



**Is it labor, technology or monetary policy ?
The Israeli economy 1989-2002***

by

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Abstract

The paper analyses the relative importance of shocks to labor supply, aggregate supply, aggregate demand, monetary policy and immigration in explaining the course of the Israeli economy in 1989-2002. We use structural VAR with short-run and long-run restrictions in order to identify the structural shocks. We learn that variations in output were due mostly to shocks to productivity. (Unexpected) changes in the intensity of immigration play a significant role in explaining the variation of labor supply and contribute to the explanation of the shocks to aggregate supply. Temporary shocks to monetary policy play a relatively minor part in explaining deviations in labor and output supply, as was found in other studies for Israel and elsewhere. Our findings concerning the factors that affected actual growth during the period studied here are consistent with the actual decline in measured labor productivity during those years.

1 Introduction

The last decade of the previous century was an eventful one for the Israeli economy. After the stabilization program of 1985, which brought Israel from an hyperinflationary environment to low double-digit inflation, the Israeli economy underwent major restructuring, adjusting to the new conditions, along side an influx of immigrants (mostly from the former Soviet Union). This inflow, which by the end of the decade accounted for about 1/6 of the total population, increased labor supply while dramatically shifting its composition in terms of skills and education towards a more human-capital-intensive labor force (see Flug and Kasir (1993) and Cohen and Hsieh (2000)). In addition, the influx of immigrants had a clear effect, especially in the early 1990s, on aggregate demand. This was particularly evident in the demand for non-tradables, primarily housing.

Disinflationary efforts remained a major issue throughout the 1990s, resulting in the achievement of price stability just before the end of the decade. This development was accompanied by an ongoing process of liberalization and opening up the goods and financial markets. In particular there was a shift from a managed exchange rate regime to an almost entirely flexible exchange rate (within a very wide band of more than 50%), with practically no intervention in the market.

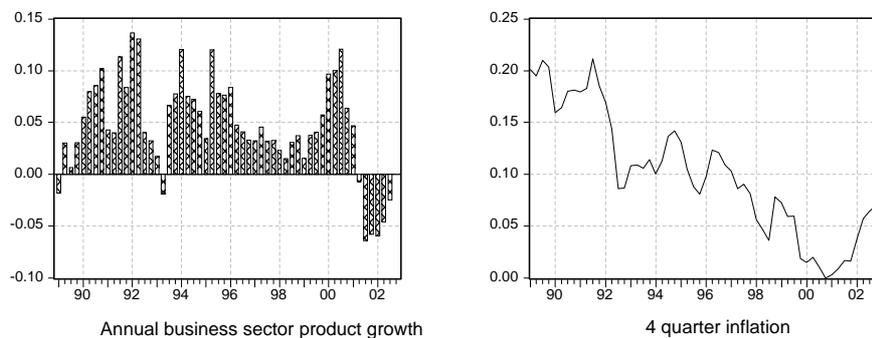


Figure 1: Business sector product growth and annual inflation

In the second half of the 1990s, like other developed countries, and though possibly to a larger extent, Israel experienced a shift to the “new economy” – once a very popular term - which is characterized as a shift towards technologically improved production processes accompanied by a higher demand for human capital and fast growth of the high-tech industries alongside stagnation and slowdown in the traditional industries (see Flug, Kasir and Ribon (2000)).

Furthermore, the geopolitical situation which had seemed to be improving after the Oslo agreements were signed in 1993, became uncertain towards the end of the decade and worsened significantly after September 2000, with the renewal of the Palestinian Intifada. This recent development had a considerable effect on aggregate demand and had evinced itself in a significant economic recession since the end of 2000.

These and other factors – both economic and political - have affected the evolution of the business cycle in Israel from the late 1980s through the beginning of the new century in various directions and to varying extent¹. The average growth rate of business-sector output from 1990 to mid 1996 was about 6.6%, after only 1.1% in 1989. From the second half of 1996 until the end of 1999, economic activity slowed down, showed some signs of recovery during 2000, and plunged into recession in 2001. (Figure 1).

