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# INFLATION, UNEMPLOYMENT, THE EXCHANGE RATE, AND MONETARY POLICY IN ISRAEL, 1990–99: A SVAR APPROACH

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In this paper we examine the effect of monetary policy on the Israeli economy, and in particular on unemployment and the evolution of prices, for the period between 1990 and 1999, using the SVAR methodology. The four endogenous variables are the unemployment rate in deviations from its trend, the inflation rate, the Bank of Israel nominal interest rate and local-currency depreciation. We posit two models. In the first the identification restrictions imply that aggregate supply does not respond immediately to changes in aggregate demand, while in the second the aggregate supply response to demand shocks has been designed to have the maximum effect. The impulse response function analysis in both models indicates that an unexpected tightening of monetary policy is followed by a relatively fast slowdown in the inflation rate and a rise in the unemployment rate. This result differs from the findings in other empirical work concerning relatively large closed economies in which prices respond with a delay to policy changes, lagging behind the output response.

The analysis of the actual structural shocks during the period surveyed indicates that supply shocks are the main reason why unemployment deviates from its long-term level. The contribution of monetary policy shocks to the evolution of unemployment between 1993 and 1994 and after 1997 in the context of the second model is in line with existing appraisals of monetary policy, according to which it was loose in the first sub-period and tighter in the second one. It may therefore be inferred that this model, which is characterized by nominal frictions, is more suitable for describing Israel's economy during the estimation period.

## 1. INTRODUCTION

In this paper we estimate a four-equation quarterly structural VAR model of the Israeli economy in 1990–99. The estimated system of equations includes an unemployment equation, an inflation equation, a nominal interest equation describing the evolution of Israel's key (BoI—Bank of Israel) interest rate, and a nominal local-currency depreciation equation.

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Our paper belongs to a large group of empirical studies which examine the effect of monetary policy on the economy in general, and especially on economic activity, employment, and the evolution of prices, by estimating SVAR models. Our estimation methodology derives from Sims (1980). Our approach does not assume recursiveness for the identification of the structural model, however. Most of the empirical studies in this field relate to the US, although some refer to other economies as well, e.g., those of Sims (1992), Eichenbaum and Evans (1995), and Cushman and Zha (1997). Surveys of this empirical work may be found in Todd (1990) and Vinals and Valles (1999). Christiano et al (1998) present an analytical and critical survey relating to both the statistical aspects of the estimations and their findings. According to their research, an unexpected monetary-policy tightening initially affects the monetary aggregates and economic activity, which contract, and at a later stage the rate of inflation, which slows down. In much of the empirical work an unexpected change in monetary policy is also followed by protracted nominal and real local-currency appreciation, and is reflected in a systematic deviation from uncovered interest-rate parity (Eichenbaum and Evans, 1995). This is in general the response pattern of large and relatively closed economies like the US. In small open economies an unexpected tightening of monetary policy also leads to nominal and real local-currency appreciation, but the response of output and prices is faster than in large closed economies, and the response of prices to the monetary policy shock does not lag behind that of output. This seems to be due to the rapid reaction of the exchange rate to monetary-policy changes and to the contribution of the former to the evolution of prices (Cushman and Zha, 1997).[1]

The variables used to measure monetary policy in these studies include the interbank interest rate in the US (Federal-funds rate), non-borrowed reserves, total reserves, and monetary aggregates such as the M1 and M2 monetary bases. The variance decomposition results indicate that these variables explain only a fraction of the variability of output relative to the other variables of the estimated models, with the exception of the Federal-funds rate. According to the results obtained by Christiano et al. (1998) for the US, the variability of the Federal-funds rate explains about 44 percent of output variability two years after the initial monetary-policy shock. Research on smaller and open economies indicates that shocks to monetary policy have weaker effects on the variability of output. Cushman and Zha (1997) report a maximum contribution of 2.75 percent in the case of Canada, with a six-month lag after the original monetary-policy shock.

In the framework of the models presented below, we impose six restrictions in order to fully identify the structural model. In choosing one of them, we followed King and Watson (1994) and Dolado et al (1996), with minor modifications, in order to distinguish two different structural models. In the first model, supply does not respond simultaneously to changes in aggregate demand, while in the second, the supply response has been designed to maximize

[1] In some studies the unexpected tightening of monetary policy was followed by nominal local-currency depreciation (Sims, 1992). This phenomenon is known as the ‘exchange rate puzzle’ in the literature. According to Cushman and Zha, the puzzle is due to inappropriate identification restrictions imposed on the coefficients of the monetary-policy equation.

the effect of demand shocks on output and hence on unemployment. The remaining five identifying restrictions reflect assumptions which make economic sense and give rise to reasonable results.[2]

According to our estimation results, positive shocks to the key (BoI) interest rate slow inflation and are reflected in both structural models in a rise in the real interest rate and unemployment. Inflation responds rapidly to interest-rate shocks, because of the exchange-rate response to changes in the interest rate. This is in line with similar findings in empirical studies of small open economies.

In spite of the response of unemployment and inflation to monetary-policy shocks, the variance decomposition results suggest that the variability of the key interest rate may be regarded as the source of a small proportion of inflation variability and an almost negligible share of unemployment variability in both structural models. These results are in line with the findings of Cushman and Zha (1997) for Canada. In the framework of our second structural model, however, the analysis of the retrieved actual structural shocks implies that interest-rate and demand shocks contributed to some extent to the fall in unemployment between 1993 and 1995 as well as to its rise between 1996 and 1999.

The estimation results indicate that there is no substantial difference between the central bank reaction functions in the two structural models. In our view, however, it is preferable to relate to this equation as describing the evolution of the central bank's interest rate rather than its reaction function, because the equation's estimated structure does not necessarily reflect central bank preferences. (Christiano et al, 1998).

The two estimated structural models differ in their response to local-currency depreciation shocks. In particular, unemployment reacts in opposite ways to local-currency depreciation shocks in the two models. While in Model 1 economic activity is not affected by the shock on impact, because it does not respond to changes in aggregate demand in the short run, in Model 2 depreciation is followed by a fall in unemployment.

Our paper consists of four additional parts. In the second part we describe the identification procedure of the structural model and the restrictions imposed upon the coefficients of the coincident variables in it. In the third part we present the data and the estimation results, including the impulse response function and the variance decomposition analyses. In the fourth part we analyze the contribution of the actual structural shocks on the evolution of the endogenous variables during the estimation period. The fifth part concludes.

## 2. THE STRUCTURAL MODEL AND ITS IDENTIFICATION

### a. A general description of the model

Our model is a structural vector autoregression model (SVAR), which consists of a system of four equations, presented below, describing the relationship between the level of unemployment,

[2] Other combinations, which are equally justified economically, gave rise to improbable results and sometimes to complex solutions for the coefficients of the coincident endogenous variables of the structural model.

the rate of inflation, the central bank's nominal interest rate, and local-currency depreciation (NIS vs. the currency basket). The data are quarterly and the estimation of the model refers to the period between 1990 and 1999. The equations of the structural model may be written as follows (1.1–1.4):

$$U_t = \lambda_1 DP_t + \lambda_2 i_t + \lambda_3 \dot{e}_t + \sum_{i=1}^{k} a_{11}^{i} U_{t-i} + \sum_{i=1}^{k} a_{12}^{i} DP_{t-i} + \sum_{i=1}^{k} a_{13}^{i} i_{t-i} + \sum_{i=1}^{k} a_{14}^{i} \dot{e}_{t-i} + \varepsilon_t^{s}$$

$$DP_t = \delta_1 U_t + \delta_2 i_t + \delta_3 \dot{e}_t + \sum_{i=1}^{k} a_{21}^{i} U_{t-i} + \sum_{i=1}^{k} a_{22}^{i} DP_{t-i} + \sum_{i=1}^{k} a_{23}^{i} i_{t-i} + \sum_{i=1}^{k} a_{24}^{i} \dot{e}_{t-i} + \varepsilon_t^{d}$$

$$i_t = \theta_1 U_t + \theta_2 DP_t + \theta_3 \dot{e}_t + \sum_{i=1}^{k} a_{31}^{i} U_{t-i} + \sum_{i=1}^{k} a_{32}^{i} DP_{t-i} + \sum_{i=1}^{k} a_{33}^{i} i_{t-i} + \sum_{i=1}^{k} a_{34}^{i} \dot{e}_{t-i} + \varepsilon_t^{i}$$

$$\dot{e}_t = \eta_1 U_t + \eta_2 DP_t + \eta_3 i_t + \sum_{i=1}^{k} a_{41}^{i} U_{t-i} + \sum_{i=1}^{k} a_{42}^{i} DP_{t-i} + \sum_{i=1}^{k} a_{43}^{i} i_{t-i} + \sum_{i=1}^{k} a_{44}^{i} \dot{e}_{t-i} + \varepsilon_t^{e}$$

For the sake of simplicity we omit the intercept and other exogenous variables which may appear in the system. The reduced-form VAR model we estimate does not include the coincident endogenous variables and is described by the four following equations (2.1–2.4):

$$U_t = \sum_{i=1}^{k} b_{11}^{i} U_{t-i} + \sum_{i=1}^{k} b_{12}^{i} DP_{t-i} + \sum_{i=1}^{k} b_{13}^{i} i_{t-i} + \sum_{i=1}^{k} b_{14}^{i} \dot{e}_{t-i} + e_t^{s}$$

$$DP_t = \sum_{i=1}^{k} b_{21}^{i} U_{t-i} + \sum_{i=1}^{k} b_{22}^{i} DP_{t-i} + \sum_{i=1}^{k} b_{23}^{i} i_{t-i} + \sum_{i=1}^{k} b_{24}^{i} \dot{e}_{t-i} + e_t^{d}$$

$$i_t = \sum_{i=1}^{k} b_{31}^{i} U_{t-i} + \sum_{i=1}^{k} b_{32}^{i} DP_{t-i} + \sum_{i=1}^{k} b_{33}^{i} i_{t-i} + \sum_{i=1}^{k} b_{34}^{i} \dot{e}_{t-i} + e_t^{i}$$

$$\dot{e}_t = \sum_{i=1}^{k} b_{41}^{i} U_{t-i} + \sum_{i=1}^{k} b_{42}^{i} DP_{t-i} + \sum_{i=1}^{k} b_{43}^{i} i_{t-i} + \sum_{i=1}^{k} b_{44}^{i} \dot{e}_{t-i} + e_t^{e}$$

Note that the coefficients of the lagged variables in the structural model, *a*, differ from the coefficients, *b*, of the lagged variables in the reduced-form VAR model. This is also the case with the structural shocks, ε, in the equations of the structural model and the random error terms, *e*, in the reduced-form VAR model. The identification restrictions allow us to identify the structural shocks, $\varepsilon_t$, *a*, and the coefficients of the contemporaneous variables of the structural model on the basis of the estimated coefficients *b* and the regression residuals $e_t$.

