation of inflation expectations to about 15 percent per year.

These developments occurred in the face of strong inflationary pressures arising from a relatively overheated economy, in which there was a marked decline in the rate of unemployment, and from a fiscal policy that took an expansionary stance. The fiscal

expansion in the period from 1994 to 1996 initially took the form of an increase of government expenditures in 1994 by about 6 billion NIS (2.7 percent of GDP) beyond the originally planned level that was the basis for that year's budget law. Then, the domestic budget deficit reached 3.2 percent of GDP in 1995 compared to the budget target that was set at 2.75 percent of GDP; and subsequently there was an additional, but sharper, overrun of the domestic budget deficit target in 1996 that reached 4.6 percent of GDP compared to a target of 2.5 percent of GDP. At the same time, during the above mentioned period, the economy rapidly moved towards "full employment" and the rate of unemployment declined from a peak of 11.2 percent in 1992 to 7.8 percent in 1994, 6.9 percent in 1995 and 6.7 percent in 1996. This move was accompanied by demand pressures on Israel's domestic resources, a development that was evident in the rate of expansion of domestic uses, that exceeded the rate of GDP growth, and in a rapid deterioration in the current account deficit of the balance of payments, which reached 5.6 percent of GDP in 1996.

These circumstances created a situation where restrictive monetary policy was needed in order to counterbalance expansionary fiscal policy and the demand pressures in an overheated economy and to reduce the implied deviation of the rate of inflation from government's inflation target.[8] There is no doubt that much of the public discussion and debate in Israel about inflation targets has to do with the evaluation of these two salient episodes which represented a severe challenge to the inflation targets and an overburdening of monetary policy.

3. The Crawling Exchange-Rate Band

Figure 2 gives the evolution of Israel's nominal exchange rate vis-a-vis a basket of foreign currencies and of the crawling exchange rate band. This crawling exchange rate band was introduced in late 1991, as a part of relaxing the fixity of the previous band system that was based on a fluctuation zone around a fixed central parity rate. The move to a more flexible system came after a series of speculative attacks on the NIS during the 1988 to 1991 period which were mainly based on the perception that a fixed exchange rate was not sustainable in view of the persistent domestic-foreign inflation differential. During this period, the interest rate was used entirely to cope with speculative attacks on Israel's foreign currency reserves and not as an instrument aimed at achieving a given inflation objective. From 1992 onwards there were no major threats to the exchange rate regime and the interest rate gradually gained a central role in the effort to meet the inflation target

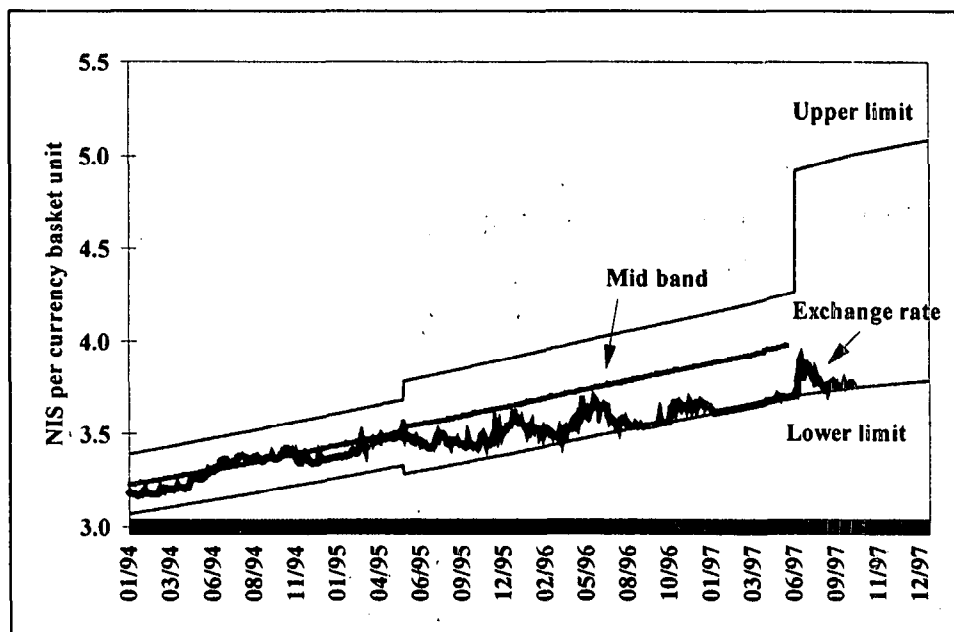that was introduced, for the first time, in December 1991 as a part of the new crawling exchange rate band system.[9]

Figure 2: The crawling exchange rate band.

During the majority of the crawling band's life span until 1996, the central bank operated an inner, intramarginal, intervention band, aimed at keeping the exchange rate relatively close to the central parity rate. During the period when capital inflows grew considerably—in part due to the progress in the Middle East peace process from late 1993 onwards and in part as a result of financial opening and liberalization measures taken in previous years—this intervention resulted in the Bank of Israel purchasing the considerable excess supply in the foreign exchange market, with little change in the nominal exchange rate. In late May 1995, the Bank of Israel and the Ministry of Finance announced the widening of the exchange rate band from 5 percent to 7 percent around the central parity rate. The initial purpose of this step was to adjust the exchange rate regime so as to potentially allow greater exchange rate flexibility. In spite of the potential increase in exchange rate risk, after a few weeks there was a strong tendency for the exchange rate to appreciate within the band, and the central bank returned to large scale intervention in the foreign currency market. It is evident that the perceived implicit commitment of the Bank

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[8] In terms of Svensson's model, it is as if all of the right-hand-side terms in equation (2.8) increased thus calling for an upward shift in the central bank nominal interest rate.
[9] Specifically, the slope of the crawl (in annual terms) was set equal to the difference between the inflation target and a forecast of foreign inflation.

of Israel to the inner band was interpreted by market participants as a signal that there was little risk associated with exchange rate fluctuations. The combination of this perception and a sizable domestic-foreign interest rate differential provided an additional incentive for domestic agents to shift from domestic-currency denominated credit into borrowing abroad, thus strengthening short-term capital inflows and their pressure toward nominal exchange rate appreciation.

The foregoing developments prompted policy decisions that enabled increased exchange rate flexibility. Specifically, the inner band was abandoned in February 1996 and as a result there was a larger room for movements of the exchange rate within the band. By the summer of 1996 the exchange rate appreciated to the band's lower (i.e., strongest) limit. With the background of a continuation of capital inflows and pressure for nominal exchange rate appreciation, the next and latest change in the band's parameters occurred in June 1997 when additional room for exchange rate flexibility was introduced in the form of enlarging the band's width from 14 percent to 28 percent, to be gradually increased later on, until mid-1998, to 30 percent. The increase of the band's width was implemented entirely through the raising of the upper (i.e. weakest) limit of the band. Parallel to the upward widening of the band, the rate of crawl of the band's lower limit was reduced to 4 percent per year and leaving the slope of the upper limit at 6 percent per year.

In sum, it seems that the very slow and gradual move toward increased flexibility of the nominal exchange rate, under considerable capital mobility and strong inflationary pressures in the economy, contributed to the conflict that monetary policy in Israel has faced over the last two-three years in the attempt to support two nominal goals (i.e. the inflation target and the exchange rate band) with one instrument (i.e. the interest rate). In other words, the level of the interest rate that was required to ensure meeting the inflation target has been larger than the level of the interest rate that would have resulted in no pressures on the exchange-rate band limits. Instead, since the exchange rate band limits became a binding constraint a large degree of sterilized intervention of capital inflows was required—sterilization that carried with it a sizable quasi-fiscal cost.

4. Interest Rate Adjustments

The implications of the interaction between current and expected future developments on current monetary policy adjustments can be discussed in terms of developments in Israel with Figures 1 and 3. From Figure 3 are clear the two recent salient episodes of marked interest rate rises by the central bank which occurred in late 1994 and early 1995 as well as in the second half of 1996. While there is no official or

commonly used inflation forecast formulated by the Bank of Israel, there is a wide use of market-based inflation expectations—namely, expectations derived from yields on indexed and non-indexed bonds traded in Israel's capital market. In many cases, these expectations, plotted in Figure 3, have served a similar role as the inflation forecast, $\pi_{t+2|t}$, as in Svensson's model. In fact, the above-mentioned interest rate rises were triggered by a combination of factors included in the reaction function (2.8): a rise in expected inflation, a rise in government's budget deficit, and reductions in the rate of unemployment. Along similar lines, when these factors signaled an easing of inflationary pressures the central bank adjusted interest rates in the downward direction.
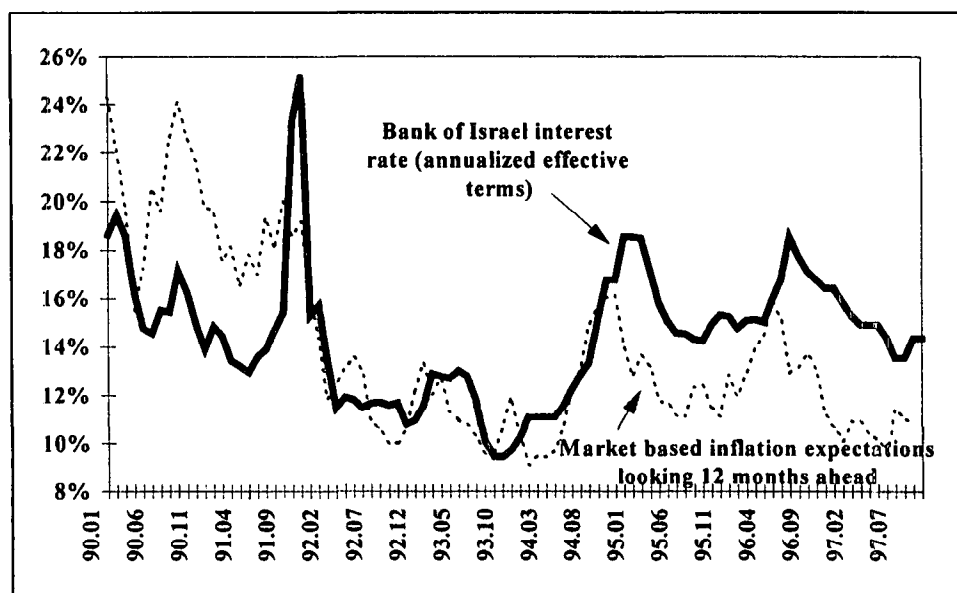
Figure 3: Inflation expectations and the interest rate on Bank of Israel funds.

Overall, recent monetary policy developments in Israel illustrate how monetary policy can become severely overburdened in its attempt to achieve the inflation target when other key factors (such as fiscal policy and the state of the business cycle) exert strong upward pressures on the rate of inflation. In addition these developments illustrate that, under a high degree of capital mobility, the coexistence of an exchange rate band and inflation targeting may make the job of monetary policy more difficult than in the absence of an explicit exchange rate commitment, especially when the level of the interest rate required based on inflation targeting considerations sharply differs from that consistent with the lack of pressures on the exchange rate band. In order to avoid potential conflicts among these nominal targets it would be useful if the authorities could prioritize their objectives in a clear and transparent manner. One possible arrangement is to make official

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inflation targets the key objective of monetary policy, and to allow for relatively free movements of the exchange rate. Alternatively, if there are any implicit or explicit exchange rate targets, these could be subordinated to the inflation target. In fact, almost all countries that are implementing inflation targeting have given primacy to the inflation target over any available intermediate targets.

III. MONETARY FACTORS AND THE INFLATION PROCESS

In this section we discuss various aspects of the role of monetary factors in the inflation process in Israel. In particular, we present some basic empirical regularities about the link between money and prices and elaborate on changes in monetary policy in the 1990s under inflation targeting.

1. Transmission Mechanisms

There are various channels of transmission from fluctuations in monetary policy variables to movements in the rate of inflation.[10] When policy alters the path of monetary aggregates or of short term interest rates, the impact of these on the rate of inflation may work through at least one of the following channels (some of which were incorporated in the Svensson model of the previous section) :

[a] Long-term interest rates and aggregate demand. Other things equal, in the short run a rise in short-term interest rates is likely to lead to a rise in long-term rates—the exact impact depending on the term-structure of interest rates—which in turn can be expected to lead to slower growth of aggregate consumption and investment and of prices.