The aim of this paper is to gain a better understanding of the relative

¹Flug and Strawczynski (2002) find that the influx of immigrants and the technological “bubble” were the two major “transitory” shocks that have dominated the Israeli economy since 1985.

importance of the roles played by the major factors mentioned above in the Israeli economy in the last decade. We distinguish between five types of shocks. Labor supply shocks, productivity shocks which relate to technological innovations, demand shocks, and monetary policy shocks, which correspond to the changes in monetary policy associated with the disinflationary process. We also refer to immigration shocks, due to their significance during the years examined. Given the immigration shocks, the labor supply shocks referred to above may be interpreted as shocks to the veteran (established) population.

This analysis will allow us to focus on central episodes in the previous decade and decompose the factors that affected the economy during these periods. Among these episodes are the influx of immigrants, especially in the early 1990s, the ending of the influx in the second half of the decade, the emergence of the "new economy" - the rapid growth of the high-tech sectors towards the end of the 1990s and the substantial deterioration in the security situation from the end of 2000.

The paper investigates the main developments of the Israeli economy in the 1990s using the conceptual framework of the SVAR (Structural Vector Auto Regressive) methodology, with long-run and short-run restrictions, in order to identify the structural shocks we are interested in. This method has been used in recent years in many studies concerned with understanding the role of monetary policy in the business cycle, particularly in the US. This approach is used, for example by Strongin (1995), Bernanke, Gertler and Watson (1997), Bernanke and Mihov (1998), Christiano, Eichenbaum and Evans (1998), Bagliano and Favero (1998), Sims (1992 and 1998), and Kim(2000). Other papers use the VAR methodology to study the supply and demand factors affecting the economy. Blanchard and Quah (1989) distinguish demand shocks from supply shocks by assuming that only supply shocks have a long-run effect on the economy. Additional studies, among them Shapiro and Watson (1988), King, Plosser, Stock and Watson (1991), Gali (1992,1999), Walsh (1993), King and Watson (1994), Rotemberg and Woodford (1996) use long run restrictions to identify supply-side disturbances which are interpreted as technology or productivity shocks. Dolado and Jimeno (1997) use the VAR methodology to investigate the unemployment rate in Spain; Monticelli and Tristani (1999) study the effects of a single monetary policy for the new European Central Bank; Kim(1999) ex-

amines the effects of monetary policy in the G-7; Keating and Nye (1999) look at unemployment and output in the G-7 countries; Kasa and Popper (1997) look at monetary policy in Japan; and Kwark (1999) uses the VAR technique to study the source of international business fluctuations. The relationship between monetary policy and the exchange rate is also examined using the VAR methodology. For example Eichenbaum and Evans (1995) study this issue for the US economy, Cushman and Zha (1997) look at the Canadian economy, and Kim and Roubini (2000) investigate the industrial countries.

The Israeli economy differs from the well-studied US economy, first of all because it is a (much) small(er) and open economy. In addition, it has a much shorter and less stable economic history. The structural changes undergone by the Israeli economy, currently and in the past, as mentioned at the beginning of this paper, make it impossible to obtain a long and stable data set, and the relevance of the analysis of a long time series (which is usually, technically, not available) is questionable. At the same time, the Israeli economy is of greater analytical interest because it experienced many shocks of different kinds in a relatively short time.

The paper includes six sections. In section 2 a theoretical framework is presented. The VAR system is described in section 3. In sections 4 and 5 the estimation and its results are discussed, and section 6 concludes.

2 The theoretical framework

The model includes four major equations, describing labor supply, aggregate supply, aggregate demand, written inversely as a price equation, and an equation describing the evolution of the central bank's interest rate, which serves as the main monetary policy instrument. A trivial equation for the influx of immigrants, referring all of it to exogenous shocks, is added as a fifth equation in the empirical part of the paper.