**b. The structural model's equations**

*i. The unemployment equation*

(1.1)

$$U_t = \lambda_1 DP_t + \lambda_2 i_t + \lambda_3 \dot{e}_t + \sum_{i=1}^{k} a_{11}^i U_{t-i} + \sum_{i=1}^{k} a_{12}^i DP_{t-i} + \sum_{i=1}^{k} a_{13}^i i_{t-i} + \sum_{i=1}^{k} a_{14}^i \dot{e}_{t-i} + \varepsilon_t^s$$

Equation (1.1) describes the deviation of the unemployment rate from its trend and may be interpreted as an inverted Phillips curve in line with the approach adopted by King and Watson (1994) and Dolado (1996). In this case, the structural error term stands for a structural shock which shifts this Phillips curve (upwards or to the right) in the inflation-unemployment plane. In the context of an AS-AD model, equation (1.1) stands for aggregate supply and the error term $\varepsilon_t^s$ for a supply shock.[3]

We assume that shocks to the BoI nominal interest rate and to the exchange rate do not affect the unemployment rate on impact. It is possible to justify this assumption on the grounds that the liquidity of the business sector and imports of raw materials are determined at the firm level in advance so that a change in their prices cannot affect output and unemployment contemporaneously. This justification is not affected if we relate to equation (1.1) as an inverted Phillips curve. Our assumption is equivalent to setting the coefficients $\lambda_2$ and $\lambda_3$ in the structural unemployment equation at zero. These are two of the six identification restrictions which allow the transition from the reduced-form VAR model to the structural model.

Different assumptions concerning the coefficient $\lambda_1$ allow us to distinguish between the two alternative structural models described briefly in the introduction. In Model 1 unemployment is insensitive to contemporaneous changes in aggregate demand, implying that $\lambda_1 = 0$ given that $\lambda_2$ and $\lambda_3$ have been assumed to be zero, while in Model 2 unemployment responds to contemporaneous changes in demand so that the impact effect of these changes on unemployment is maximal. A necessary and sufficient condition for unemployment to be insensitive to instantaneous changes in demand is that the coefficient $\lambda_1$ is equal to zero. For Model 2 we assume, following Dolado et al (1996), that the parameter $\lambda_1$ maximizes the coincident effect of structural demand shocks on unemployment.[4] This assumption gives the model Keynesian attributes by emphasizing the contribution of aggregate demand in determining employment in the short run. In particular a positive demand shock is expected to raise output, thus reducing unemployment, so that the coefficient $\lambda_1$ is expected to be negative in Model 2.

[3] The difference between the error terms in these two interpretations is a multiplication constant (see King and Watson, 1994) and note 5 below.

[4] For this to happen $\lambda_1$ has to fulfill the first-order condition for a maximum $d\left(\frac{dU_t}{d\varepsilon_t^d}\right) \Big/ d\lambda_1 = 0$ or the condition: $d\left(\frac{de_t^s}{d\varepsilon_t^d}\right) \Big/ d\lambda_1 = 0$.

*ii. The inflation equation*

(1.2)

$$DP_t = \delta_1 U_t + \delta_2 i_t + \delta_3 \dot{e}_t + \sum_{i=1}^{k} a_{21}^{i} U_{t-i} + \sum_{i=1}^{k} a_{22}^{i} DP_{t-i} + \sum_{i=1}^{k} a_{23}^{i} i_{t-i} + \sum_{i=1}^{k} a_{24}^{i} \dot{e}_{t-i} + \varepsilon_t^{d}$$

Equation (1.2) represents an inverted aggregate demand. In the context of an AS-AD model the structural shock, $\varepsilon^{d}_{t}$, stands for a demand shock which shifts the aggregate demand curve upwards in the inflation unemployment plane.[5] Such a shock is reflected in Model 2 in a shift of the AD curve along the unemployment curve defined in equation (1.1).

We assumed here that changes in the interest rate affect aggregate demand with a lag and as a result $\delta_2=0$. We also assumed that changes in employment have no direct structural contemporaneous effect on aggregate demand and hence on inflation so that $\delta_1=0$. We assumed that aggregate demand does respond to contemporaneous changes in the depreciation of the exchange rate and as a result the coefficient $\delta_3$ may be different from zero. Other things constant, an acceleration in the depreciation of the exchange rate implies a higher real local-currency depreciation which enhances aggregate demand, requiring $\delta_3$ to be positive.

*iii. The interest-rate equation*

(1.3)

$$i_t = \theta_1 U_t + \theta_2 DP_t + \theta_3 \dot{e}_t + \sum_{i=1}^{k} a_{31}^{i} U_{t-i} + \sum_{i=1}^{k} a_{32}^{i} DP_{t-i} + \sum_{i=1}^{k} a_{33}^{i} i_{t-i} + \sum_{i=1}^{k} a_{34}^{i} \dot{e}_{t-i} + \varepsilon_t^{i}$$

Equation (1.3) could be regarded as the reaction function of the BoI, as perceived by econometricians, on the basis of the observed data. In this context, the error term in expression (1.3) might stand for random shocks to the central bank's preferences as a result of, say, a temporary change in the balance of power on its monetary policy board (Christiano et al, 1998). Since in Israel there is no such board, we could give the structural shock a broader interpretation as a random change in the influence that various members of the central bank's management exert on the Governor regarding the formulation of monetary policy. Another way of interpreting this shock is as reflecting statistical errors in the data available to the central bank in the decision-making process (Bernanke and Mihov, 1995).

The way the interest rate is set by the central bank, as described in equation (1.3), may reflect the fact that the unemployment rate appears in the bank's utility function, so that when unemployment rises the central bank will tend to lower interest rates. But it is equally possible that the unemployment rate will also appear in the central bank's reaction function even if an inflation target is the only monetary-policy target. This is because at a higher unemployment rate it may be possible to attain the same inflation rate with a relatively lower interest rate.

[5] The standard demand shock which shifts the AD curve to the left in the inflation unemployment plane is equal to $\varepsilon^{d}/\delta_1$.

Similarly, it is not clear whether the inclusion of local-currency depreciation in the interest-rate equation reflects the fact that the central bank's utility is affected by, say, the variability of the exchange rate or that local-currency depreciation affects inflation, which is the central bank's sole target. Christiano et al (1998) point out in this respect that while a central bank need not relate to variables included in its so-called reaction function, their inclusion in an econometric equation may reflect the fact that they constitute a reliable measure of unobservable variables. As a result, the coefficients of the equation used for setting the interest rate do not necessarily reflect the central bank's preferences or reaction function, but rather the outcome of the reaction function as perceived by econometricians. It therefore seems preferable to relate to expression (1.3) as an equation describing the evolution of the central bank's interest rate rather than as a feedback rule.

We assume that the BoI does not respond to contemporaneous changes in the unemployment rate because employment data become available with a lag of at least one quarter in Israel. As a result, the structural equation coefficient $\theta_1$ was assumed to be zero. This assumption constitutes the last identification restriction needed for the the two structural models.

If expectations for $U_t$ are based on lagged values of the unemployment rate, in line with the specification of equation (1.1), then $U_t$ need not appear in the specification of the interest-rate equation even though unemployment forecasts may be part of the variables taken into consideration in formulating monetary policy. As a result it cannot be claimed that our identification restriction, $\theta_1 = 0$, implies a disregard by the BoI for indicators of economic activity when setting interest rates during the estimation period. This argument warns also against a narrow interpretation of the estimation results as reflecting the policy maker's relative preferences between inflation and real activity and it is consistent with earlier discussion on this subject.

We expect the central bank to raise interest rates following positive demand and local-currency depreciation shocks, so that coefficients $\theta_2$ and $\theta_3$ should be positive. This assumption is consistent with any kind of central bank target provided we assume that it follows a stabilizing policy with respect to either inflation or economic activity, or both.

The BoI sets its interest rate for a particular month at the end of the preceding month. In view of the fifteen-day delay in the announcement of the CPI (Consumer Price Index) by the CBS, this procedure for setting the interest rate implies that the BoI does not have exact information about the CPI in two of the three months making up a particular quarter when it sets the interest rate for the last month of that quarter. We included the coincident quarterly inflation rate in the interest-rate equation even though it is partially unobservable, because information concerning many of the developments which affect it is available to both the public and the central bank at the time the latter sets the interest rate. Moreover, this information affects the formation of inflation expectations, which serve as an input in the BoI's decision-making process, a consideration that also helped to tip the scales in favor of introducing the coincident inflation rate in the interest-rate equation.[6]

[6] A more prosaic reason for including this variable in the equation specification is that setting the corresponding coefficient to zero required lifting other restrictions. The results of this experiment lead either to complex roots or to unsatisfactory estimation results.

Local-currency depreciation is included in the interest-rate equation because it may help to predict future inflation, which affects the determination of the central bank's interest rate. In this context, including the contemporaneous local-currency depreciation in equation (1.3) gives some forward-looking characteristics to the interest-rate equation.

*iv. Local-currency depreciation equation*

(1.4)

$$\dot{e}_t = \eta_1 U_t + \eta_2 DP_t + \eta_3 i_t + \sum_{i=1}^{k} a_{41}^{i} U_{t-i} + \sum_{i=1}^{k} a_{42}^{i} DP_{t-i} + \sum_{i=1}^{k} a_{43}^{i} i_{t-i} + \sum_{i=1}^{k} a_{44}^{i} \dot{e}_{t-i} + \varepsilon_t^e$$

Equation (1.4) describes the endogenous determination of nominal local-currency depreciation in a small open economy such as Israel's. We introduce this equation because the exchange rate plays a primary role in determining both the inflation rate and the level of economic activity, the latter through its short-run effect on the determination of the real exchange rate. The inclusion of local-currency depreciation as an endogenous variable in our model is not costless, however. Israel's exchange-rate regime underwent drastic shifts during the period under consideration: a fixed exchange rate was changed to a horizontal exchange-rate band at the beginning of 1989 (30.1.1989) with extensive intra-band intervention by the central bank, eventually converging to a crawling and gradually widening exchange-rate band without any central bank intervention.[7] Moreover, periods of discrete devaluations in Israel were generally preceded by speculative attacks, to which the BoI responded by raising interest rates. This sequence of developments is reflected in a positive correlation between interest rates and local-currency depreciation and requires the imposition of additional restrictions to identify periods of speculative attacks. These factors constitute very important regime changes, which weaken the assumption of the stability of the coefficients during the period surveyed, but the relatively small number of available observations limit our ability to distinguish different exchange-rate regimes.[8] In an effort to partly overcome this problem, we set the beginning of the sample period in 1990, thus excluding the first quarter of 1989, which included the discrete devaluation of January 1989 and the transition period from a fixed exchange-rate policy—between the introduction of the stabilization plan in 1985 and January 1989—to a horizontal exchange-rate band.