[b] Real balance and wealth effects. Similarly to the above, a reduction in the rate of growth of outside money may generate real-balance and wealth effects that lead to slower aggregate demand growth. These effects can become particularly strong in the presence of a large body of liquidity-constrained economic agents.   [c] Nominal exchange rates. In a small open economy, changes in short-term interest rates can have an immediate impact on the nominal exchange rates of the domestic currency against foreign currencies. Nominal exchange rate fluctuations, in turn, typically will affect the domestic prices of a large number of goods and services, whose pricing closely follows that in foreign countries, but

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[10] For a detailed discussion of transmission mechanisms in a small open economy, see The Transmission of Monetary Policy in Canada, Bank of Canada, 1996.

expressed in domestic currency units. In addition, in the short run nominal exchange rate fluctuations can influence the path of domestic-currency denominated goods and services such as housing prices and rentals.   [d] Inflation expectations. Expectations are a key variable in the dynamics of the inflationary process. Changes in monetary policy can influence the evolution of these expectations, which in turn may affect the price- and wage-setting process as well as the pricing of various assets.

[e] Credit channel. Changes in monetary conditions may also influence the volume and terms of credit in the economy. On the one hand, there is a credit channel affecting aggregate consumption and investment decisions; on the supply side, shifts in credit may affect production and employment decisions. As in item [b], the existence of liquidity constraints can strengthen these credit-channel effects.

Previous research has stressed that it is very difficult to determine which of the above channels of transmission is the dominant one at a given point in time. First, the various channels may work with different lags. For example, the lags for nominal exchange rates impact on prices is likely to be shorter than for real-balance- or wealth effects. Moreover, these lags are likely to change over time. Second, the specifics of the transmission mechanism may not be invariant to frequently observed changes in policy regimes and in the structure of the behavioral relations describing the economy. Accordingly, what might have been a strong transmission channel from nominal exchange rates to prices in a high-inflation environment might become a much weaker channel under low inflation. Along similar lines, substantial changes in the degree of international capital mobility can alter the specifics of the transmission mechanism. It is not surprising that these complications have given rise to different positions and debates on the specifics of the transmission mechanism for monetary policy.

In spite of the foregoing considerations, there are some basic relations between monetary policy variables and the rate of inflation that can be expected to hold independently of the exact nature of the transmission mechanism. Given the lack of a fully blown structural model of the Israeli economy, we concentrate below on an empirical investigation of various such basic relations. In particular, popular macroeconomic models embody a money-market equilibrium condition which can be expressed in dynamic terms as:

$$\pi = \frac{\Delta M}{M} - \frac{\Delta Y}{Y} + \frac{\Delta V}{V} \qquad (3.1)$$

where π denotes the rate of inflation, $\Delta M/M$ is the rate of growth of the nominal money supply, $\Delta Y/Y$ is the rate of growth of output, and $\Delta V/V$ denotes the rate of change of velocity of circulation.[11] Other things equal, higher money growth should result in higher inflation. This relation should hold not only for a closed economy but for an open economy operating under a flexible exchange rate, or a fixed-but-adjustable exchange rate as well. However, under strictly fixed nominal exchange rates (e.g., under a currency board), money growth becomes endogenous and domestic inflation can not differ much from foreign inflation. Another basic relation from monetary theory is that sustained higher inflation yields higher nominal interest rates. However, in the short run raising interest rates tends to weaken inflationary pressures.
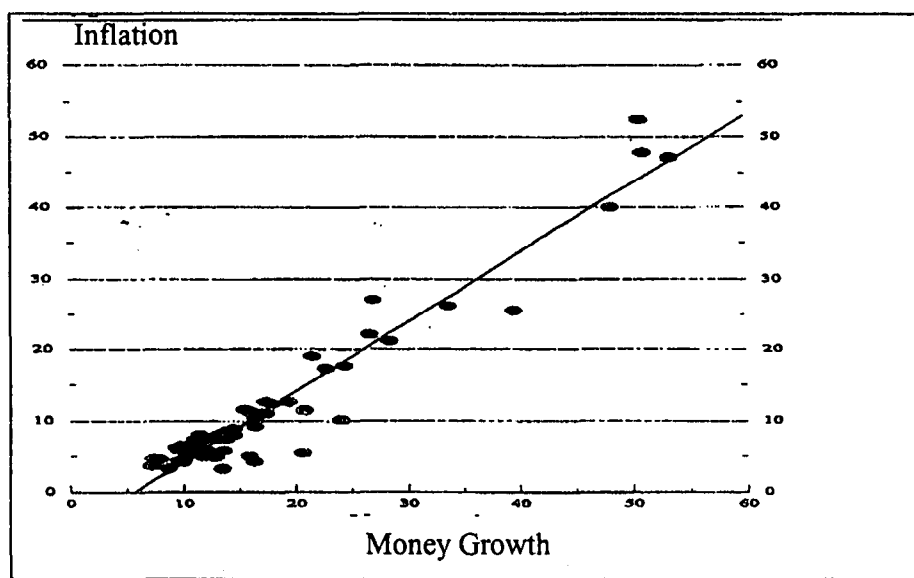
Figure 4: Inflation and money growth, 1960-1995, selected industrial and developing countries (in percent change, annual averages).[12]

2. Basic Monetary Regularities

Figures 4 and 5 provide a cross-section view of the relation between money growth and inflation. Figure 4 is a scatter diagram of annual averages of money growth and inflation from 1960 to 1995 across a sample of 53 developed and developing countries. Figure 5 documents similar evidence for a larger sample of countries, this time separating averages by the periods 1970-80 and 1980-91. The evidence in both figures is clear: the

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[11] Svensson (1997b) shows that his original model, discussed above, can be extended to incorporate a money market, including a money demand function as implicit in equation (3.1).

[12] Source: International Monetary Fund, World Economic Outlook, September 1996.

points lie close to the diagonal, thus indicating that countries with a high rate of money growth experience a high rate of inflation, and vice-versa.
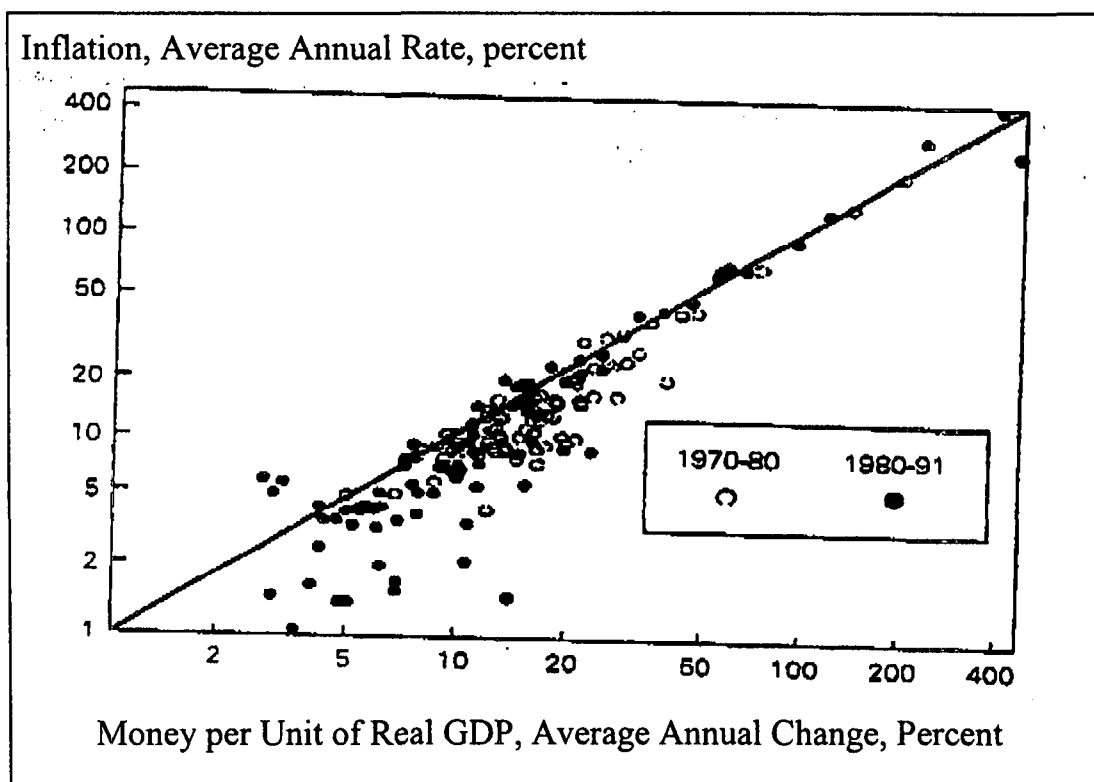
Figure 5: Money growth and inflation: all countries 1970-1991.[13]

We begin our discussion of monetary regularities in Israel with Figure 6 that plots the ratio of actual real M1 money balances to GDP against the Bank of Israel interest rate over the period 1989-1996. As discussed below, the use of an M1 aggregate is in line with previous research that has documented that among all monetary aggregates M1 is the one that has a closer relation to inflation and to nominal income in Israel.[14] According to standard monetary theory, the existence of a relatively stable money demand relation is an important prerequisite for predicting a well-defined link between money growth and inflation. The impression that the observations in Figure 6 depict a well-behaved money demand function is confirmed by econometric findings, based on quarterly data from 1989 to 1996, which resulted in an income elasticity of money demand of about unity and in an

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[13] Source: World Bank, World Development Report 1993, Table 1,2, and 13. Reproduced from Poole (1994).

interest-rate elasticity of money demand of about -0.2 (evaluated at the sample mean). These parameters were found to be significantly different from zero and we could not reject the hypothesis that they were stable during the sample period.[15]
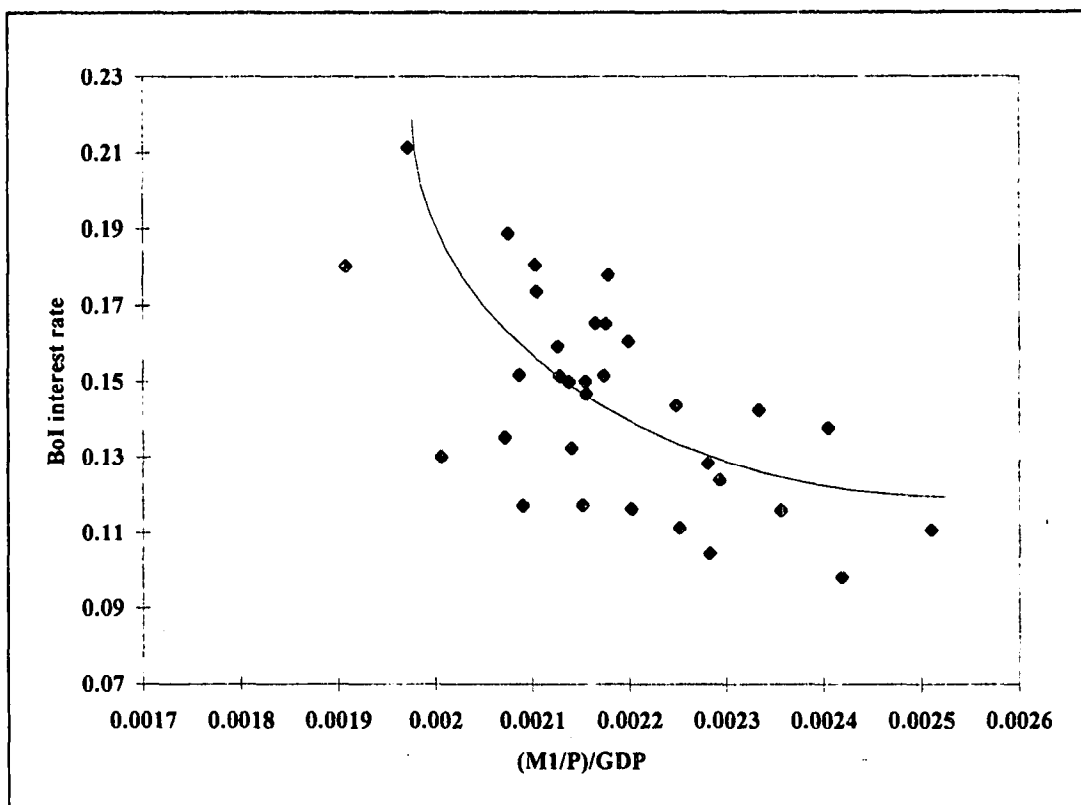
Figure 6: The relation between real money balances and the nominal interest rate on Bank of Israel funds (1989-1996).

[14] For example, Cohen and Soreni (1995) found that M1 was the monetary aggregate most closely correlated with nominal GDP.