We avoid the inclusion of the exchange rate, and external demand (exports) or supply (imports), although Israel is a small and open economy. This is due to the lack of sufficient degrees of freedom in our sample, and the increasing complexity of identifying and understanding the structural shocks when additional equations are added to the system. We assume that the effects of changes in the exchange rate are captured, at least partially, by

fluctuations in the nominal interest rate and shocks to the price (inflation) equation.

The VAR approach does not require a defined theoretical framework in order to specify the estimated equations. On the contrary, an advantage (or disadvantage) of this approach is that it allows the dynamics of the economic environment in question to be analyzed without any restrictions stemming from the theoretical specification chosen. I have therefore preferred not to introduce a full theoretical model, but rather to present the basic concept according to which the VAR equations will be specified. A similar approach is presented in Shapiro and Watson (1988). The main attributes of that approach are employed here.

Aggregate supply and labor supply: We assume that in the long run, aggregate supply is determined by the long-run level of capital and labor. In log terms, this may be written as:

$$y_t^* = A^* + \alpha l_t^* + (1 - \alpha)k_t^* \quad (1)$$

where y_t^* is the long-run aggregate supply, A^* is the long-run level of technology, and l_t^* and k_t^* are the long-run levels of labor and capital. If we assume that in the steady state the capital-output ratio is constant, that is $k_t^* = y_t^* + \eta$, we get the relationship:

$$y_t^* = \eta(1 - \alpha)/\alpha + l_t^* + (1/\alpha)A_t^* \quad (2)$$

We also assume that labor supply and technology evolve according to the following processes.

$$l_t^* = \lambda_l + l_{t-1}^* + \varepsilon_{lt} \quad (3)$$

$$A_t^* = \lambda_A + A_{t-1}^* + \varepsilon_{At} \quad (4)$$

ε_{lt} are shocks to labor supply that may result from shocks to the tastes of individuals or institutional factors in the labor market. ε_{At} originate from shocks to technology. Both shocks are assumed to be serially and mutually uncorrelated.

Actual levels of labor supply and output may deviate from their long-run values due to transitory shocks:

$$l_t = l_t^* + \theta_l(L)(\varepsilon_{lt}, \varepsilon_{At}) \quad (5)$$

$$y_t = y_t^* + \theta_y(L)(\varepsilon_{lt}, \varepsilon_{At}) \quad (6)$$

where L is the lag operator

Differencing equations 5 and 6 and substituting l_t^* and A_t^* according to equations 3 and 4 we get:

$$\Delta l_t = \lambda_l + (1 - L)\theta_l(L)(\varepsilon_{lt}, \varepsilon_{At}) \quad (7)$$

$$\Delta y_t = \lambda_A + (1 - L)\theta_y(L)(\varepsilon_{lt}, \varepsilon_{At}) \quad (8)$$

In addition to the supply-side shocks, we allow demand-side shocks to affect labor supply and aggregate output in the short run. The two additional variables included in the model for this purpose are price changes and the (nominal) interest rate, as the latter is a major instrument of monetary policy². These variables may represent the goods market and the money market respectively. Temporary shocks in these markets effect the change in labor supply and output in the short run, so that in the short run we have:

$$\Delta l_t = \lambda_l + (1 - L)\theta_l(L)(\varepsilon_{lt}, \varepsilon_{At}) + \sigma_l(L)(\varepsilon_{\pi t}, \varepsilon_{it}) \quad (9)$$

$$\Delta y_t = \lambda_A + (1 - L)\theta_y(L)(\varepsilon_{lt}, \varepsilon_{At}) + \sigma_y(L)(\varepsilon_{\pi t}, \varepsilon_{it}) \quad (10)$$

In order to complete the model we include an inflation equation and an interest rate equation.