Shocks to the structural equation may measure unrest in foreign asset markets. However, we cannot exclude the possibility that the structural shocks will also include the effect of some of the changes in the exchange-rate regime.

We assume that the exchange rate, which is determined in the financial markets, is affected without a lag by macroeconomic conditions, and is therefore affected by the coincident unemployment and interest rates as well as by demand conditions in the goods market, even though these variables may not be observable in real time.

[7] The fixed exchange-rate regime period was characterized by discrete devaluations with speculative attacks. Discrete devaluations also characterized the period of the horizontal exchange-rate band during realignments (September 1989, March 1991, and October 1991).

[8] An attempt to introduce a dummy variable for the period after February 1996, when the BoI discontinued its intervention within the exchange-rate band, was not successful. For a discussion of the introduction of additional exogenous variables in the estimation process, see next section.

We expect that a negative structural shock to the supply side, reflected in higher unemployment, will be accompanied by a deterioration in the balance of payments because exports will fall and imports rise, leading to nominal local-currency depreciation. Under these conditions, the coincident unemployment coefficient $\eta_1$ should be positive. The inflation coefficient $\eta_2$ measures the immediate effect of changes in aggregate demand on local-currency depreciation. Our model does not differentiate between domestic demand shocks, which are expected to lead to a deterioration in the balance of payments and give rise to local-currency depreciation, and foreign demand shocks, which are expected to improve the balance of payments and lead to nominal appreciation. It is impossible, therefore, to define the sign of $\eta_2$ ex-ante and we leave this to the estimation results. We expect changes in the BoI's interest rate to be negatively correlated with local-currency depreciation, in spite of the positive correlation between the two during periods of turbulence in the foreign-exchange market. The restrictions we have imposed and the signs of the remaining free coefficients are summarized in Table 1.[9]

**Table 1**
**The Coefficients of the Contemporaneous Endogenous Variables**

| Equation | $U_t$ | $DP_t$ | $i_t$ | $\dot{e}_t$ |
|---|---|---|---|---|
| Unemployment (inverted Phillips curve or AS) $U_t$ | | $\lambda_1 = 0$<br>$\lambda_1 < 0$ | $\lambda_2 = 0$ | $\lambda_3 = 0$ |
| Inflation (AD) $DP_t$ | $\delta_1 = 0$ | | $\delta_2 = 0$ | $\delta_3 > 0$ |
| Bank of Israel nominal interest rate $i_t$ | $\theta_1 = 0$ | $\theta_2 > 0$ | | $\theta_3 > 0$ |
| Local-currency depreciation $e_t$ | $\eta_1 > 0$ | $\eta_2$? | $\eta_3 < 0$ | |

## 3. THE DATA AND THE ESTIMATION RESULTS

### a. The data

The system we estimated is described by equations (2.1)–(2.4) and the estimation results appear in Table A.1 in the Appendix. The estimation is based on quarterly data from the beginning of 1990 to the end of 1999, a total of 40 observations. The unemployment data are seasonally adjusted data of Israel's CBS. Following statistical tests, we found that the unemployment rate is an I(1) variable, in contrast with the rest of the variables which are I(0). In order to establish the same degree of integration for the unemployment rate with the other endogenous variables, we detrended the unemployment data using the HP filter (Figures 1 and 2). The HP filter serves as a proxy for a moving average, and may be considered as providing a measure for the NAIRU without losing any observations, as would have happened

[9] Our choice of identification restrictions, given in Table 1, reflects the combination which yields the most sensible estimation results from the economic point of view.

had we been using a simple moving average method. This is a very important property of the HP filter as far as our estimation is concerned given the limited number of observations available.[10]

**Figure 1**
**The Unemployment Rate (deviation from trend), Inflation Rate, Interest Rate, and Exchange Rate, 1990–1999**

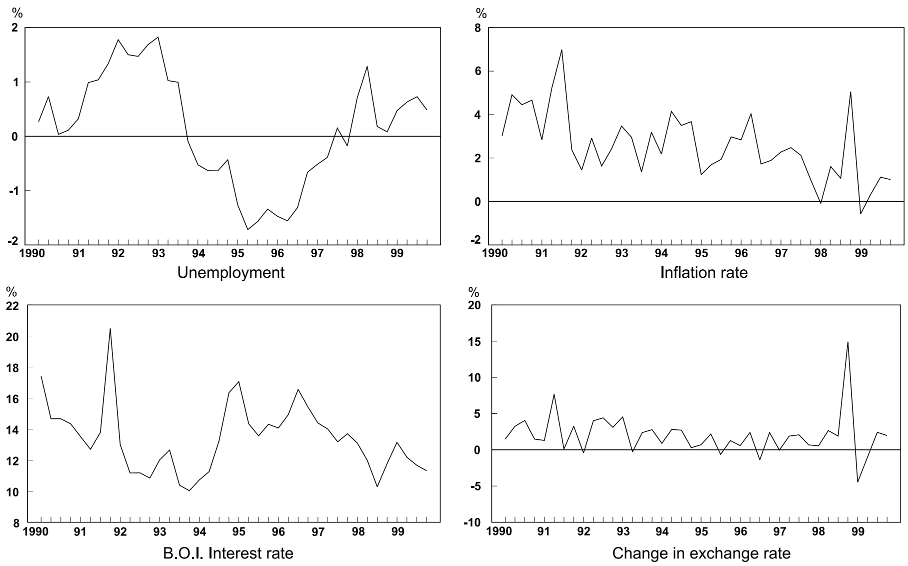
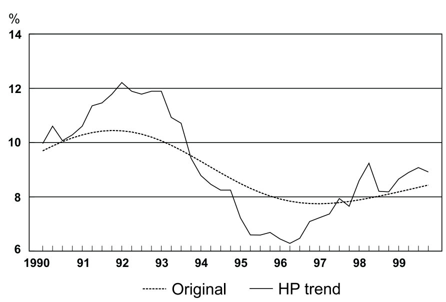



**Figure 2**
**Unemployment: Original Data and HP-Filtered**




[10] There is no considerable difference in the results for different values of the smoothing parameter (1000,1600 or 5000) in the HP filter. The results reported here are based on a smoothing parameter of 1600.

The rates of change of the CPI and the exchange rate are calculated as the change in the average quarterly level of these two variables between two consecutive quarters. The BoI's interest rate used is the marginal interest rate on the monetary loan at the discount window. Since the estimated equations did not all contain the same number of lagged variables, we used the SUR method for estimating our VAR model.

As a result of the limited number of observations and degrees of freedom, we economized on the number of lagged variables in each of the estimated equations. The lag length was chosen on the basis of the nature of the estimated variable and the estimation results. The longest lags were four-quarter lags. In the unemployment equation all the endogenous variables appear with four lags. In the aggregate demand (inflation) equation all endogenous variables appear with three lags besides local-currency depreciation, which appears with two lags only. In the BoI's nominal interest-rate equation we include only two lags of the endogenous variables and in the local-currency depreciation equation we include three lagged values of the endogenous variables.

The lag structure in the estimated VAR model and the restrictions imposed on the coincident coefficients of the endogenous variables in the structural model determine the lag structure of the structural model. This is characterized by four lagged values of the endogenous variables in the unemployment and the local-currency devaluation equation and by three lags in the other two equations.

### b. The exogenous variables[11]

In three of the four estimated equations we also introduce some exogenous variables. In the *unemployment equation* we introduce two exogenous variables: the influx of new immigrants—a population characterized by a higher unemployment rate during the sample period than the non-immigrant population—with a two- and three-quarter lag, and foreign workers—including Palestinian workers—with a three- and four-quarter lag. We expect this to enable us to incorporate a possible substitution effect.[12]

In the *aggregate demand* equation we include seven exogenous variables, four of which are dummies; one of these is a seasonal dummy variable for the second quarter because of the seasonality of the CPI, which tends to rise above average during this period. Two additional dummy variables were used to account for the lower inflation plateaux after 1991 and after 1997. The fourth seasonal dummy was introduced to differentiate between the last quarter of 1998 and the remaining observations, to account for the turbulence in the foreign-exchange market, the substantial local-currency depreciation, and relatively high inflation during this period. The fifth exogenous variable is the rate of change of the dollar price of imported consumer goods, a rise in which is reflected in real local-currency depreciation, supporting the expansion of exports and substitution of imports. The high correlation coefficient between

[11] The exogenous variables were introduced in our model through the reduced-form VAR equations. As a result, these variables appear in the specification of all four structural equations.

[12] The influence of the new immigrants on unemployment is partly reflected in the detrended unemployment rate. We detrended the number of foreign workers using an HP filter, as was the case with the unemployment rate. The inclusion of this variable substantially improved the fit of the model and the results of the dynamic simulation.

the rates of change of dollar import and export prices (about 75 percent) implies that the inclusion of this exogenous variable in the aggregate demand equation accounts to a great extent for the effect of changes in the price of tradable goods on aggregate demand (or on the inflation rate).

The sixth exogenous variable included in the estimation of the aggregate demand equation is the share in GDP of the government's civilian expenditure, which we expect to be positively correlated, *ceteris paribus*, with aggregate demand and hence with the inflation rate. The seventh exogenous variable included in this equation is the influx of new immigrants with the same specification we used in the unemployment (AS) equation. We include this variable in the specification of the AD equation because we assume that it will lead to an increase in aggregate demand, particularly for nontradables.