[15] The estimated equation is: $Log\left(\dfrac{M1_t}{P_t}\right) = \dfrac{-6.564 - 1.416 \cdot i_t + 1.063 \cdot Log(GDP_t)}{(11.897) \quad (5.822) \qquad (19.870)}$

$DW = 1.420$, Adj. $R^2 = 0.908$. Numbers in parenthesis are the t values of the parameter estimates. Sample period: 1990-1996, quarterly data. Similar money demand equations have been estimated in Israel, see for example Azoulay and Elkayam (1996).
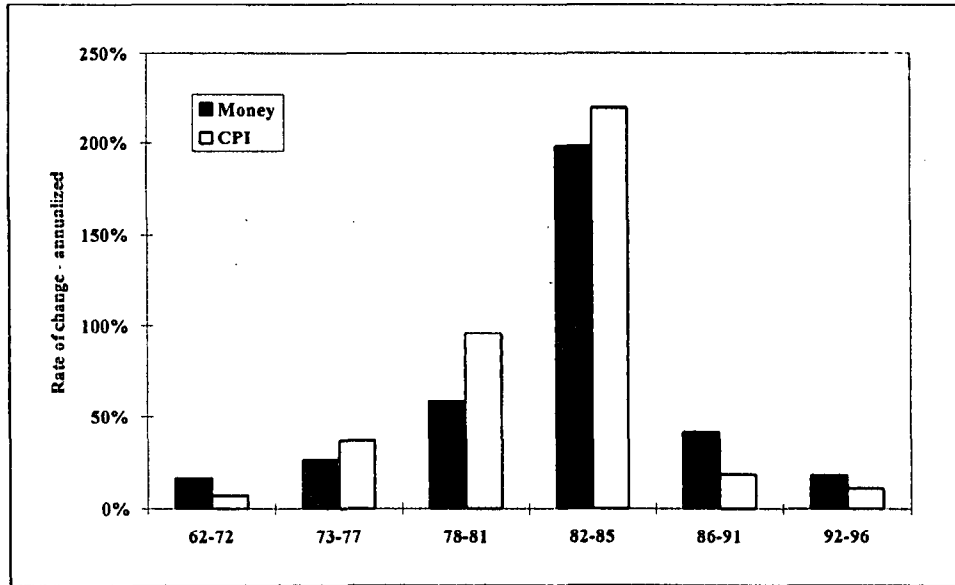
Figure 7: Inflation and money growth in Israel, average annualized rates of growth.
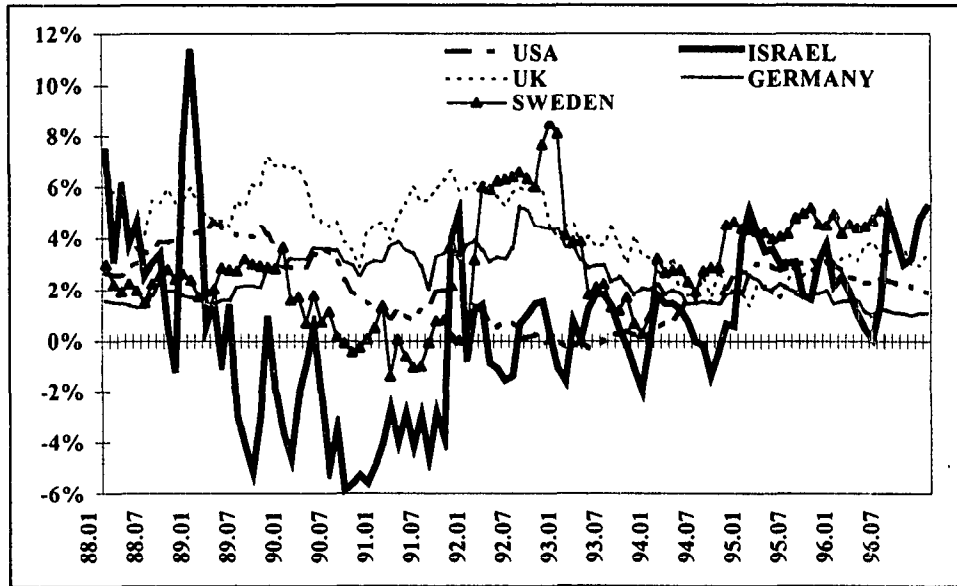
**Figure 8: Central bank Interest rates, in real terms,
Israel and other countries in the world**

That Israel is no exception to the general principle that for period averages there is a close link between money growth and inflation is evident from Figure 7, which provides data from 1962 to the present. It can be seen that for any sub-periods in which there was an acceleration in the rate of inflation there was an acceleration in the rate of growth of money. And conversely, when the rate of inflation was reduced, money growth was decreased as well. Examining closely recent periods, note that the escalation of inflation to triple-digit annual rates in 1982-85 was associated with a sharp rise in money growth. In

fact, between 1984-85 M1 was growing at an annual rate of about 300 percent. Then, the period 1986-91 marks the first phase of disinflation, with annual inflation rates of about 16-18 percent. At that time, M1 was growing at relatively sizable rates; in particular, M1 growth was of about 28 percent per year in 1991-92. There is reason to believe that these considerable money growth rates had an important explanatory role in accounting for the fact that inflation was not reduced below 16-18 percent per year at that time. The latest period, 1992-96, is characterized by a lower rate of inflation, of about 10 percent per year. This has been supported by lower money growth. For example, during 1995-96 M1 grew at about 12 percent per year, which is less than one-half of the M1 growth rate in 1991-92.

These conclusions on the evolution of monetary policy are strengthened by examining the (ex-ante) expected real interest rate on central bank funds and by comparing it to real interest rates (or real repo rates) on foreign central banks funds. As shown in Figures 8 and 9, before 1992 there was a negative real interest rate on Bank of Israel funds (on average equal to -2.2 percent per year), while at the same time real interest rates for foreign central bank funds were positive. These negative real interest rates can be taken as another indicator of the existence of a relatively easy monetary policy at that time. This pattern changed after 1992, and especially so from 1994 on, at which time Bank of Israel real rates reached positive territory, and became of similar orders of magnitude than those abroad thus indicating a tighter stance for monetary policy.
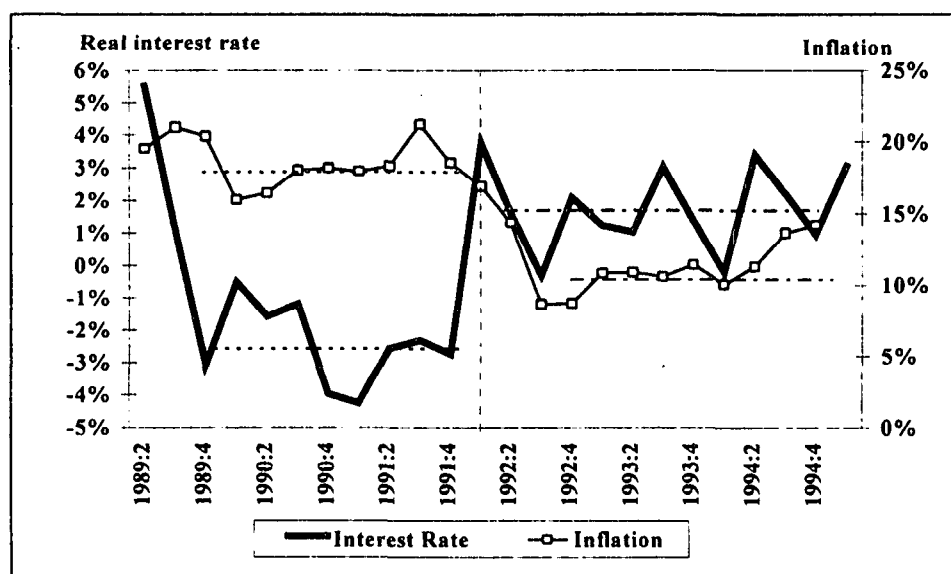
Figure 9: The ex-ante real interest rate on Bank of Israel funds and the step-down of inflation in late 1991 (quarterly data).

3. The Step-Down of Inflation in 1991-92 to About 10 Percent Per-Year

The marked reduction in the rate of inflation to about 10 percent per year--from late 1991 and early 1992 on—is a major development in the process of disinflation since the stabilization program of 1985. For more than six years following the initial anti-inflation plan of mid 1985 the rate of inflation had remained in the 16-20 percent (annual) interval, with an average annual rate of 18.1 percent. Yet from 1992 to the present the average annual rate of inflation was about 10 percent, which coincided with the average upper limit of government's official inflation target ranges. In what follows we elaborate on some of the factors behind this major development, including the role of monetary variables.
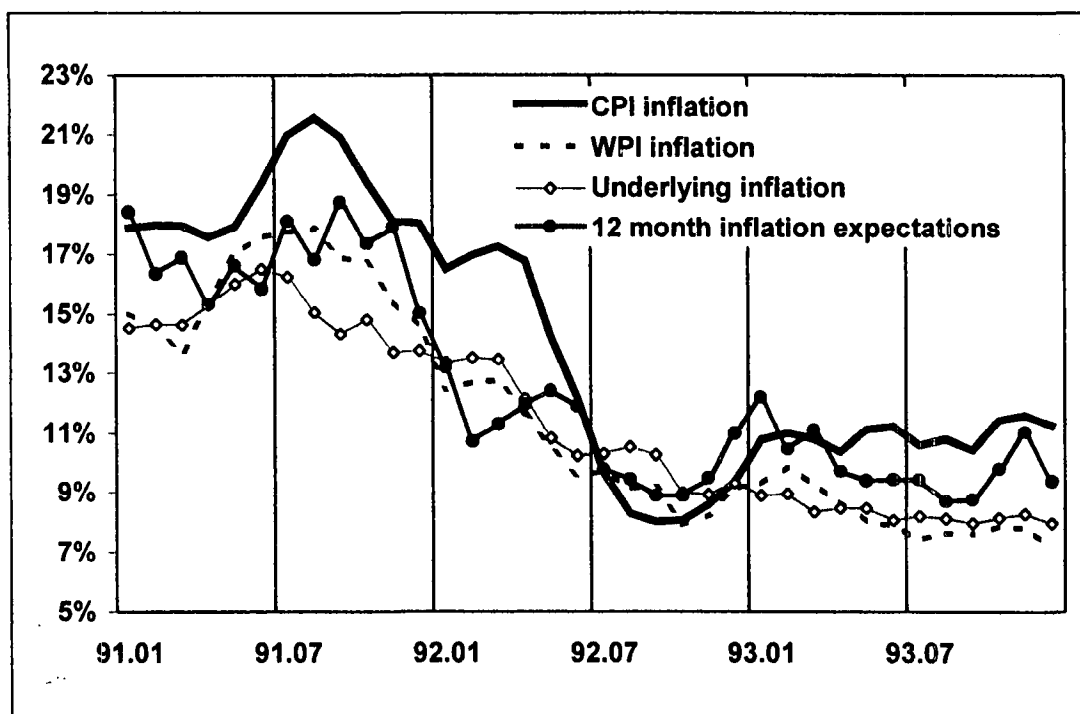
Figure 10: The 1991-92 decline in the rate of inflation[16]

The marked decline in the rate of inflation is documented in Figure 10. After reaching a peak in the third quarter of 1991, the annual rate of inflation started a continued fall up until the third quarter of 1992. This process applied commonly to various definitions of the rate of inflation beyond the standard measure based on the consumer price index, such as the wholesale price index, and a measure of underlying inflation which excludes from the CPI highly-volatile items such as housing prices and prices of fruits and

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[16] Underlying inflation is a reduced CPI measure that excludes prices of housing, seasonal and volatile items.

vegetables. The shift in behavior also applied to forward looking market-based inflation expectations.

Finding a good explanation for the decline in the rate of inflation to about 10 percent per year after 1991-92 has become a controversial task in Israel. It is well to emphasize that the reduction in the rate of inflation was not the result of a pre-conceived set of policy measures undertaken by the authorities with the original purpose of generating such an outcome. Instead, there is evidence to believe that the reduction in inflation was the outcome of a combination of developments in various important factors—including fiscal, monetary, labor market, and external fundamentals—which provided a fertile territory for consolidating a shift to a lower rate of inflation from then on.