Inflation: Inflation, which represents aggregate demand, is affected by both supply shocks and demand shocks and may therefore be written as:

$$\pi_t = \sigma_\pi(L)(\varepsilon_{lt}, \varepsilon_{At}, \varepsilon_{\pi t}, \varepsilon_{it}) \quad (11)$$

Monetary policy : In line with recent literature and in accordance

²Labor supply and output are I(1), so that differentiating them results in a I(0) series. Inflation and the nominal interest rate are both I(0), and therefore may be related to short-run shocks in the differentiated variables. The stationarity of the model variables is discussed in section 4.1.1.

with the conduct of monetary policy in Israel, we specify the interest rate as the central bank's sole instrument of monetary policy. We do not model the liquidity market or the money market explicitly. The central bank implicitly injects liquidity or takes it out of the system in order to equate demand and supply for liquidity, at the desired interest rate. This specification is in accordance with the conduct of monetary policy in Israel, where the central bank sets and announces each month the (change in) the nominal interest rate and uses the discount window and an auction facility to accommodate liquidity in order to maintain this short-run interest rate. The development of money supply serves only as an indicator, among other real and nominal indicators, examined by the central bank in making its decision, but it is not targeted. While the central bank's behavioral equation describes the evolution of the interest rate and may be interpreted at the most as its reaction function, the preferences of the central bank can not be identified. Even though both real activity and inflation appear in the reaction function, quantitative or qualitative conclusions cannot be drawn regarding the ultimate targets of the central bank. For example, we cannot discern whether the Bank is aiming at a pure inflation target, or whether real activity included is in its loss function. This is because the structural parameters, in the sense of its underlying loss function, are not identifiable. The specification of the central bank's behavior is similar to the well-known Taylor (1993) rule. Taking into account the bank's smoothing considerations, we add the lagged interest rate and write³:

$$i_t = m_0 + m_1(y_t - y_t^*) + m_2(\pi_t - \pi_t^T) + m_3i_{t-1} + \varepsilon_{it} \quad (12)$$

y_t is the (log of) actual output and y_t^* is potential output, π_t is the actual rate of change in prices⁴ and π_t^T is the exogenous inflation target for period t . Because output is dependent on shocks to labor supply, ε_{lt} , and to technology, ε_{At} , the interest rate is expected to be affected by these disturbances. Demand shocks, $\varepsilon_{\pi t}$, are represented in the interest rate function by changes in actual inflation. ε_{it} is a random error in the interest rate

³See Clarida, Gali and Gertler (1999) for a further discussion of monetary policy rules.

⁴Some models include expected inflation instead of past inflation in the central bank's reaction function since monetary policy is considered to be forward looking (see Haldane and Batini (1998) and Clarida, Gali and Gertler (1999)). Empirically, in Israel, past inflation is highly correlated with expected inflation, as it is derived from the capital markets, so that past inflation may serve as a reasonable indicator of expected inflation.

driven by the afore mentioned disturbances to the decision-making process. Christiano, Eichenbaum and Evans (1998) propose possible interpretations for these disturbances. They suggest that these shocks may reflect stochastic shifts in the weights given to unemployment and inflation by each of the members in the deciding committee, a change in the political power of each of the members in the committee, a strategic response to shocks to the public's expectations, or shocks due to technical factors such as measurement errors in preliminary data.

Supply shocks tend to increase output while lessening the pressure on prices⁵, and therefore induce a lower interest rate. Demand shocks, represented by shocks to prices, tend to exert pressure on prices and are expected to result in a higher interest rate. In the notation adopted above and allowing lagged shocks to affect the decisions of the central bank, the interest rate rule is:

$$i_t = i_t(\pi^T) + \sigma_i(L)(\varepsilon_{lt}, \varepsilon_{At}, \varepsilon_{\pi t}, \varepsilon_{it}) \quad (13)$$

The system: The small model presented above results in a system of four equations - (9), (10), (11) and (13). The evolution of the economy can thus be described according to the four possible shocks: a labor supply shock (ε_{lt}), a shock to productivity (ε_{At}), a price shock resulting from a shock to aggregate demand ($\varepsilon_{\pi t}$), and a shock to monetary policy (ε_{it}).