In the *local-currency depreciation equation* we include three exogenous variables: a dummy variable for the last quarter of 1998 for the reasons mentioned above, the nominal interest rate on foreign currency, and the flow of foreign direct investment lagged by one quarter. The foreign-currency interest rate we include is the weighted three-month Libor interest on the currencies constituting the currency basket in Israel. We introduce the dummy variable for the last quarter of 1998, which is characterized by exceptional local-currency depreciation, in order to neutralize the effect this could have on the estimation of the coefficients of the other variables in the equation. The foreign-currency interest rate is introduced to account for the fact that the differential between domestic and foreign interest rates affects capital flows, and thereby nominal local-currency depreciation, rather than the absolute level of domestic nominal interest rates. We introduce foreign direct investment, which constitutes a substantial component of capital flows, because it affects local-currency depreciation but is not affected by the interest-rate spread between domestic and foreign currency, which has been already included in the equation specification.

### c. The estimation results

In this section we present the estimation results and examine the dynamic evolution of the estimated system through a dynamic simulation, and an impulse response function analysis. While the latter enables us to evaluate the effect of a given shock on the endogenous variables of the estimated model, the Variance Decomposition analysis permits us to evaluate the relative effect of a given shock on the evolution of a single endogenous variable at different time horizons. This is achieved by focusing on the contribution of a specific structural shock to the variability of a particular endogenous variable.[13]

[13] We do not report confidence intervals for the impulse response function, as we do not yet have definite results for it. The identification of the structural model was made on the basis of our assumptions and by simultaneously solving a six-equation system with six unknown variables, using the mathematical package *Mathematica* to obtain exact solutions. An alternative statistical package (RATS) makes it possible to identify any kind of structural model using the maximum likelihood approach. We used this program to test for the robustness of our estimation results, and it transpired that the estimation results were highly dependent on the initial values on which the convergence of the coefficient estimation was based.

*i. The coefficients of the contemporaneous variables*

The estimation results indicate that the sign of the coefficients of the contemporaneous variables of the structural model are in the expected direction. Moreover, the coefficient of the inflation rate in the local-currency depreciation equation, $\eta_2$, is negative.

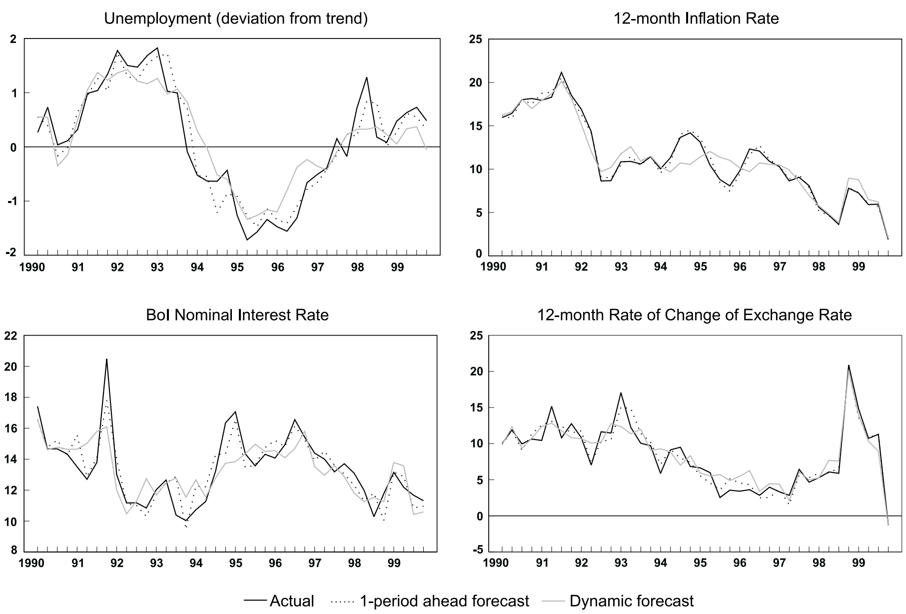
**Table 2**
**The Estimated Coefficients of the Contemporaneous Endogenous Variables**

| Equation | Coefficients | | Model 1 | Model 2 |
|---|---|---|---|---|
| **Unemployment** | Inflation rate | $\lambda_1$ | 0 | –0.249 |
| | BoI nominal interest rate | $\lambda_2$ | 0 | 0 |
| | Local-currency depreciation | $\lambda_3$ | 0 | 0 |
| **Aggregate demand** | Unemployment rate | $\delta_1$ | 0 | 0 |
| | BoI nominal interest rate | $\delta_2$ | 0 | 0 |
| | Local-currency depreciation | $\delta_3$ | 0.214 | 0.708 |
| **BoI nominal interest rate** | Unemployment rate | $\theta_1$ | 0 | 0 |
| | Inflation rate | $\theta_2$ | 0.135 | 0.134 |
| | Local-currency depreciation | $\theta_3$ | 0.386 | 0.369 |
| **Local-currency depreciation** | Unemployment rate | $\eta_1$ | 1.938 | 2.777 |
| | Inflation rate | $\eta_2$ | –2.076 | –2.952 |
| | BoI nominal interest rate | $\eta_3$ | –0.054 | –0.054 |

This may indicate that structural aggregate-demand shocks during the period surveyed originate mainly in shocks to the demand for exports.[14] The results of both the static and the dynamic simulations trace the actual evolution of the endogenous variables in a satisfactory manner (Figure 3), and we can therefore conclude that in the specification of our model we have not omitted basic explanatory variables. The estimation residuals were tested and found to be white noise.

[14] In order to distinguish between shocks to domestic demand and shocks related to foreign demand, we also include in the initial estimation stages the change in the volume of international trade and the deviation from its trend, but the results are not significant or have the wrong sign.

**Figure 3**
**Simulation Results**

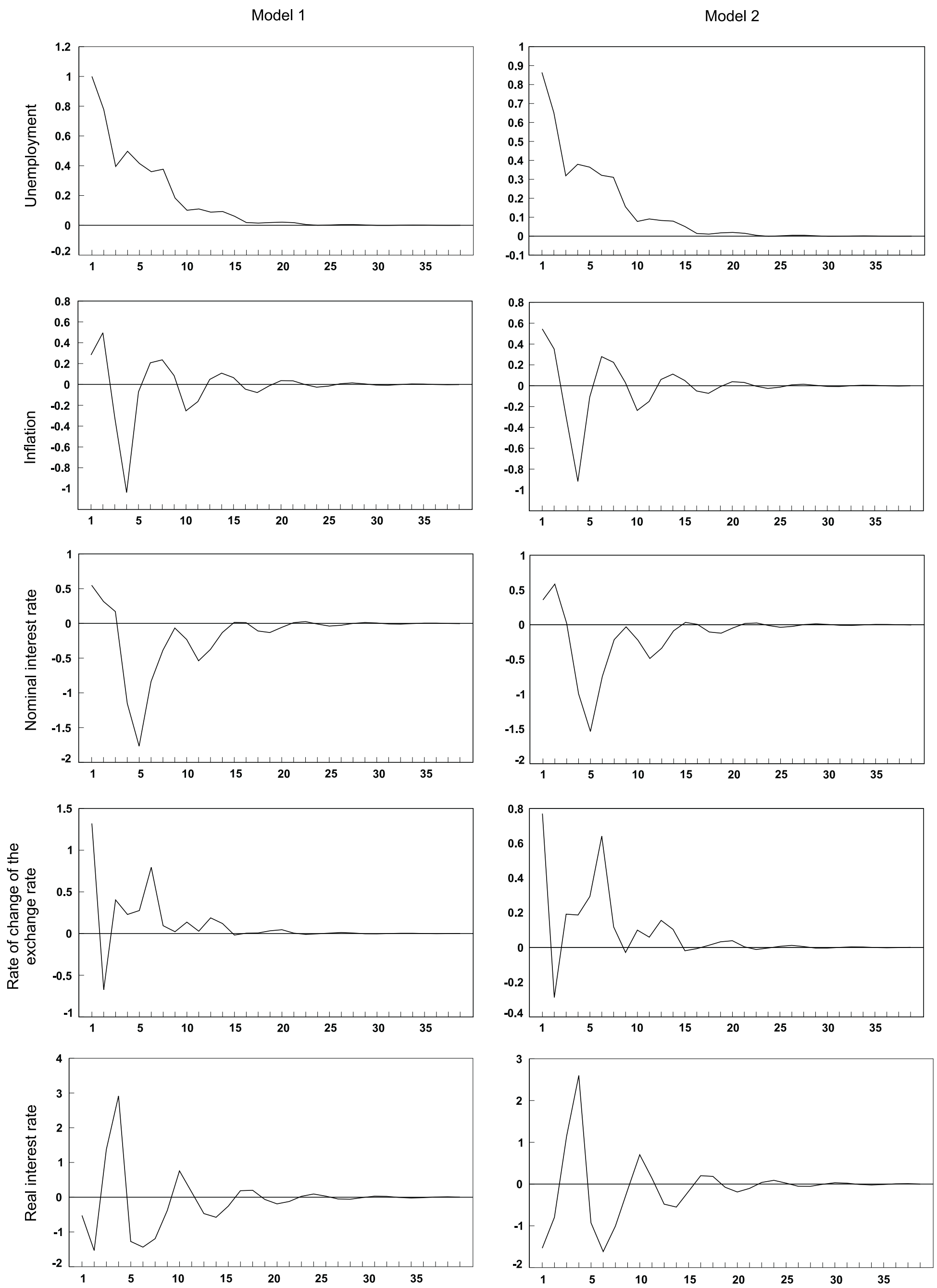



*ii. The impulse response function*

The analysis of the structural model's impulse response function is presented graphically in diagrams 4–7. The immediate effect of the structural shocks on the endogenous variables is given in Table A.2 in the Appendix. The diagrams and the table also include the evolution of the real interest rate derived from a combination of the impulse response functions of the nominal interest rate and the inflation rate to different structural shocks. The results of the impulse response function are similar in both models, with the exception of the response of unemployment to random disturbances in local-currency depreciation.