The favorable role of various key economic variables for disinflation is documented in the six panels in Figure 11. It is possible to group the factors into four main categories. Consider first external price impulses in the form of Israel's 'imported' inflation. The decline in Israel's rate of inflation was supported by a substantial drop in foreign price pressures to the point that the latter exhibited deflation during the relevant period. As a matter of fact, import prices in U.S. dollar terms fell by an average of 5.6 percent in 1991 and by a further 1.2 percent in 1992. A second set of disinflationary factors was related to the labor market and the state of the economy. Starting in the late 1980s there was a considerable rise in the rate of unemployment, from 6.4 percent in 1988 to 11.2 percent in 1992, which initially reflected mainly a major restructuring of business activities after the 1985 stabilization, and later on the massive inflow of new immigrants into the labor force. It appears that these developments contributed to attenuate existing labor market rigidities and sharply reduced the extent of price- and wage pressures. Accordingly, real wages in the business sector declined by a cumulative 8 percent in the 1989-91 period, and the official minimum wage set by government which was applicable to most of the new immigrants during their entry into the labor market declined in real terms for four consecutive years starting in 1990. Third, as documented in the foregoing subsection and in the one that follows, there was an important shift in monetary policy from late 1991 or early 1992 onward. Specifically, policy begun to focus on achieving government's inflation targets and given other developments it took a tighter stance than in the preceding period. As a result of this shift there was a gradual increase in the real, ex-ante, interest rate on central bank funds, from negative levels in the preceding periods to positive rates. This was accompanied by a substantial reduction in the rate of growth of M1. Last, but not least, while various fiscal policy indicators pointed to continuous tighter discipline after 1985, fiscal policy credibility was enhanced in 1991 with the passing of the 'law of

diminishing budget deficits,' and with a strengthening in the already existing trend of decline in the ratio of public sector debt to GDP.[17]
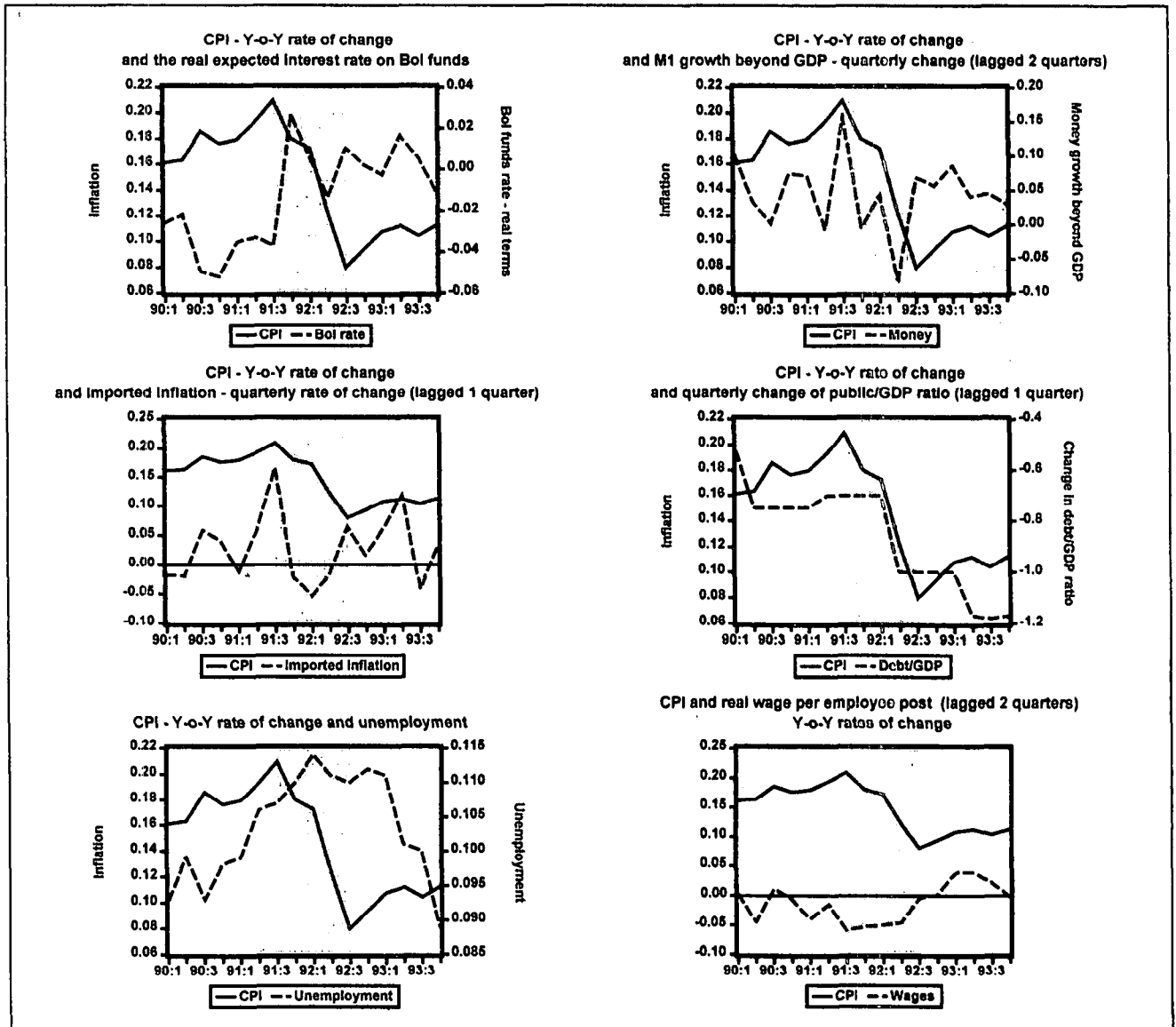

Figure 11: The development of inflation and fundamental macro-economic factors during the 1991-92 inflation step-down

In Section IV below we discuss an attempt to use econometric methods in order to examine the quantitative importance of the foregoing four groups of variables in accounting for the decline in inflation in 1991-92. Specifically, an inflation equation including these variables was estimated using quarterly data for the 1987-91 period and its estimated

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[17] On the role of fiscal policy variables in the inflation process, see Dahan and

coefficients were used to obtain an out-of-sample forecast for the rate of inflation from the fourth quarter of 1991 to the fourth quarter of 1992. It turns out that the equation was able to predict a drop of about 7 percentage points (annual) in the rate of inflation, while actual inflation was reduced by about 12 percentage points over that period, thus leaving an 'unexplained' residual of about 5 percentage points. In other words, the equation was able to account for slightly more than 50 percent of the decline in the rate of inflation. Out of the forecasted drop of 7 percentage points in the rate of inflation, about 2.5 percentage points could be attributed to external price factors, about 3 percentage points to the tightening in monetary policy, and the remaining 1.5 percentage points by both the fiscal policy and labor market factors.
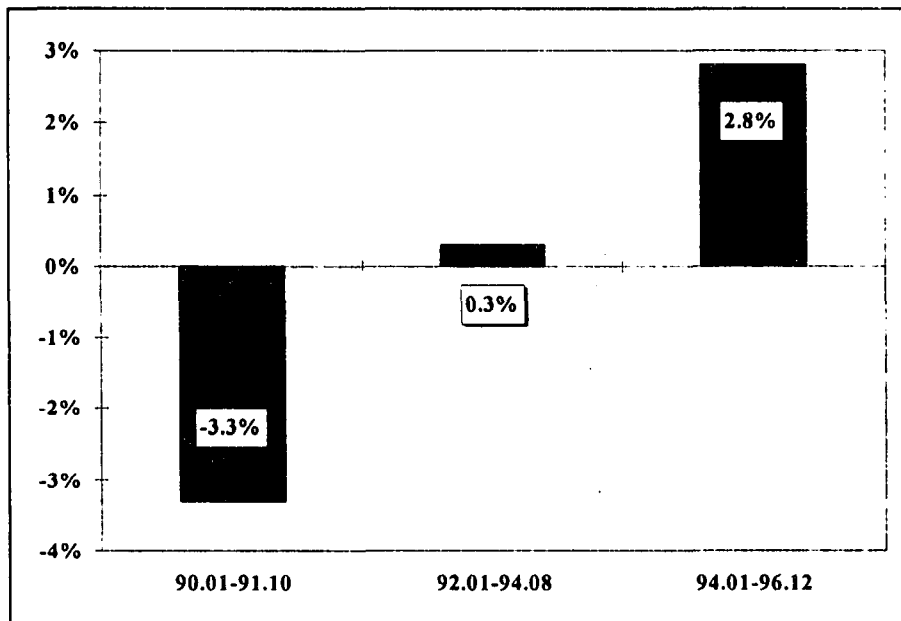
Figure 12: Interest rate on BoI funds, real ex-ante terms, annualized period averages[18].

To recapitulate, it is hard to find a single economic factor that explains the major reduction in the rate of inflation to about 10 percent in 1991-92, and this reduction can not be attributed to a single specific decision by the authorities to that matter. Instead, foreign price deflation, tight fiscal and monetary policies, and a rise in unemployment together with a more flexible labor market and the lack of autonomous wage pressures combined to result in a decline in the rate of inflation, which was then further supported and

Strawczynski (1997).
[18] The figures for November and December 1991 were not included in Figure 12 as these months were characterized by a sharp increase of the interest rate in response to a speculative attack on the NIS at the time.

transformed into a persistent change by the behavior of fundamentals (and in particular, of monetary policy) in the period that followed.
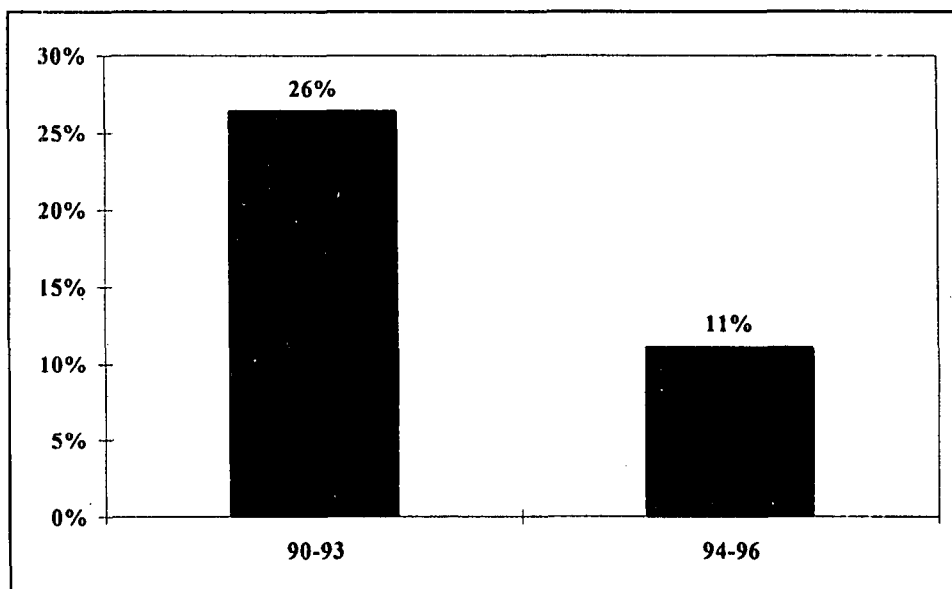

Figure 13: M1 growth, annualized terms.

4. A Change of Monetary Regime?

As evident from the discussion in the previous sections, there has been a change in the behavior of monetary policy in the period from 1992 to the present. In particular, there has been a changing emphasis in the extent to which monetary policy has acted in response to exchange-rate vs. inflation rate developments. As mentioned before, the advent of inflationary pressures and the absence of foreign exchange market pressures in late 1994 and early 1995 prompted the central bank to act sharply in an attempt to reduce (or eliminate) the deviation of inflation from target.[19] That episode vividly illustrated to the monetary authorities that inflationary pressures might arise through channels other than exchange rate depreciation and that it would be dangerous to accommodate to higher inflation. In a broader sense, this episode marked the transition from a monetary policy that is mainly focused on maintaining and supporting a nominal exchange rate target (as in the period from 1986 to 1991) to a scheme where achieving the inflation target is at the center of monetary policy formulation. Figures 12 and 13 document some of the manifestations of that change: the ex-ante expected real interest rate on Bank of Israel funds became positive after 1994 and together with this M1 growth was reduced from 26 percent on average, per year, in 1990-93 to 11 percent per year in 1994-96. Thus, monetary policy took a tighter stance than that before 1992, and the new stance contributed

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[19] On the changing focus of emphasis see also the detailed discussion by Sokoler (1997).

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to consolidate the reduction in the rate of inflation to about 10 percent per year.