In practice, because immigration was an important factor in the development of the Israeli economy in the 1990s, we distinguish between shocks to the labor supply that result from the behavior of the established population and shocks that emerge from changes in the flow of new immigrants to the country. These latter shocks are expected to affect aggregate demand as well, and will therefore show up in all the equations of the system.

3 The methodology

We use a structural VAR identification method to distinguish between the different structural shocks to the economy which in our model are shocks to

⁵The specification of the central bank's reaction function commonly refers to short-run deviations from potential output as demand shocks, requiring tighter monetary policy. Here we also allow short-run supply shocks that temporarily increase (potential) output to also appear in the bank's reaction function.

the labor supply, productivity, aggregate demand and monetary policy. The flow of new immigrants which is added to the system as a fifth equation is assumed to be exogenous, and therefore depends only on its own shocks. The dependent variables in the system are the change in (the log of) the number of participants in the labor market - Δl , (log) business sector product growth - Δy , the Bank of Israel (BoI) nominal interest rate - i , the inflation rate - π , and the flow of new immigrants - Δm . All the variables are stationary⁶. In order to identify the structural shocks we impose both long-run and short run restrictions. Because there are five equations in the system, the exact identification of the structural shocks requires ten restrictions⁷. Five of them are long-run restrictions - the remaining are short-run restrictions. Four of the long-run restrictions imply that shocks to aggregate demand and the nominal interest rate do not have a long-run effect on labor or the growth rate of GDP, as is implied from the theoretical framework. In addition, we assume that changes in the aggregate supply do not have a long-run effect on labor supply. The fifth restriction is imposed by assuming the quantitative rate of (positive) response of the interest rate set by the central bank to contemporaneous shocks to aggregate demand (the price level). We do not restrict the contemporaneous response of prices or supply to monetary policy shocks and the reaction of monetary policy to other shocks apart from the aggregate demand shock. The last four restrictions are that none of the four major variables in the system affect the flow of immigrants. The econometric method employed is similar to the approach in Shapiro and Watson (1988).

3.1 The labor supply

The labor supply equation is specified as:

$$\Delta l_t = \sum_{j=1}^{\infty} \beta_{ly,j} \Delta l_{t-j} + \sum_{j=0}^{\infty} \beta_{ly,j} \Delta y_{t-j} + \sum_{j=0}^{\infty} \beta_{li,j} i_{t-j} + \sum_{j=0}^{\infty} \beta_{l\pi,j} \pi_{t-j} + \sum_{j=0}^{\infty} \beta_{lm,j} \Delta m_{t-j} + \varepsilon_{lt} \quad (14)$$

⁶Inflation is stationary in steps, (see discussion below).

⁷The fifth equation is the identity that the immigration flow is affected only by its own shocks. This implies four restrictions, which are that all the other variables (l, y, p, i) do not affect the immigration flow.

In order to satisfy the long-run constraints that shocks to aggregate demand (inflation) and to monetary policy (interest rates) have no long-run effects on the level of output, and that aggregate supply does not have any long-run effects on labor supply, the sum of the lagged coefficients of these variables must be zero. We therefore estimate the equation, substituting the level of inflation and the interest rate with their differences and the (log) rate of output growth with its second difference.

$$\Delta l_t = \sum_{j=1}^{\infty} \beta_{ll,j} \Delta l_{t-j} + \sum_{j=0}^{\infty} \beta_{ly,j} \Delta^2 y_{t-j} + \sum_{j=0}^{\infty} \beta_{li,j} \Delta i_{t-j} + \sum_{j=0}^{\infty} \beta_{l\pi,j} \Delta \pi_{t-j} + \sum_{j=0}^{\infty} \beta_{lm,j} \Delta m_{t-j} + \varepsilon_{lt} \quad (15)$$

ε_{lt} are exogenous iid serially uncorrelated shocks to the labor supply. The most important shock during the 1990s was, as mentioned above, the influx of immigrants into Israel. The flow of new immigrants is therefore included in the equation. Figure 2, which shows the log change in total labor supply and the number of new immigrants lagged 2 quarters, reveals the high correlation between the volume of newcomers and the changes in the labor force⁸.