The impulse response to *unemployment shocks (AS shocks)* appears in Figure 4. An unemployment-augmenting structural shock, which is qualitatively equivalent to a negative supply shock, leads on impact to higher unemployment and local-currency depreciation, giving rise to inflationary pressures. The nominal local-currency depreciation following this shock may reflect the deterioration in the current account implied by a negative supply shock. The transmission of the supply shock to prices through the exchange-rate channel derives solely from our identification restriction, according to which shocks to unemployment have no immediate effect on either aggregate demand or inflation. The local-currency depreciation and inflationary pressures on impact are consistent with a rise in the BoI interest rate, as it is not immediately affected by unemployment. This rise in the interest rate is more moderate than the acceleration of inflation, however, and gives rise to an ex-post decline in the real interest rate. The rise in inflation is moderate relative to local-currency depreciation, since it

**Figure 4**
**The Impulse Response Function to Supply Shocks**



is the result of the latter and we assume that supply-side shocks have no immediate effect on prices. As a result, the structural negative supply shock leads initially to real local-currency depreciation.

In the wake of the immediate effect of the shock, the rise in unemployment weakens aggregate demand and inflationary pressures, thus supporting lower nominal interest rates. Convergence to long-run equilibrium is characterized in this case by a gradual rise in the interest rate as the inflation rate rises and unemployment falls to their equilibrium levels.

The immediate effect of *demand shocks* (Figure 5) is different in the two structural models, in line with our assumption concerning the inflation coefficient, $\lambda_1$, in the unemployment equation. We assume that this parameter is equal to zero in Model 1, so that a demand-augmenting shock affects only the inflation rate and not the unemployment rate on impact.

In Model 2 the supply-side reaction to a shock of this kind is reflected in a rise in real economic activity and a fall in unemployment, accompanied by a moderate rise in prices. The demand shock is followed by nominal local-currency appreciation. This is because of the negative sign of the inflation coefficient, $\eta_2$, in the local-currency depreciation structural equation, implying that random demand-side disturbances in the period surveyed reflect mainly shocks to exports. Given the relative size of the inflation and local-currency depreciation coefficients in the structural interest-rate equation, the nominal local-currency appreciation allows for a lower nominal interest rate on impact despite the rise in inflation. However, as inflation remains higher and unemployment lower than their trends, the nominal interest rate rises after the shock in both models. In spite of the difference between the two models on impact, the evolution of the endogenous variables and their convergence to equilibrium is nevertheless similar and it is oscillatory as far as nominal and real interest and inflation rates are concerned, being characterized by a gradual reduction in the central bank nominal interest rate and a rise in unemployment to their equilibrium level.

*Interest-rate shocks:* in line with the identification restrictions we imposed on the estimated structural models the transmission of the shock to the rest of the economy on impact is based on the exchange-rate channel (Figure 6). An unexpected interest rate increase leads to an exchange rate appreciation in both models. However, the supply side of the economy does not respond on impact to the exchange rate appreciation in Model 1 either directly ($\lambda_3 = 0$) or indirectly through the effect of the latter on aggregate demand ($\lambda_1 = 0$). As a result the unexpected change in the interest rate does not have any impact effect on economic activity as the latter is measured by the unemployment rate.

In contrast to Model 1, in Model 2 a positive interest rate shock affects economic activity and unemployment on impact through the exchange rate appreciation effect on aggregate demand ($\lambda_1 \neq 0$). However, in view of the relatively small size of the nominal interest rate coefficient in local-currency depreciation equation, the impact effect of a positive interest rate shock on the nominal exchange rate and through it on aggregate demand and economic activity is limited. As a result the ex-post response of the two models to interest rate shocks appears to be the same even though the transmission mechanism is substantially different between the two models. As a result the subsequent evolution of the economy is identical in both models.