It is useful to further discuss the change in policy focus in terms of a change in the degree of monetary accommodation to present and past changes in the rate of inflation. Monetary theory suggests that a reduction in the degree of monetary accommodation can lead to a reduction in the extent of inflation persistence as well as in the steady state rate of inflation.[20] In order to assess whether there has been such a change in monetary accommodation, we estimated a bivariate VAR for the rate of inflation and M1 growth using monthly data for two periods, 1988-91 and 1992-96, and have derived impulse responses for the effect of inflation shocks on M1 growth, interpreting these impulse responses as a measure of monetary accommodation. The cumulative impulse responses of M1 to a one-percent shock in the rate of inflation are plotted in Figure 14. It can be seen that the impulse responses for the later period are well below those in the preceding period thus providing evidence that indeed there is a lower degree of monetary accommodation in the last 3 years than in the earlier period. When added to the previous evidence, this finding provides further support to the notion that the inflation-target-oriented monetary regime of recent years is quite different from the regime before 1992.
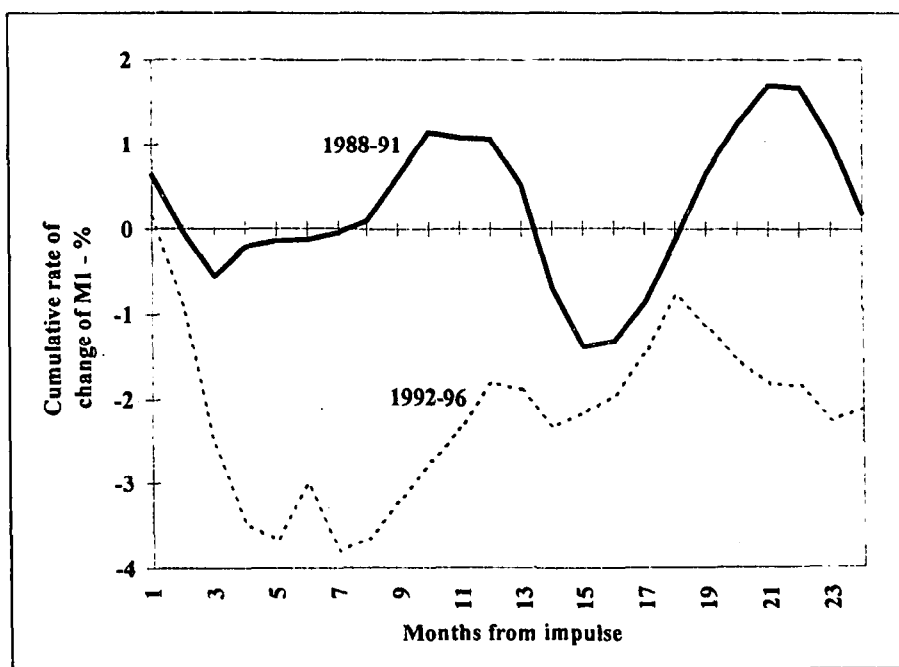
Figure 14: Cumulative response of the rate of change of M1 to a 1 percent shock to the rate of inflation. Based on VARs of M1 growth and inflation for the 1988-91 period and the 1992-96 period.

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[20] See, e.g., the analysis in Obstfeld (1995).

IV. ECONOMETRIC EVIDENCE

In this section we provide econometric evidence on the relation between monetary policy variables and the rate of inflation[21]. The first stage in this exploration is to determine which monetary policy variables to use and the lag structure of their impact on the rate of inflation. In the analysis that follows we used two measures of monetary policy: a monetary aggregate and the ex-ante, expected, real interest rate on Bank of Israel funds. As far as the choice of the monetary aggregate is concerned, previous research in Israel has indicated that M1 is the aggregate most closely associated with the rate of inflation. This is confirmed in our work. In particular, Figure 15 depicts the cross correlations between the rate of inflation at time t against various lags and leads of M1 growth beyond real GDP growth for a sample of quarterly data from 1990 to 1996. The cross correlations suggest that the lag structure in the impact of excess money growth on the rate of inflation is such that correlations gradually increase from the current period to past periods, reach a peak at about a 2-quarter lag and gradually decrease beyond that. In addition, the figure indicates that while inflation is related to current and previous periods' money growth, the evidence for a link in the opposite direction is weak.
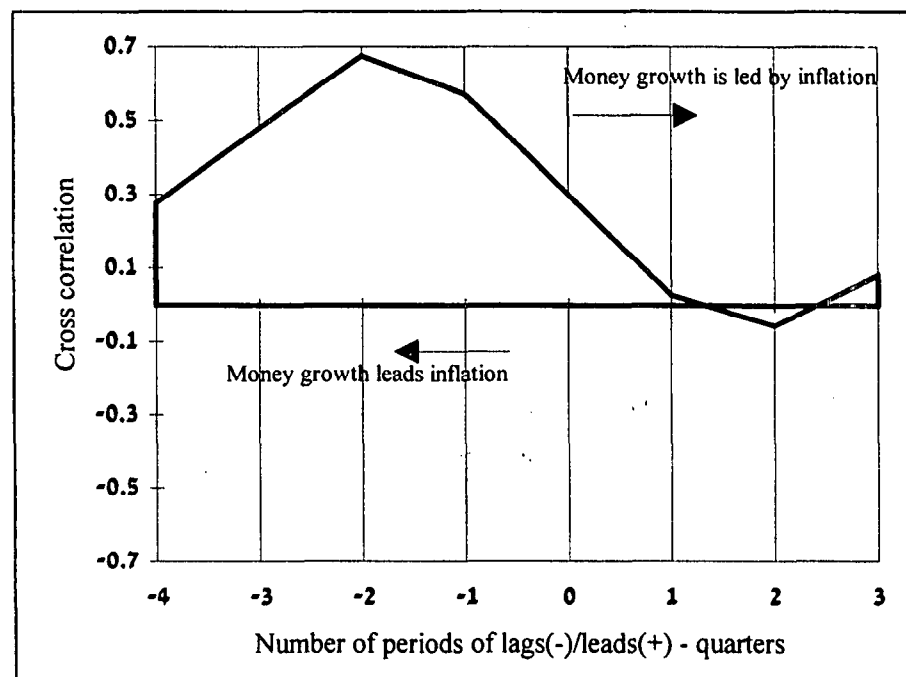
Figure 15: Cross correlation between excess money growth over GDP and inflation.

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[21] For early evidence on the effects of changes in the quantity of money on prices in Israel, in 1955-65, see Kleiman and Ophir (1975).

If the monetary aggregate is defined as M2 growth instead of M1 growth, there is a weaker link between money and inflation as indicated by Figure 16. In that Figure we examine the cross correlations between (M2-M1) growth (corrected for real GDP growth) and the rate of inflation and find that there is little additional explanatory power in the non-M1 component of M2. Put differently, the cross correlations between M2 growth and the rate of inflation are indeed weaker than those for M1 growth and the rate of inflation.
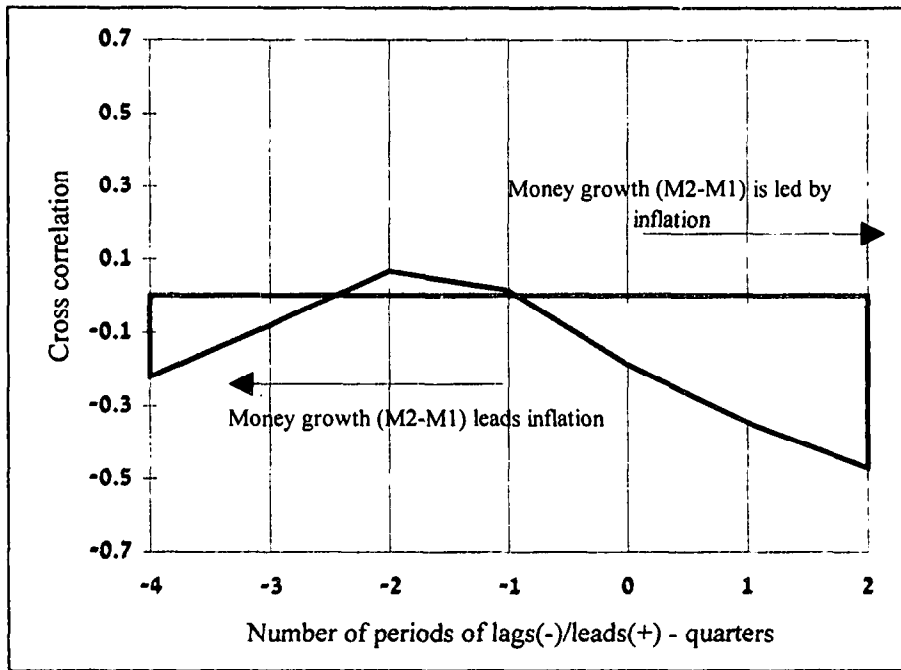
Figure 16: Cross correlation between growth in the non-M1 component of M2 and inflation.

When the ex-ante real interest rate on central bank funds is used as the monetary policy variable, the lagged impact on the rate of inflation has a lag structure as shown in Figure 17. Note that the strongest impacts are found at lags of 1 and 2 quarters, and the effects diminish at longer lags. The cross correlations are of negative sign; namely, higher real interest rates in a given quarter are associated with lower rates of inflation in subsequent quarters.

A useful way to illustrate these lagged effects is to relate movements in the rate of inflation to lagged shifts in money growth in excess of real GDP growth, as in Figure 18. The figure plots the annual rate of inflation (monthly, year over year) against a properly chosen lag of the annual rate of M1 growth in excess of real GDP growth (monthly, year over year). In the figure, we have chosen a lag of 8 months, and the period from 1993 to the present.
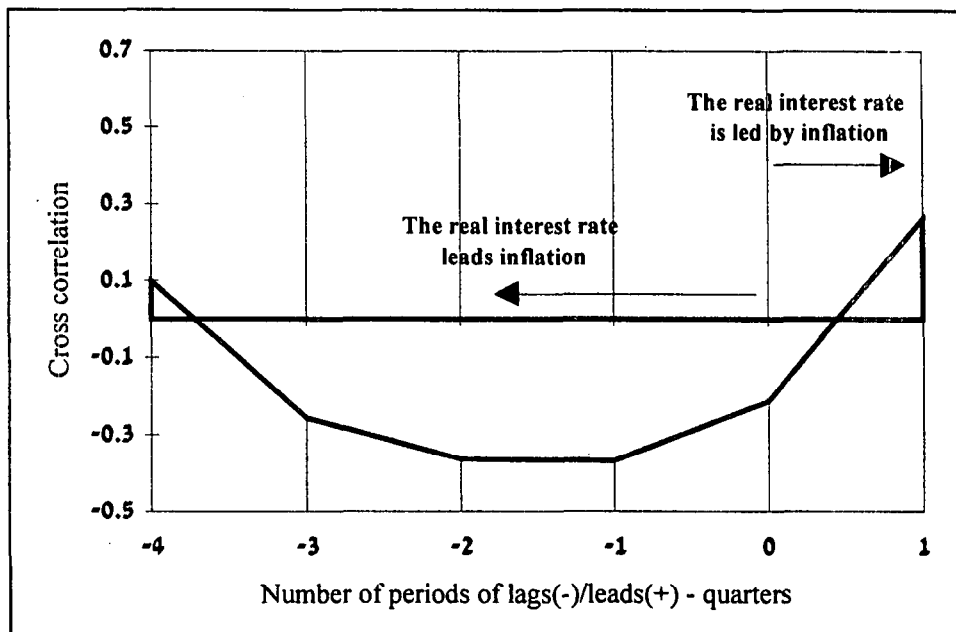
Figure 17: Cross correlation between the real, ex-ante, interest rate on Bank of Israel funds and inflation.
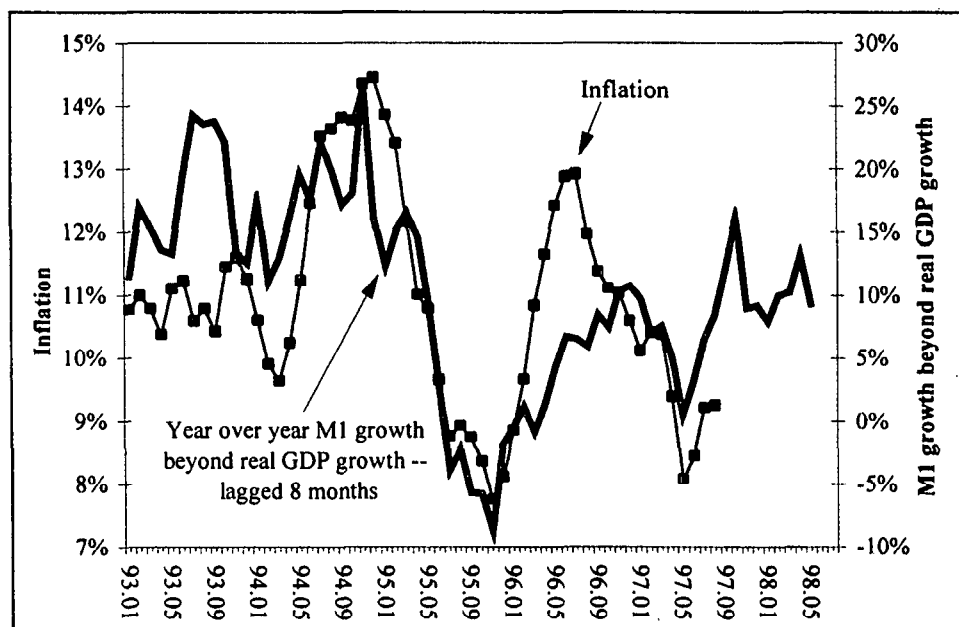

Figure 18: M1 growth as a leading indicator of inflationary pressure.

The main points arising from the figure are as follows: (1) the sharp acceleration in the rate of inflation in 1994 was associated with a marked rise in money growth starting the second half of 1993; (2) the rapid slowdown in the rate of inflation in late 1994 and throughout most of 1995 was associated with the tighter monetary stance implemented from mid 1994 into early 1995; (3) the renewed acceleration of money growth from the second quarter of

1995, that came after a rapid reduction of the interest rate, was later felt in an acceleration of inflation from the last quarter of 1995 to the first half of 1996. Note that such an acceleration was above and beyond that implied by money growth alone thus suggesting the relevance of other factors for the rise in prices, such as faster nominal exchange rate depreciation before the 1996 elections; (4) the reduction in the rate of inflation in the second half of 1996 and early 1997 can be related to a relatively slow rate of money growth starting in May 1996, though other factors had an impact on such a development as well; and (5) the reversal to some acceleration in the rate of inflation towards mid 1997, which was related to a preceding easing in monetary conditions. In summary, over and beyond the role of non-monetary factors in the inflation process, the figure indicates that there is a close link between movements in the rate of inflation and shifts in money growth in previous periods.

As evident from Figure 19, the dual of these fluctuations in money growth were movements in the ex-ante expected real interest rate on central bank funds. Not surprisingly, periods of tight money growth were also periods of high and rising real interest rates, and easier money growth came along with lower real interest rates.
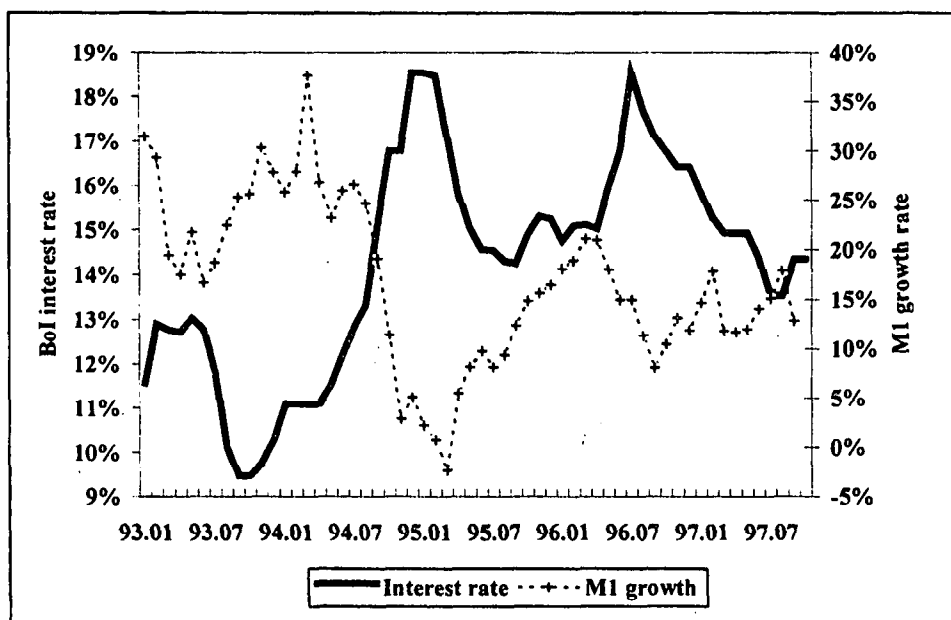
Figure 19: Annual rate of M1 growth and the interest rate on BoI resources

1. <u>Estimating Inflation Equations</u>[22]

The next stage in our research consists of exploring various econometric specifications for the role of monetary and non-monetary variables in accounting for fluctuations in the rate of inflation. Our basic approach is to estimate equations for the rate of inflation as a function of monetary policy variables, the exchange rate and foreign prices, and the rate of unemployment. Although these equations are not formally derived here from a structural model, they represent common reduced-form representations for the rate of inflation that typically arise in standard aggregate demand and supply models of small open economies. Put differently, the estimated equations can be viewed as open-economy empirical counterparts of reduced-form equation 2.4 in Svensson's model of the previous section. Needless to say, a more comprehensive approach would formulate a structural simultaneous equation model of the economy, one in which the exchange rate and the rate of unemployment become truly endogenous variables.

Specifically, equation (4.1), shown in Appendix 1[23], regresses, using quarterly data for the period from 1989 to 1996, the rate of inflation of the CPI excluding prices of fruits and vegetables (which in Israel are an extremely volatile component) against various lags of the following explanatory variables: 'imported' inflation, measured by the rate of change of the nominal exchange rate of the NIS against the U.S. dollar plus the rate of change of the foreign price of imported consumer goods; the rate of change of M1 beyond the rate of real GDP growth, and a 4-quarter moving average of the rate of unemployment.[24]

The estimated parameters have the expected signs and are significantly different from zero. Specifically, the 'imported' inflation variable affects domestic inflation with relatively short lags; the monetary variable is positive and significant for lags of 2 to 5 quarters (namely, an average lag not much different than the 8-months lag used in Figure 18 above); and the unemployment variable has a negative sign and appears with a 2-quarter lag. The equation's diagnostics indicate the lack of first-order serial correlation in the residuals and a relatively high explanatory power. The latter feature is evident in the

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[22] As indicated (see footnote 2), some of the specifications discussed below are similar to those in important previous empirical work by Azoulay and Elkayam (see references).
[23] For convenience, all estimated equations, diagnostics, actual, fitted, and residual values are given in Appendix 1.
[24] At a preliminary stage of this investigation we searched over various possible lags for the explanatory variables. The specifications reported here and below are those which were found most satisfactory from the goodness of fit perspective. Note that the estimated equations typically include a constant term and a seasonal dummy variable for the second quarter of each year. In addition, we estimated similar specifications applying instrumental variables and these yielded very similar results as those in the text.

figure shown in Appendix 1, adjacent to the estimation results of equation (4.1), which plots actual, fitted, and residual values for the estimated equation: in spite of the absence of the lagged dependent variable (which was used as an explanatory variable in several previous inflation equations in Israel) the equation is able to track relatively well fluctuations in the rate of inflation within the sample.

In order to examine the potential explanatory role of a wider monetary aggregate, equation (4.2) expands the previous inflation equation to include the rate of growth of the non-M1 component of M2 beyond the real GDP growth rate. The F-test for the statistical significance of the block of added variables indicates non-rejection (at standard significance levels) of the hypothesis that these variables have no marginal explanatory power for fluctuations in the rate of inflation. In contrast, when similar tests were conducted separately for the 'imported' inflation and M1-growth variables the null-hypothesis was rejected indicating that these variables significantly contribute to accounting for movements in the rate of inflation.

Another extension of the basic inflation equation consists of replacing the previous dependent variable by a rate of inflation that excludes housing prices (in addition to the previously excluded prices of fruits and vegetables). The results are presented in equation (4.3). Most explanatory variables—including monetary variables—remain with the expected signs and significance as before, yet the coefficients on the 'imported' inflation and monetary variables are now generally lower than in the previous specification.

Turning to the case where monetary policy is represented by the ex-ante real interest rate on central bank funds, the basic estimated relation is equation (4.4). The rate of inflation at quarter t is found to be related to the real interest rate at quarter t-2, and the estimated coefficient is -0.2. Interestingly, the absolute values of the coefficients on the 'imported' inflation and unemployment variables are now slightly larger than in the previous (M1 growth) specification. The estimated equation diagnostics are satisfactory and the actual, fitted, and residual values indicate that the equation tracks relatively well movements in the rate of inflation. This general pattern of results applies to the case in which the dependent variable excludes housing price inflation; in particular, there is a strong negative and significant effect of the real interest rate on the rate of change of the consumer price index excluding fruits, vegetables, and housing.

In principle, a more comprehensive model would incorporate into the specifications the possibility of monetary policy effects on the rate of change of the nominal exchange rate, with the presumption that other things equal a tighter monetary policy would result in slower nominal exchange rate depreciation than otherwise. In order to provide some

preliminary evidence on this issue, we regressed in two separate equations our exchange rate (or imported inflation) variable, DEPM, on exactly the same monetary policy variables that appeared in the foregoing inflation equations (i.e., RMIC and DMY). It turned out that the coefficients on the monetary variables were not significantly different from zero and the explanatory power of the regressions was nil.[25] Hence, there is no evidence of a systematic and significant relation from the present measures of monetary policy to the path of nominal exchange rate over the entire sample period (1989-1996). Needless to say, this does not preclude the presence of such a relation in specific episodes such as in the second half of 1996 when contractionary monetary policy measures were followed by slower nominal exchange rate depreciation than the 6-percent slope of the current exchange-rate band.

2. Inflation Rate Impulse Responses to Monetary Shocks

Although a relatively plausible set of results was obtained from the above inflation equations, it was produced in the context of restricted reduced form specifications. It is well to examine whether similar results about the impact of monetary variables on the rate of inflation arises in more unrestricted specifications, such as in vector autoregressions (VARs). Accordingly, we estimated a 4-variables VAR which included current and lagged values of the rate of inflation, imported inflation, money growth in excess of real GDP growth or (alternatively) the ex-ante real interest rate on central bank funds, and the rate of unemployment—all defined exactly as they appeared in the foregoing inflation equations. The estimation period was 1989 to 1996 (quarterly). Two systems of VAR were estimated based on the two alternative definitions of the monetary policy variable.

Based on these estimates, impulse responses were derived for the rate of inflation as a function of an innovation (i.e., a unit shock) in the monetary policy variable. These impulse response functions are given in Figures 20 and 21. From Figure 20 we see that a positive unit shock to the rate of growth of M1 net of the rate of growth of real GDP leads to an acceleration in the rate of inflation for a number of subsequent quarters. The peak impact of money growth on inflation arises two quarters after the shock, much as in the above estimated equations. Interestingly, the quantitative impact of the money growth shock on the rate of inflation is of the same order of magnitude as the estimated coefficients

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[25] Needless to say, the detailed results are available from the authors.

on these monetary variables in the inflation equations[26]. A similar finding arises from Figure 21 for the impact of ex-ante real interest rate shocks. A rise in the real interest rate is associated with a reduction in the rate of inflation in subsequent quarters, and the orders of magnitude are about the same as those in the estimated inflation equations. In conclusion, empirically assessing the impact of monetary policy variables on the rate of inflation in the context of a relatively unrestricted time-series model (such as a VAR) yields generally similar results to those derived from estimating restricted reduced form specifications. Thus, we interpret the findings as providing further support to these specifications.
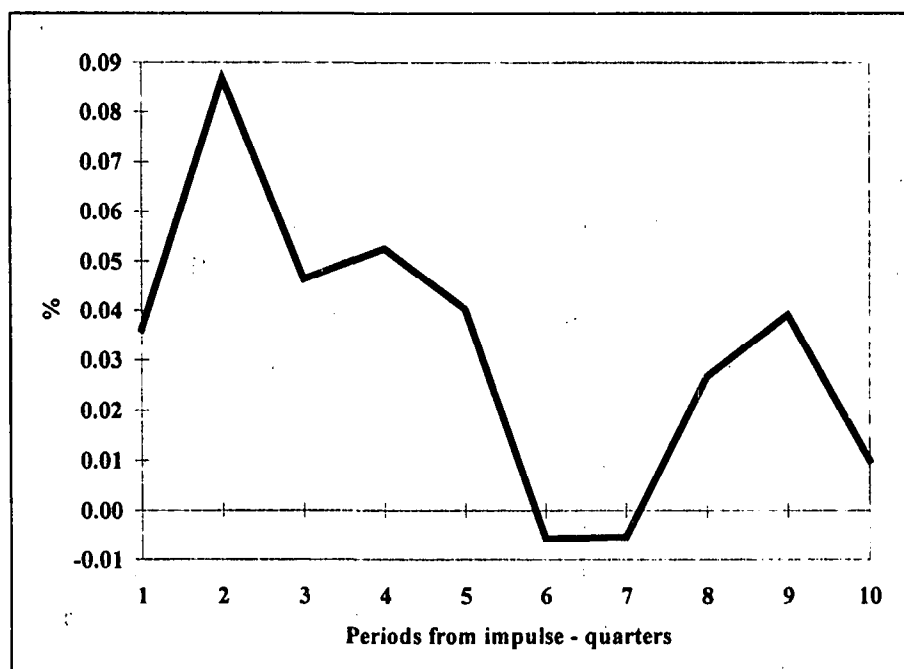
Figure 20: Response of the quarterly rate of change of the CPI excluding fruit and vegetables to a 1 percent shock to the rate of money growth in excess of real GDP growth.