**Figure 5**
**The Impulse Response Function to Demand Shocks**

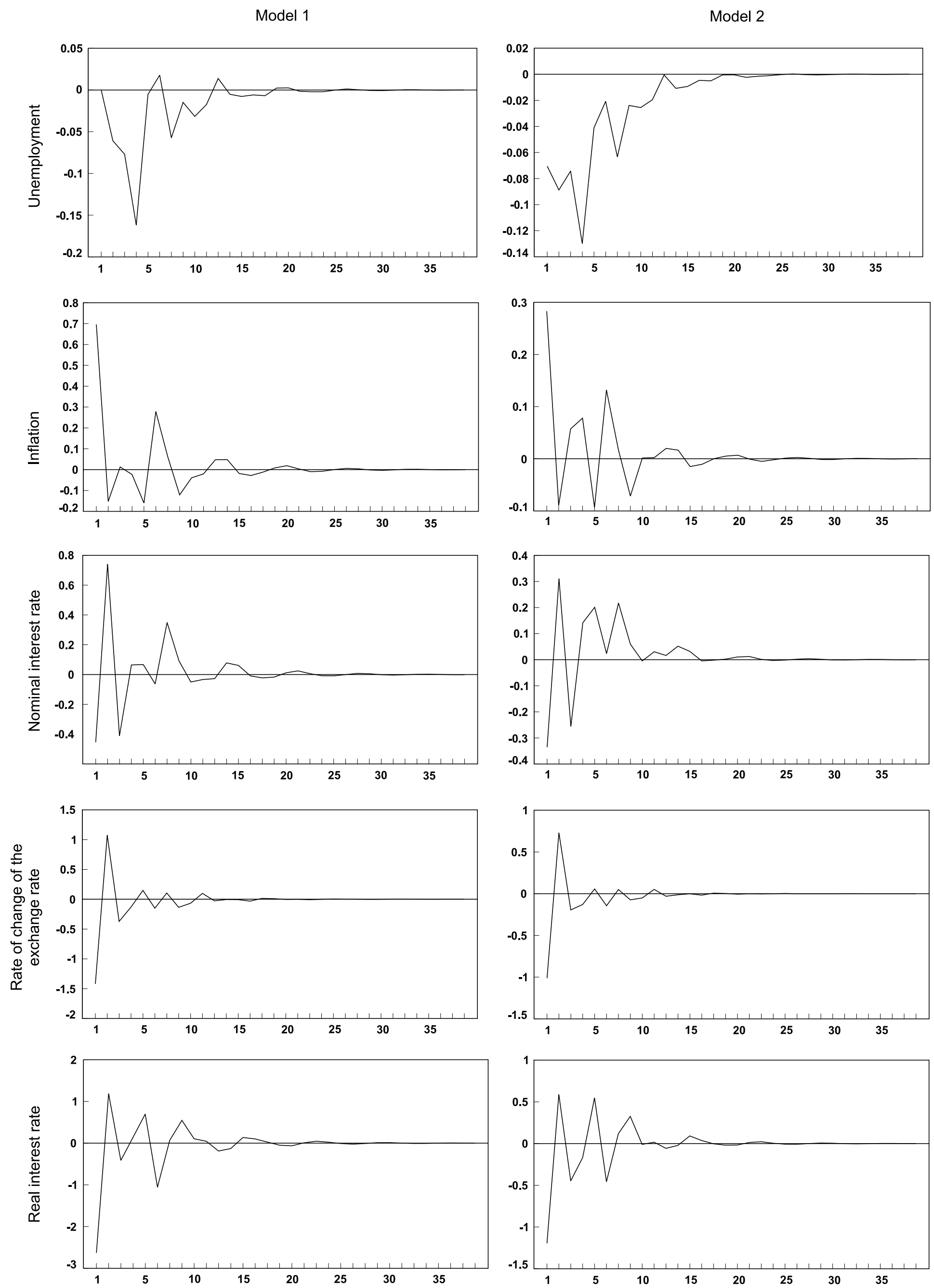


**Figure 6**
**The Impulse Response Function to Interest-Rate Shocks**

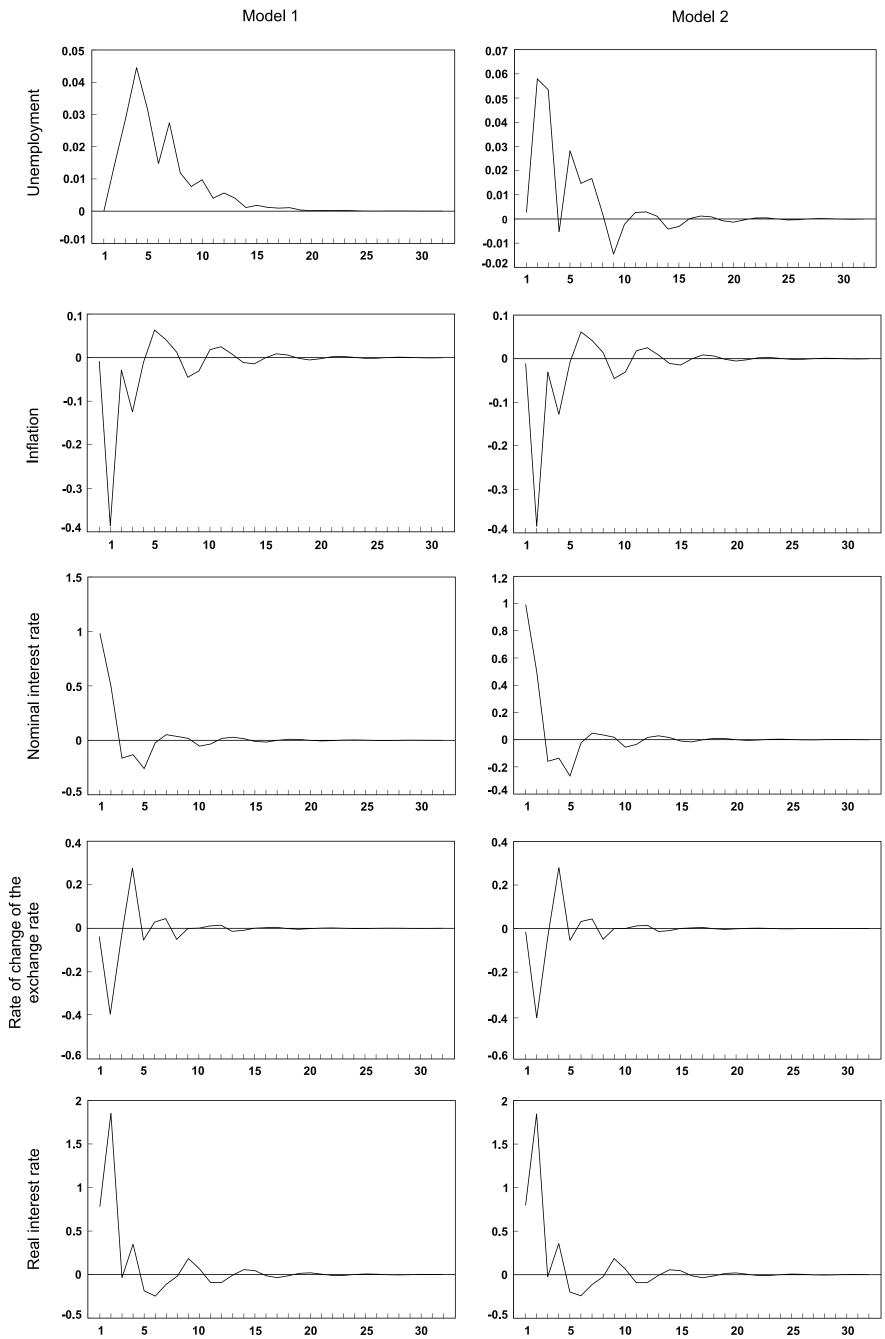
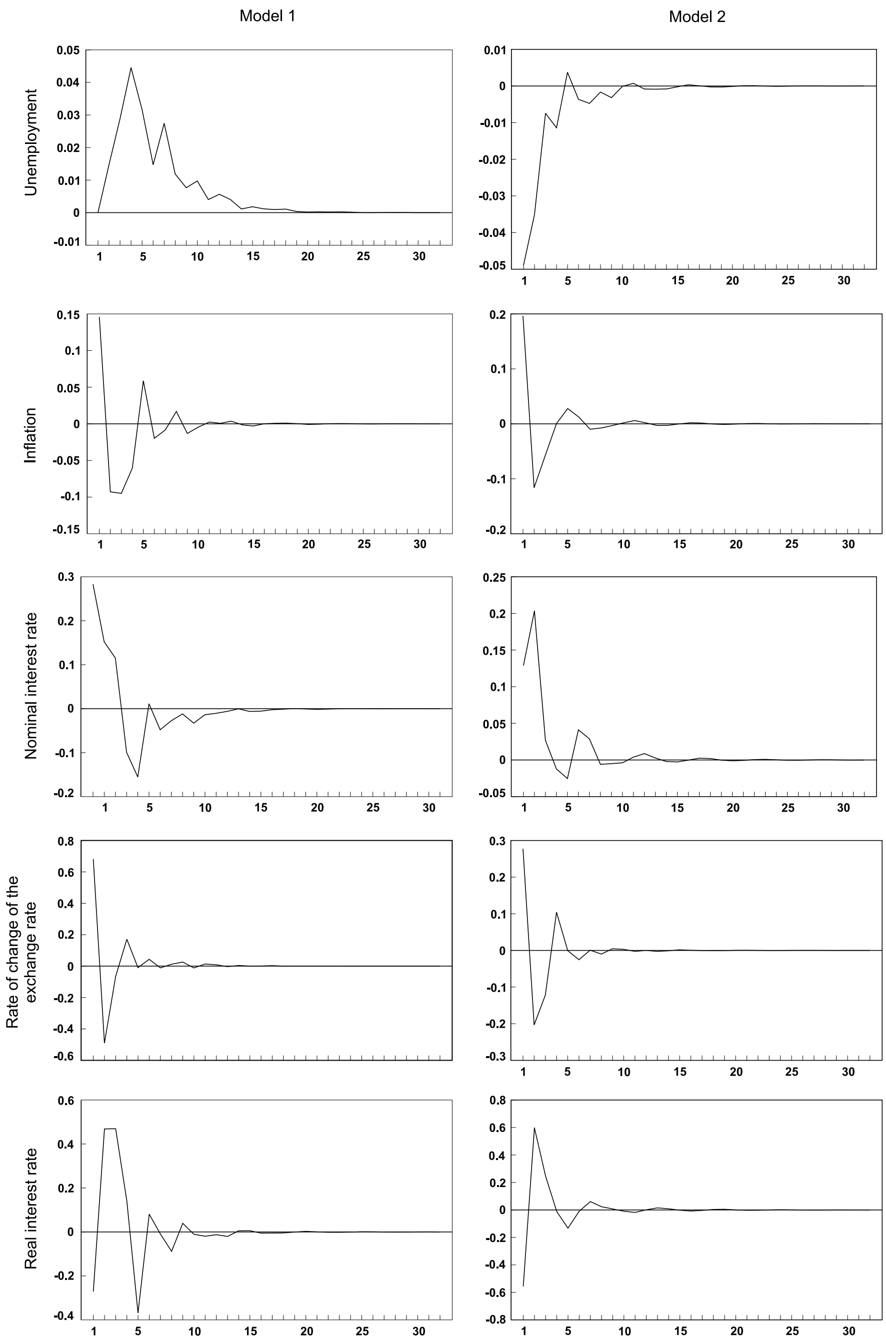


**Figure 7**
**The Impulse Response Function to Exchange-Rate Shocks**



The impact of the rise in the interest rate is intensified in the subsequent periods, as it affects the unemployment rate directly and local-currency appreciation indirectly. The exchange rate constitutes a channel for transmitting monetary policy to economic activity in addition to the conventional interest-rate channel which characterize large closed economies. The results of the impulse response function also emphasize the role of the exchange rate in transmitting monetary policy to prices, both directly, through the effect on prices of a change in the nominal exchange rate and indirectly, through the lagged effect of changes in the exchange rate on unemployment and, eventually, on prices.

According to the results of the impulse response function, prices in Israel respond sooner and in the expected direction to changes in the BoI interest rate than in other economies in which prices react to monetary policy shocks with some delay (Vinals and Valles, 1999).[15] As a result, our model does not suffer from the 'price puzzle' encountered in other SVAR models. This is because of the relatively quick response of the exchange rate to changes in monetary policy, on the one hand, and the relative small delay in the transmission of this response to prices and aggregate demand, on the other. Consequently, the period during which the economy deviates from equilibrium because of the change in monetary policy is shorter than in larger closed economies. In both models the convergence process to long-run equilibrium is characterized by a fall in nominal and real interest as well as by nominal local-currency depreciation.

*Local-currency depreciation shocks* (Figure 7): the different evolution of the two models following an unexpected increase in the rate of local-currency depreciation is notable. In both models a shock of this kind is reflected by an immediate rise in inflation because of the resulting expansion of aggregate demand. While in Model 1 economic activity is not affected by the local-currency depreciation shock ($\lambda_1 = \lambda_2 = 0$), in Model 2 it is followed by the expansion of economic activity and hence a fall in unemployment. In Model 1 the nominal interest rate rises immediately because of local-currency depreciation and the inflationary pressures leading to a slowdown in economic activity and rise in unemployment in the following period. In Model 2, on the other hand, the contractionary effect of the higher interest rate is reflected in the slowing of economic activity from its higher level following the depreciation shock. As a result, the process of the economy's convergence to long-run equilibrium is characterized by a gradual rise in economic activity and a fall in unemployment in Model 1, and by a gradual slowdown in economic activity from its higher levels in Model 2.

*iii. The variance decomposition*

The variance decomposition results for the two estimated structural models are presented in Table 4.

The main conclusions of the variance decomposition analysis may be summarized as follows:

- The contribution of demand, interest-rate, and local-currency depreciation shocks to the variability of unemployment, which is explained mainly by the variability of supply shocks, is limited. The data nonetheless indicate that there is a rise in the contribution of demand

[15] It takes eight quarters for unemployment to converge to its original level in Israel, in contrast with other countries, where the process takes between eight and twelve quarters.

**Table 3**
**Results of Variance Decomposition**

| Number of quarters | Supply shock | | Demand shock | | Interest-rate shock | | Depreciation shock | |
|---|---|---|---|---|---|---|---|---|
| since shock | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 |
| **Unemployment equation (AS)** | | | | | | | | |
| 0 | 1.000 | 0.927 | 0.000 | 0.043 | 0.000 | 0.001 | 0.000 | 0.030 |
| 3 | 0.976 | 0.858 | 0.013 | 0.087 | 0.028 | 0.030 | 0.005 | 0.051 |
| 20 | 0.921 | 0.819 | 0.038 | 0.138 | 0.023 | 0.026 | 0.017 | 0.018 |
| **Inflation equation (AD)** | | | | | | | | |
| 0 | 0.054 | 0.237 | 0.818 | 0.449 | 0.001 | 0.001 | 0.127 | 0.312 |
| 3 | 0.125 | 0.181 | 0.376 | 0.230 | 0.400 | 0.386 | 0.102 | 0.201 |
| 20 | 0.325 | 0.367 | 0.300 | 0.209 | 0.295 | 0.291 | 0.078 | 0.132 |
| **Interest-rate equation** | | | | | | | | |
| 0 | 0.029 | 0.016 | 0.051 | 0.096 | 0.850 | 0.868 | 0.070 | 0.020 |
| 3 | 0.028 | 0.039 | 0.156 | 0.160 | 0.746 | 0.752 | 0.070 | 0.049 |
| 20 | 0.280 | 0.269 | 0.121 | 0.152 | 0.536 | 0.543 | 0.061 | 0.035 |
| **Local-currency depreciation equation** | | | | | | | | |
| 0 | 0.159 | 0.069 | 0.162 | 0.839 | 0.001 | 0.001 | 0.377 | 0.091 |
| 3 | 0.128 | 0.049 | 0.452 | 0.772 | 0.077 | 0.085 | 0.342 | 0.093 |
| 20 | 0.156 | 0.080 | 0.417 | 0.714 | 0.106 | 0.115 | 0.320 | 0.090 |

shocks to the variability of unemployment in the long run in the context of Model 2. Vinals and Valles (1999) report similar results for other countries, although the weight of monetary shocks in the variability of output is limited, and does not exceed 10 percent.

- The contribution of demand shocks to the variability of inflation is substantial both on impact and in the long run. The contribution of supply and interest-rate shocks to the long-run variability of inflation is similar to that of demand shocks, although that of supply shocks is more pronounced.
- The variability of interest rates is explained mainly by interest-rate shocks. The contribution of supply shocks is substantial in the long run in both models.
- In the local-currency depreciation equation, the results of the decomposition of variance differ between the two models, in line with the impulse response analysis. The contribution of demand shocks to the variability of local-currency depreciation is substantial in both models for all time horizons, although in Model 2 it is considerably greater. The relative contribution of interest-rate and supply shocks is limited in both structural models.