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[26] As shown in figure 20, the cumulative response of inflation to a 1 percent shock of the rate of money growth is 0.33 percent. Similarly, the results of the econometric inflation equations (see for example equation 4.1), show that the sum of the point estimates of the money growth parameters is 0.34.
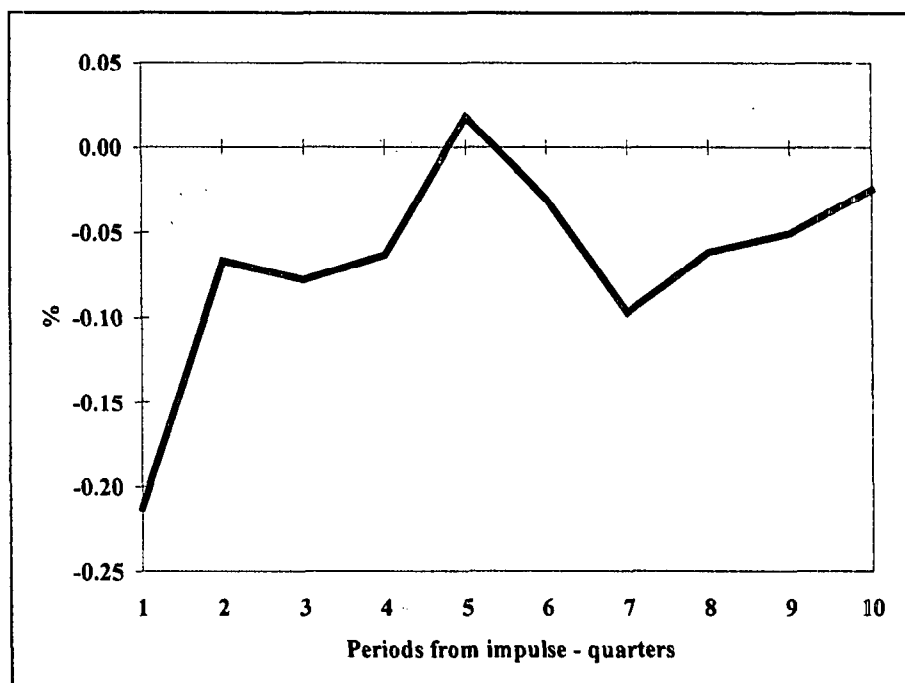
Figure 21: Response of the quarterly rate of change of the CPI excluding fruit and vegetables to a 1 percent shock to the real, ex-ante, interest rate on Bank of Israel funds.

3. Inflation Forecasting

An important and useful application of the estimated equations is in attempting to forecast future inflation developments. We explored this issue by looking at one-quarter-ahead forecasts based on estimating our specifications up until the quarter before that in the forecast and by comparing actual and forecast inflation rates. Table 2 reports the evidence for forecasts from the first quarter of 1996 to the first quarter of 1997 and for the two main specifications of the monetary policy variable in equations 4.1 and 4.4. In each case, the forecast included an assumption about the path of the 'imported' inflation variable DEPM in that quarter which was the focus of the forecast. We typically assumed that the nominal exchange rate is expected to depreciate at the annual rate of 6 percent; yet, there were two exceptions to this rule: we assumed an accelerated nominal depreciation of 12 percent in annual terms (i.e. double the rate of crawl of the band) for the second quarter of 1996 (right before the elections) and a unchanged nominal exchange rate for the quarter that followed.

	Forecast - using:		Actual
	Equation 4.1	Equation 4.4	
96.1	0.9%	1.3%	0.9%
96.2	1.4%	1.3%	1.5%
96.3	1.0%	1.2%	0.3%
96.4	0.9%	0.9%	0.8%
1996 average	1.1%	1.2%	0.9%
1996 average excluding Q3	0.8%	0.9%	0.8%
97.1	0.9%	1.0%	0.7%
97.2	1.2%	1.1%	0.9%
1997.1- 1997.2	1.0%	1.1%	0.8%

Table 1: Out of sample forecasts of the rate of change of the CPI, excluding fruit and vegetables -- all figures shown are in monthly terms.

The main features of the results in Table 1 are as follows. First, the equations have done relatively well in forecasting movements in the rate of inflation. This is particularly so for the increase in inflation in the first half of 1996 and for the much lower rates of inflation observed in the last quarter of 1996 and the first quarter of 1997. It is only in the third quarter of 1996 that the equations predicted a substantially different rate of inflation (i.e., higher) than that observed. This may reflect a change in the 'structure' of the model, in that developments at that time reflected the full impact of central bank's decision to stop the policy of intramarginal intervention (within the exchange-rate band) and to let the nominal exchange rate freely shift within the band in response to the behavior of demand and supply in the foreign exchange market. Second, note that in spite of the use of two different measures of monetary policy the differences in the forecasts are not large. For almost all quarters shown in the Table, the inflation rate forecasts from equation 4.4 (i.e., using the ex-ante real interest rate as a measure of monetary policy) have been slightly higher than those from equation 4.1 (which used M1 growth). Overall, the forecast performance is quite satisfactory: relatively simple econometric specifications relating the rate of inflation to 'imported' inflation, to monetary policy variables, and to the rate of unemployment do a relatively good job at predicting most recent movements in the quarterly rate of inflation.

An additional application of forecasting with our estimated inflation equations has

to do with the step-down of inflation to a rate of about 10 percent in 1991-92, as discussed in subsection 3 of the foregoing section. In particular, we examined whether a relatively satisfactory version of an inflation equation estimated with quarterly data from 1987 to 1991 could predict (out-of-sample) the marked fall in the rate of inflation from the last quarter of 1991 to the last quarter of 1992. Specifically, equation 4.5 shown in Appendix 1 regressed using quarterly data the rate of inflation of the CPI excluding prices of fruits and vegetables against the following explanatory variables: 'imported' inflation, measured by the rate of change of the nominal exchange rate of the NIS against the U.S. dollar plus the rate of change of the foreign price of imported consumer goods, the rate of change of M1 beyond the rate of real GDP growth (lagged two periods), the change of the fiscal debt to GDP ratio, and the change in the rate of unemployment lagged four quarters.

The estimated parameters turned out to have the expected signs, and all coefficients, except that on the rate of unemployment, are significantly different from zero. More in detail, the 'imported' inflation variable affects domestic inflation with relatively short lags; the monetary variable has a positive and significant coefficient for lags of two to four quarters; and the unemployment variable has a negative sign. In spite of various attempts with alternative labor market variable definitions used in order to improve the precision of estimation of the unemployment variable, the resulting coefficient still was imprecisely estimated. The equation's diagnostics indicated the lack of first-order serial correlation in the residuals and a relatively high explanatory power. The parameter estimates were applied in order to obtain an out-of-sample forecast of the rate of inflation from 1991:4 to 1992:4. Using the development of explanatory variables over the sample, the equation predicted a fall in the rate of inflation of about 7 percentage points over that time interval in comparison to the four quarters previous to that period (all in annualized terms). The actual fall in the rate of inflation was of about 12 percentage points, thus leaving a 5 percentage points 'unexplained' residual.

When assessing the quantitative importance of various explanatory factors for the decline in the rate of inflation, it turned out that 'imported' inflation accounted for 2.5 percentage points of the fall, and monetary variables for about 3 percentage points of the fall, thus leaving a remainder of 1.5 percentage points for the fiscal variable and the rate of unemployment. In other words, the bulk of the reduction in the rate of inflation could be attributed to both 'imported' inflation and monetary factors, though these findings should be regarded as preliminary and should be subject to further sensitivity analysis in future work.

V. CONCLUSIONS

In this paper we documented a set of basic empirical regularities on the relation between monetary policy variables and the rate of inflation in the period from the late 1980s up to the present time. We found that

- there is a relatively well defined, and stable, empirical demand for M1 balances, with a long-run income elasticity of about 1.0 and an interest rate elasticity of about -0.2.

- among the various monetary aggregates, M1 is the one whose movements are most relevant in accounting for fluctuations in the rate of inflation.

- the impact of monetary policy variables—such as the rate of change of M1 beyond the rate of growth of GDP and the interest rate on Bank of Israel funds—on the rate of inflation works with lags that peak at about two quarters after the change in the monetary variable. Casual evidence suggests that most movements in the rate of inflation in recent years have been preceded (with the foregoing lags) by shifts in monetary policy variables in the pertinent direction.

- relatively simple econometric specifications of inflation equations, relating the rate of inflation to current and lagged measures of 'imported' inflation, of monetary policy (i.e., the rate of growth of M1 beyond GDP growth or the ex-ante real interest rate on central bank funds), and the rate of unemployment account relatively well for fluctuations in the rate of inflation. Moreover, the same equations do a relatively satisfactory job at predicting—in a one-step-ahead sense--most recent quarterly movements in the rate of inflation.

- the finding that monetary policy variables have a key explanatory role for fluctuations in the rate of inflation is confirmed by the results of unrestricted vector autoregressions in which innovations in the rate of growth of M1 beyond GDP growth and in the ex-ante real interest rate on central bank funds have impacts on the rate of inflation in subsequent quarters that are consistent with those derived from the earlier, more restricted, specifications.

Most of these findings conform with those of earlier studies on the inflation process in Israel. When proper lags and the role of other explanatory variables are taken into account, there is a close association between movements in the rate of inflation and shifts in monetary policy variables. Having established that, however, it is well to stress

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that there is ample room for future work attempting to detect, in a structural model, the specifics of monetary policy transmission mechanisms in Israel.

In discussing the evolution of monetary policy regimes in Israel, we noted that since the exchange-rate-based stabilization program of 1985 there has been a gradual shift toward increased flexibility of the nominal exchange rate coupled with increased emphasis on inflation targeting.[27] Current monetary policy is oriented toward achieving the inflation target set by government—which is the range from 7 to 10 percent for both 1997 and 1998—while maintaining and supporting, at the same time, the crawling band for the exchange rate of the NIS against a basket of foreign currencies. Monetary policy is now conducted along lines of what Svensson (1997a) has termed 'inflation-forecast targeting;' that is, adjustments in monetary policy instruments are made when discrepancies arise between central bank's forward-looking forecast of the rate of inflation in the relevant future and the inflation target. To the extent that these adjustments lead to foreign-exchange market pressures on the limits of the exchange rate band, sterilized intervention in the forex market is implemented in order to support and defend this band. We emphasized that recent experience illustrated some of the difficulties that arise—especially under a high degree of international capital mobility--when one policy instrument (i.e., the interest rate on central bank funds) has to support two objectives: the inflation target and the crawling exchange-rate band. In order to avoid potential conflicts between these nominal targets, it would be essential for the authorities to prioritize among their objectives in a clear and transparent manner, such as making official inflation targets the key objective of monetary policy, and subordinating any existing nominal exchange rate commitments to that target.[28]

Special attention was given in our analysis to attempting to explain the reduction in the rate of inflation from about 16-18 percent in the period before 1991-92 to about 10 percent per year thereafter. We stressed that this decline in the rate of inflation (in late 1991 and early 1992) per-se was not the result of a pre-conceived specific set of policy decisions for that matter. Instead, various developments in key variables—such as fiscal, monetary, labor market, and external—combined to produce a decline in the rate of

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[27] Similar trends in the evolutiJn of monetary policy and exchange-rate policy have been observed in other countries—such as Chile and Mexico—who undertook exchange-rate based disinflation programs.

[28] In fact, most inflation targeting countries are now operating under relatively free floating exchange rate regimes. At the same time, it is recognized that the effects of monetary policy on the nominal exchange rate play a key role in the transmission mechanism of this policy.

inflation, which was then further supported and transformed into a persistent change in the years that followed by the behavior of fundamentals, and especially that of monetary policy. The fact that the rate of inflation remained close to 10 percent per year in the period from 1992 to the present time, and did not decrease further, is not puzzling. After all, the average inflation targets set by governments in Israel during that period were in that range, and no additional major disinflation was then planned.

In addition, the analysis of monetary developments in recent years illustrated how monetary policy can become severely overburdened in an attempt to achieve the official inflation target when other key factors—such as fiscal policy, the state of the business cycle, and public-sector wage policy—create strong inflationary pressures. Two salient episodes of such overburdening occurred in late 1994 and in the first half of 1996, when the underlying trends indicated a convergence to annual inflation of about 15 percent, a figure much higher than the official target. In both these cases restrictive monetary policy measures were taken and for a short time ex-ante real interest rates on central bank funds reached about 5 percent, or higher, per year. The resistance of monetary policy to accommodate to a rate of inflation of about 15 percent together with the restrictive measures that were taken contributed to reduce the rate of inflation toward the official target, thus making the foregoing deviation of inflation from target only a transitory phenomenon. As indicated before, much of the public debate in Israel about monetary policy and disinflation was triggered by these two salient episodes which represented a severe challenge to the inflation targets and an overburdening of monetary policy.