## 4. THE ROLE OF MONETARY POLICY

We examined some aspects of the effect of changes in monetary policy on the economy through the impulse response function and the decomposition of variance. While the former examines the effect of a change in monetary policy on the evolution of the model's endogenous variables, the latter provides a relative measure of this effect with respect to structural shocks to other endogenous variables. In both cases monetary policy is evaluated relative to hypothetical changes in the interest rate. However, an evaluation of monetary policy should also relate to its contribution to the actual development of endogenous variables during the surveyed period. To achieve this, we retrieved the actual structural shocks to Israel's economy during the surveyed period, and identified their contribution to the evolution of the endogenous variables, concentrating on the effect of monetary policy shocks.

The effect of structural shocks in general, and interest-rate shocks in particular, on the dynamic evolution of our model is measured by the difference between the results of a dynamic simulation containing the retrieved shocks and the results of the basic dynamic simulation.[16]

The analysis of the contribution of the different structural shocks to the evolution of unemployment (Figure 8) suggests that the Israeli economy experienced supply shocks between 1993 and 1997 which reduced unemployment below the level foreseen by both versions of the estimated SVAR models. The employment-inducing effect of the supply shocks was enhanced by exchange-rate shocks in Model 1 and by interest-rate shocks between 1993 and 1994 in Model 2.

From the same exercise it transpires that in both models the economy experienced unemployment-inducing supply shocks after 1997, the effect of which was reinforced in both models after 1995 by positive interest-rate shocks. The rise in unemployment because of the monetary-policy shocks after 1997 is smoother in Model 2. Note in this context the positive correlation between unemployment and the deviations of the real interest rate from its original equilibrium level following a shock in the nominal interest rate (Figure 9).

The contribution of monetary-policy shocks to the evolution of unemployment between 1993 and 1994 and after 1997 in Model 2 is in line with existing appraisals of monetary policy, according to which it tended to be loose during the first sub-period and tight in the second one.[17] From this it may be inferred that Model 2, which is characterized by nominal frictions, is more suitable for describing the Israeli economy during the estimation period.

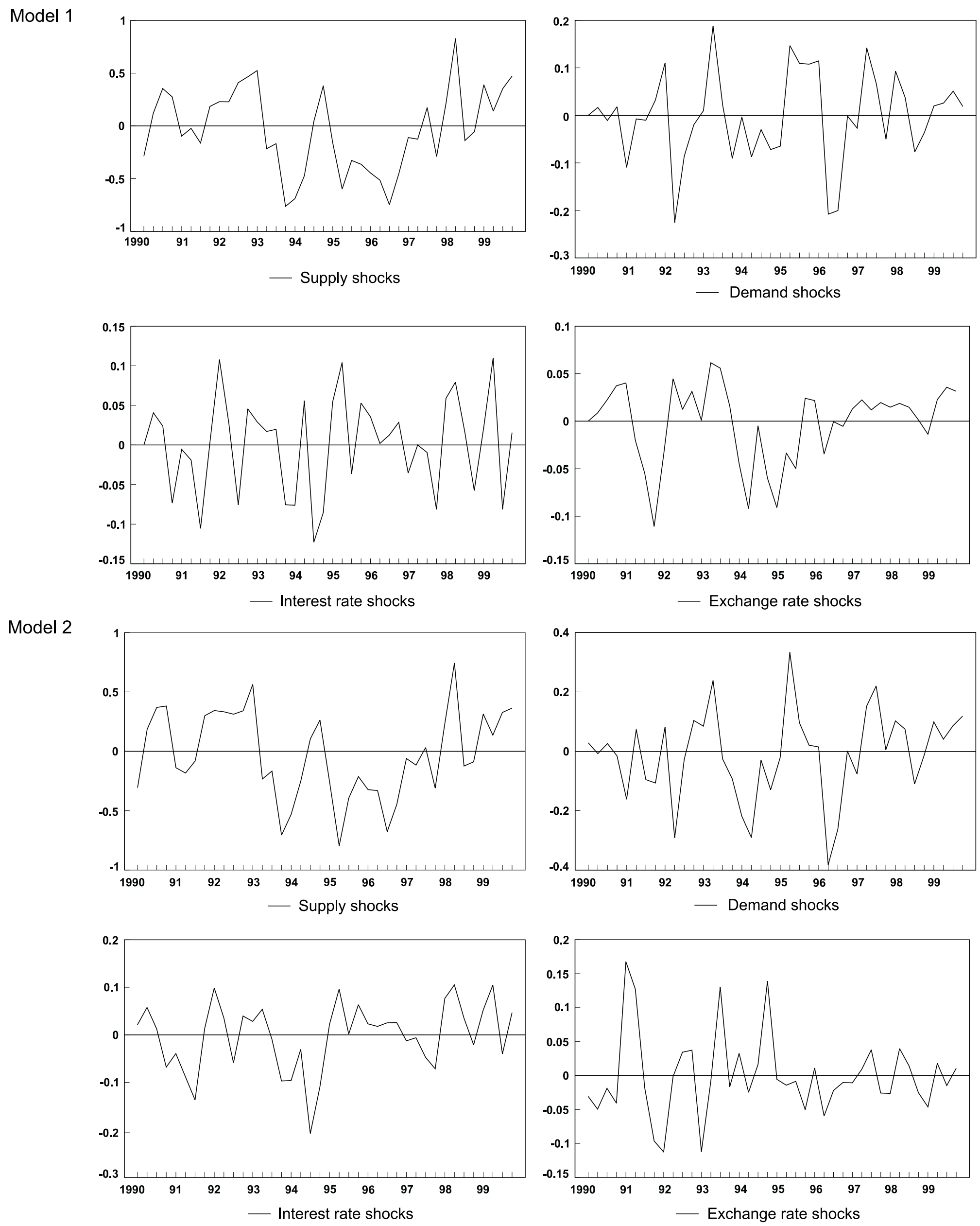
The inclusion of two dummy variables in the AD equation after the second half of 1991 and the end of 1997, in order to account for the transition of the Israeli economy to lower inflation plateaux, prevents us from evaluating the contribution of the derived monetary-policy shocks, or the changes in the monetary-policy stance, to this transition.

In this section we also report the results of a hypothetical permanent interest-rate shock. The results of this exercise (Figure 10) indicate that the monetary-policy transmission mechanism is such that an unexpected tightening of monetary policy lowers inflation and raises the unemployment rate. The rise in unemployment is more limited in Model 1 than in Model 2, where economic activity and hence unemployment respond immediately to changes in aggregate demand.

[16] The results of this exercise are identical to those obtained by comparing the actual evolution of the endogenous variables with the dynamic simulation results obtained when all the derived actual shocks except for those whose contribution we wish to evaluate are included in the simulation.

[17] These deviations may reflect changes in the monetary-policy stance, which are not captured by the specification of the interest-rate equation and imply the existence of misspecification problems. However, this interpretation does not affect our characterization of monetary policy during the two periods mentioned.

**Figure 8**
**The Contribution of Supply, Demand, Interest Rate and Exchange Rate Shocks to Unemployment**



The role of this exercise is to highlight the transmission mechanism between monetary policy and inflation and unemployment, the trade-off between the latter two variables, and the contribution of price rigidities—which enhance the sensitivity of economic activity to demand shocks—to this trade-off. Our purpose is not to answer the question of how the economy is expected to behave following a permanent increase in the interest rate, since such an exercise is likely to be subjected to a Lucas critique. A protracted monetary tightening perceived by both the public and the government as credible could lead, for instance, to changes inducing a fall in the steady state inflation (a dummy in the intercept) and a return of unemployment to its long run equilibrium level, contrary to the result of our exercise.

**Figure 9**
**The Contribution of the Actual Structural Shocks to Monetary Policy**

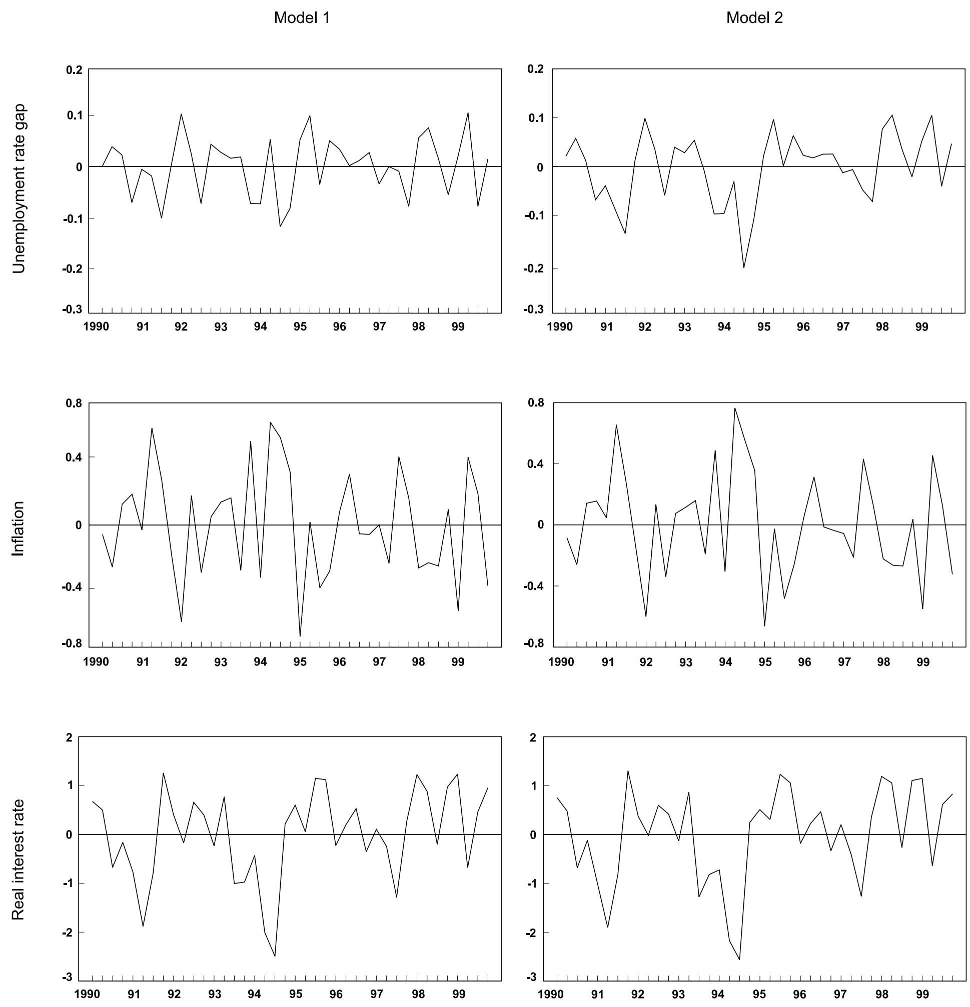
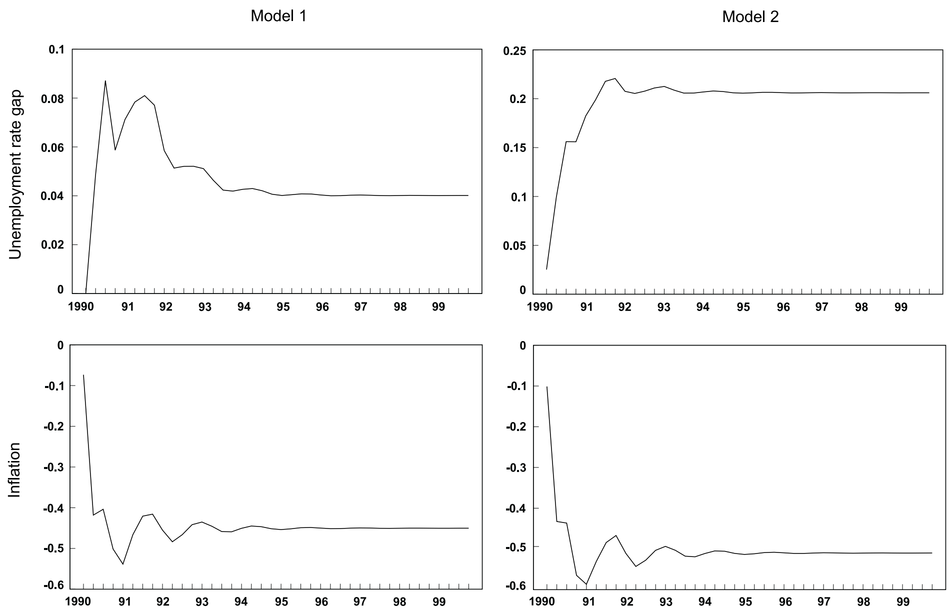