Although the Israeli economy has not been subject to the discipline process emerging from Maastricht convergence criteria, **further disinflation is an important policy objective in Israel**. In setting the inflation target range as 7-10 percent for 1997 the government stressed that it aims to generate a multiyear gradual convergence of the rate of inflation to that in OECD economies by the year 2001. In setting the same inflation target range for 1998 the government also stressed the aim to make progress at disinflation in 1998 within that range. Based on the findings of our research work, monetary policy has a key role to play in achieving convergence of Israel's inflation to that in western economies. However, there are other key policy players whose actions can also contribute to disinflation and can help reduce—in as much as possible—the economic and other costs in the convergence process. These are fiscal policy, wage policy, and competition-enhancing structural changes. Put differently, the stronger the degree of coherence between the various types of macroeconomic policies from the

standpoint of disinflation—and the smaller the extent of reliance (or overburdening) on a single set of policy measures—the smoother will be the transition to persistent single-digit rates of inflation.

APPENDIX 1

In this appendix the notations are as follows:

PAIX= Quarterly rate of change of the CPI excluding fruit and vegetables.

PAIXH= Quarterly rate of change of the CPI excluding housing, fruit and vegetables.

DEPM= Quarterly rate of change of the exchange rate of the NIS vis-a-vis the dollar +

the rate of change of the price index of imported private consumption.

RMIC= Real ex-ante BoI interest rate, in annualized terms.

DMY= Quarterly rate of change of M1/GDP.

DM12Y= Quarterly rate of change of (M2-M1)/GDP.

MU4=4 quarter moving average of the rate of unemployment.

D2=Dummy variable for Q2 of each year.

Equation (4.1)

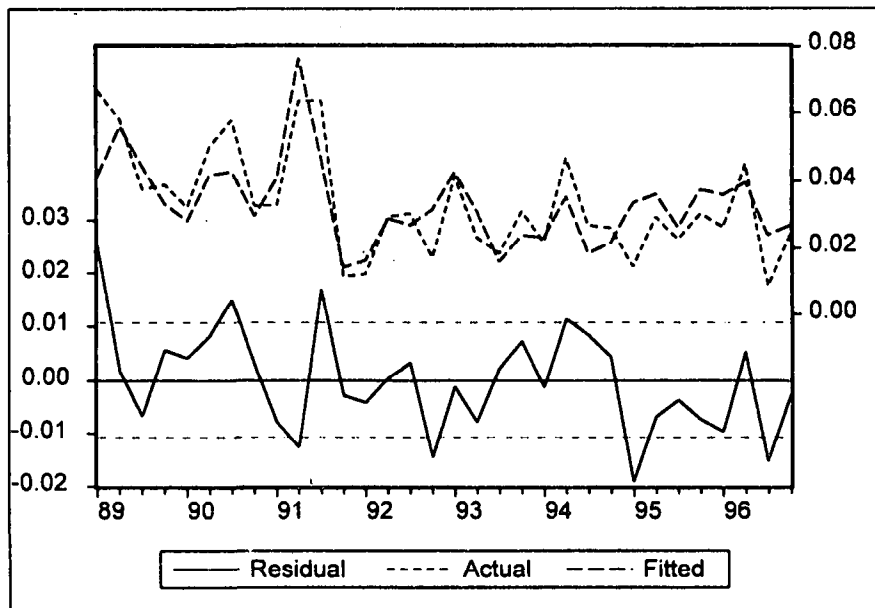LS // Dependent Variable is PAIX
Sample: 1989:1 1996:4
Included observations: 32
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.036468	0.008947	4.076134	0.0005
D2	0.011306	0.005592	2.021975	0.0550
DEPM	0.185321	0.033796	5.483575	0.0000
DEPM(-1)	0.101461	0.040191	2.524448	0.0189
DMY(-2)	0.137589	0.040832	3.369672	0.0026
DMY(-3)	0.055674	0.027194	2.047280	0.0522
DMY(-4)	0.060287	0.034651	1.739827	0.0953
DMY(-5)	0.090768	0.027850	3.259143	0.0035
MU4(-2)	-0.298984	0.097117	-3.078610	0.0053

R-squared	0.763943	Mean dependent var	0.033450
Adjusted R-squared	0.681837	S.D. dependent var	0.015939
S.E. of regression	0.008990	Akaike info criterion	-9.190922
Sum squared resid	0.001859	Schwarz criterion	-8.778683
Log likelihood	110.6487	F-statistic	9.304284
Durbin-Watson stat	2.156036	Prob(F-statistic)	0.000012
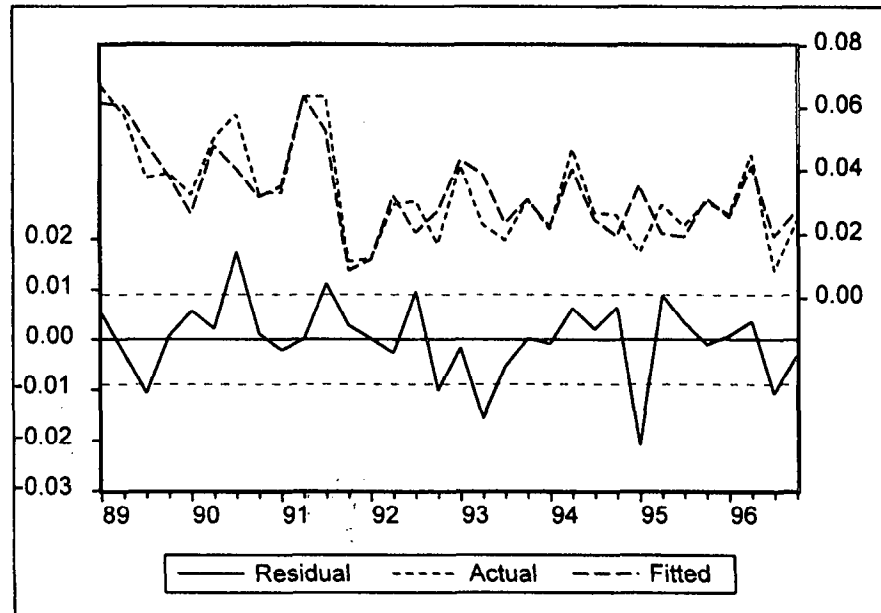
Equation (4.2)

LS // Dependent Variable is PAIX
Sample: 1988:4 1996:4
Included observations: 33
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.046962	0.012381	3.792950	0.0010
D2	0.009923	0.007480	1.326616	0.1982
DEPM	0.173868	0.044961	3.867070	0.0008
DEPM(-1)	0.076504	0.045112	1.695880	0.1040
DMY(-2)	0.110487	0.056111	1.969084	0.0617
DMY(-3)	0.073027	0.038256	1.908924	0.0694
DMY(-4)	0.061059	0.039464	1.547222	0.1361
DM12Y(-2)	0.025351	0.018417	1.376552	0.1825
DM12Y(-3)	0.000754	0.027454	0.027459	0.9783
DM12Y(-4)	-0.035294	0.029738	-1.186833	0.2480
MU4(-2)	-0.345916	0.116978	-2.957105	0.0073

R-squared	0.702208	Mean dependent var	0.033940
Adjusted R-squared	0.566848	S.D. dependent var	0.015938
S.E. of regression	0.010489	Akaike info criterion	-8.853578
Sum squared resid	0.002421	Schwarz criterion	-8.354742
Log likelihood	110.2591	F-statistic	5.187705
Durbin-Watson stat	1.883064	Prob(F-statistic)	0.000627

Tests for redundant variables:
Redundant Variables: DM12Y(-2) DM12Y(-3) DM12Y(-4)

F-statistic	0.845300	Probability	0.483821
Log likelihood ratio	3.600132	Probability	0.308006

The hypothesis that M2-M1 does not contribute to the explanation of inflation cannot be rejected at the usual significance levels.

Redundant Variables: DMY(-2) DMY(-3) DMY(-4)

F-statistic	4.265248	Probability	0.016164
Log likelihood ratio	15.12894	Probability	0.001710

The hypothesis that M1 does not contribute to the explanation of inflation is rejected at the usual significance levels.

Redundant Variables: DEPM DEPM(-1)

F-statistic	9.457035	Probability	0.001087
Log likelihood ratio	20.47424	Probability	0.000036

The hypothesis that the exchange rate + import prices not contribute to the explanation of inflation is rejected at the usual significance levels.

Equation (4.3)

LS // Dependent Variable is PAIXH
Sample: 1989:1 1996:4
Included observations: 32
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.039790	0.008420	4.725383	0.0001
DEPM	0.111258	0.040242	2.764753	0.0110
DEPM(-1)	-0.014946	0.032629	-0.458065	0.6512
DMY(-2)	0.081628	0.033278	2.452910	0.0222
DMY(-3)	0.068874	0.037170	1.852919	0.0768
DMY(-4)	0.027724	0.026786	1.034986	0.3114
DMY(-5)	0.066295	0.032143	2.062529	0.0506
MU4(-2)	-0.283391	0.114729	-2.470098	0.0214
D2	0.008170	0.003471	2.353545	0.0275

R-squared	0.602821	Mean dependent var	0.028671
Adjusted R-squared	0.464672	S.D. dependent var	0.012131
S.E. of regression	0.008876	Akaike info criterion	-9.216544
Sum squared resid	0.001812	Schwarz criterion	-8.804306
Log likelihood	111.0587	F-statistic	4.363552
Durbin-Watson stat	1.893260	Prob(F-statistic)	0.002565
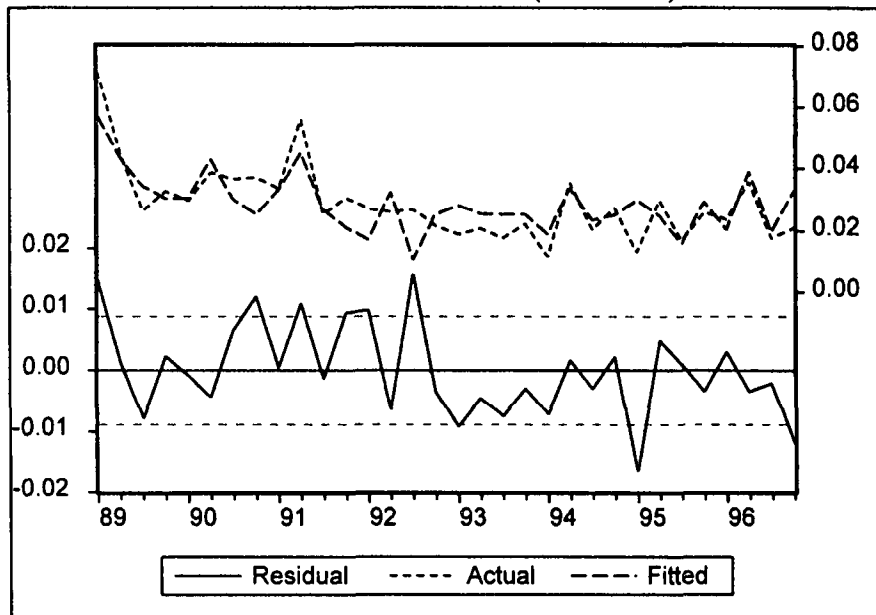
Equation (4.4)

LS // Dependent Variable is PAIX
Sample: 1989:1 1996:4
Included observations: 32
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.056908	0.012823	4.438119	0.0001
DEPM	0.175348	0.049730	3.526010	0.0016
DEPM(-1)	0.135355	0.046949	2.883033	0.0078
RMIC(-2)	-0.203458	0.076376	-2.663883	0.0131
MU4(-2)	-0.372503	0.131755	-2.827236	0.0089
D2	0.007281	0.004231	1.721051	0.0971

R-squared	0.623089	Mean dependent var	0.033450
Adjusted R-squared	0.550607	S.D. dependent var	0.015939
S.E. of regression	0.010685	Akaike info criterion	-8.910485
Sum squared resid	0.002968	Schwarz criterion	-8.635659
Log likelihood	103.1617	F-statistic	8.596373
Durbin-Watson stat	1.648380	Prob(F-statistic)	0.000066

Equation (4.5)

LS // Dependent Variable is PAIX
Sample: 1987:1 1991:4
Included observations: 20
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.041822	0.005229	7.997631	0.0000
DEPM	0.203039	0.048224	4.210303	0.0008
DMY(-2)	0.130567	0.047022	2.776715	0.0141
D(DEBT(-1))	0.012685	0.004410	2.876422	0.0115
D(UNEMP(-4))	-0.603137	0.503493	-1.197906	0.2495

R-squared	0.499418	Mean dependent var	0.043532
Adjusted R-squared	0.365930	S.D. dependent var	0.014690
S.E. of regression	0.011697	Akaike info criterion	-8.684443
Sum squared resid	0.002052	Schwarz criterion	-8.435510
Log likelihood	63.46566	F-statistic	3.741283
Durbin-Watson stat	1.741944	Prob(F-statistic)	0.026446

Note:

DEBT is the government's debt as a percentage of GDP.

UNEMP is the rate of unemployment.

D() is the difference operator

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