**Figure 10**
**The Response to a Permanent Monetary Policy Shock**




## 5. CONCLUSIONS

In this paper we have presented a four-equation structural VAR model of the Israeli economy during the 1990s. The four equations model unemployment (deviations from the unemployment trend), the inflation rate (aggregate demand), the key (BoI) nominal interest rate, and nominal local-currency depreciation against the currency basket. We have included the local-currency depreciation equation in our model in spite of the drastic changes which characterized the foreign exchange market and the exchange-rate regime during the period surveyed and suggest that the risks of misspecification are high. This is especially true in view of our inability to account for the changes in the exchange-rate regime because of the small number of observations. We have followed this approach because of the importance of the exchange-rate channel for the transmission of monetary policy in a small open economy such as Israel's. The identification of the structural model is based on the estimation results of its reduced-form VAR model, which includes some exogenous variables, and on the imposition of restrictions on its coefficients. On the basis of these identification restrictions, we have differentiated between two models. In the first, supply does not respond contemporaneously to changes in aggregate demand while in the second, which has a Keynesian character, the supply (unemployment) response maximizes the effect of demand shocks on output.

The estimation results attest to the ability of the reduced-form VAR model to reproduce the major changes which characterized the evolution of the endogenous variables during the period surveyed, in both a static (one period ahead) and a dynamic simulation.

According to our findings, monetary-policy shocks reflected in an interest-rate increase cause inflation to decelerate and unemployment to rise, because aggregate demand contracts. However, in view of the relatively small size of the nominal interest-rate coefficient in the local-currency depreciation equation, the immediate effect of a positive interest-rate shock on the nominal exchange rate—and through it on aggregate demand and economic activity—is limited, so that ex-post the response of the two models to interest-rate shocks appears to be the same even though the transmission mechanism differs substantially between them.

Prices respond relatively rapidly to changes in monetary policy and do not lag behind changes in unemployment. This is due mainly to the quick response of the exchange rate to monetary-policy shocks, on the one hand, and to the short lags with which changes in the exchange rate affect prices through aggregate demand and supply, on the other. This is a common feature of small open economies like Israel's, and is not shared by large relatively closed economies, where, according to empirical findings, the transmission process between exchange-rate changes and prices is relatively slow.

We include two dummy variables in our estimation of the inflation (aggregate demand) equation to account for the transition of the Israeli economy to lower inflation plateaux in the second half of 1991 and at the end of 1997. As a result, the effect on the inflation rate of the structural interest-rate shocks retrieved from the observed estimation residuals can reflect only the fluctuation of inflation around a given plateau and cannot enhance our understanding of the contribution of monetary policy to the transition of the Israeli economy to lower inflation levels.

In spite of the effect of monetary-policy shocks on unemployment and inflation, their relative contribution in explaining the variability of these two variables is limited in both the structural models we estimated. These results are in line with empirical findings for other economies. Moreover, our estimation results suggest that supply shocks constitute the main sources of unemployment variability in both the short and the long run.

Monetary-policy shocks do not constitute an important source of inflation variability in the short run. The importance of such shocks as sources of inflation variability in the medium and long run increases and is similar to that of demand shocks—which constitute the major source of inflation variability in the short run—and of supply shocks.

A local-currency depreciation shock leads to different outcomes in the two estimated structural models. In Model 1 the shock is reflected in substantial local-currency depreciation, inducing an interest-rate hike due to inflationary pressures. Whereas in Model 1 economic activity is not affected by the shock, in Model 2 the shock is followed by the expansion of economic activity and hence by a fall in unemployment, so that the contractionary effect of the interest-rate increase is reflected in a slowing of economic activity from its higher level rather than in a contraction of economic activity, as in Model 1.

An analysis of the contribution of the retrieved actual structural shocks to Israel's economy in the period reviewed indicates that the deviation of employment from its equilibrium level can be attributed primarily to supply-side shocks. Nevertheless, in Model 2 monetary policy also contributed to lower unemployment between 1993 and 1995 and to its higher level between 1996 and 1999. The looseness of monetary policy during the first sub-period, and its tightness in the second one (documented elsewhere), are consistent with this finding and implythat Model 2 is more appropriate for describing Israel's economy during the estimation period.[18]

[18] See Djivre and Tsiddon (2002).

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## APPENDIX

**Table A.1**
**The Estimation Results of the VAR Model 1990–1999**

| | U | DP | i | De |
|---|---|---|---|---|
| **Constant** | –1.185 | 3.619 | **6.498** | **8.105** |
| **U (-1)** | **0.749** | 0.675 | 0.020 | 0.276 |
| **U (-2)** | –0.198 | –0.456 | **–0.691** | 0.413 |
| **U (-3)** | **0.332** | **–0.982** | | –0.119 |
| **U (-4)** | –0.133 | | | |
| **DP (-1)** | –0.038 | **–0.292** | **0.989** | 0.114 |
| **DP (-2)** | –0.063 | 0.136 | **–0.340** | 0.023 |
| **DP (-3)** | –0.047 | **–0.199** | | –0.027 |
| **DP (-4)** | **0.118** | | | |
| **i (-1)** | 0.056 | **–0.391** | **0.509** | **–0.422**# |
| **i (-2)** | –0.029 | 0.051 | –0.114 | –0.041# |
| **i (-3)** | –0.020 | **–0.217** | | 0.026# |
| **i (-4)** | 0.041 | | | |
| **De (-1)** | 0.006 | **0.089** | **–0.200** | **–0.568** |
| **De (-2)** | 0.039 | **–0.093** | **0.166** | **–0.389** |
| **De (-3)** | **0.068** | | | –0.010 |
| **De (-4)** | 0.006 | | | |
| **Dimm 23** | **0.010** | **0.009** | | |
| **Efor_terr34** | **$1.1^{*}10^{-5}$** | | | |
| **DQ2** | | **0.578** | | |
| **D913aft** | | **–2.109** | | |
| **D973aft** | | **–2.208** | | |
| **D98q4** | | **4.251** | | **11.64** |
| **Ggdp** | | **0.312** | | |
| **Dpim** | | **0.132** | | |
| **FDI (-1)** | | | | **–0.003** |
| **$i^*$ (-1)** | | | | **–2.663** |
| **$i^*$ (-2)** | | | | **4.350** |
| **$i^*$ (-3)** | | | | **–1.804** |
| **Adj. $R^2$** | 0.815 | 0.877 | 0.729 | 0.758 |

*Characters in bold indicate statistical significance at a level of at least 10 percent.

# The explanatory variable in the exchange-rate equation (all lags) is the differential between domestic and foreign interest rates.

**List of Variables**

U – The deviation of unemployment from the HP trend.
DP – Quarterly change in CPI (%).
i – BoI marginal interest rate at the discount window (%).
De – Rate of change of the nominal exchange rate between the currency basket and the NIS (%).
DQ2 – Dummy variables for 2nd quarters.
D913aft – Dummy variable = 1 starting from 3rd quarter 1991.
D973aft – Dummy variable = 1 starting from 3rd quarter 1997.
D98Q4 – Dummy variable = 1 in the 4th quarter of 1998.
Dimm23 – Influx of new immigrants (with 2 and 3 quarter lag)
Dpimc – Rate of change in dollar prices of imported consumer goods.
Eterr_for34 – Foreign and Palestinian workers, deviation from HP trend (with 3 and 4 quarter lag)
FDI – Foreign direct investment ($).
Ggdp – Civilian government consumption ratio to GDP (seasonally adjusted).
i* – Foreign interest rate – weighted according to the basket.

**Table A.2**
**The Contemporaneous Effect of Shocks on Endogenous Variables**

| | Supply shock | | Demand shock | | Interest-rate shock | | Depreciation shock | |
|---|---|---|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 |
| Unemployment | 1.000 | 0.864 | 0.000 | –0.070 | 0.000 | 0.003 | 0.000 | –0.049 |
| Inflation | 0.282 | 0.545 | 0.696 | 0.283 | –0.008 | –0.001 | 0.146 | 0.196 |
| Nominal interest rate | 0.549 | 0.357 | –0.454 | –0.336 | 0.984 | 0.993 | 0.283 | 0.129 |
| Rate of change of exchange rate | 1.321 | 0.771 | –1.420 | –1.013 | 0.984 | 0.993 | 0.681 | 0.277 |
| Real interest rate | –0.525 | –1.535 | –2.631 | –1.195 | –0.037 | –0.015 | –0.272 | –0.557 |