The equation is estimated with instrumental variables for the contemporaneous change in the endogenous variables. The contemporaneous flow of immigrants serves as an instrumental variable, together with the remaining lagged variables in the equation. We add the exogenous variables that appear in the i and π equations as instrumental variables for the contemporaneous endogenous variables, Δi_t and $\Delta \pi_t$.

3.2 The output

The output equation is specified in a similar fashion, implying similar long-run restrictions on the effect of aggregate demand and the interest rate⁹:

⁸The correlation between the changes in labor supply and the flow of immigrants lagged 2 quarters is 0.40. The correlation with the current and 1 quarter lagged flow is 0.32 and 0.26. High correlation with the lags arises from the ability of new immigrants to postpone joining the work force due to state funds especially assigned to assist new comers.

⁹We chose to specify the aggregate supply equation with output as the dependent variable, contrary to the customary Phillips Curve specification of the supply function, where prices are set as the dependent variable. This is in order to allow the assignment

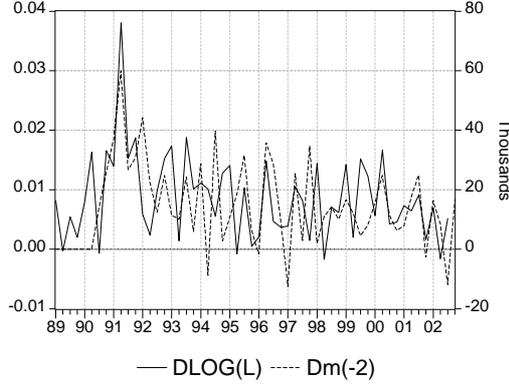


Figure 2: Log change in the labor force (solid line, right-hand axis) and the flow of immigrants (-2).

$$\begin{aligned}
 \Delta y_t = & \sum_{j=1}^{\infty} \beta_{yy,j} \Delta y_{t-j} + \sum_{j=0}^{\infty} \beta_{yl,j} \Delta l_{t-j} + \sum_{j=0}^{\infty} \beta_{yi,j} \Delta i_{t-j} \\
 & + \sum_{j=0}^{\infty} \beta_{y\pi,j} \Delta \pi_{t-j} + \sum_{j=0}^{\infty} \beta_{ym,j} \Delta m_{t-j} + \beta_{yf} \textit{foreign} + \beta_{y\epsilon l} \epsilon_{lt} + \epsilon_{At}
 \end{aligned} \tag{16}$$

The contemporaneous structural labor supply shock, ϵ_{lt} , which was estimated (and identified) in the first equation, is included here. ϵ_{At} are exogenous iid serially uncorrelated shocks, which we will identify as productivity shocks. We include in this equation an additional exogenous variable, *foreign*, which is the change in the non-Israeli labor supply - foreign and Palestinian - in order to accommodate for the growing share of these workers, which is not accounted for in the (Israeli) labor supply variable¹⁰. As with the previous equation, we use instrumental variables for the contemporaneous endogenous variables.

3.3 The interest rate

We estimate a reaction function of the central bank. The specification in the framework of the VAR system does not allow us to identify the pref-

of the long-run restrictions on the effect of demand-side shocks on output in the long run.

¹⁰See additional discussion below.

erences of the bank regarding inflation and output, but instead it imitates the actual path of the monetary instrument, as the econometrician observes it, acting as a function of various relevant economic variables. According to the theoretical specification in equation (13), we include in the estimated equation the inflation target, as it was set annually, beginning from 1992¹¹. Because the sample includes pre-target years, a dummy variable $d92aft$ and an independent coefficient for the target, β_T , are also included.

$$\begin{aligned}
i_t = & \sum_{j=1}^{\infty} \beta_{iy,j} \Delta y_{t-j} + \sum_{j=1}^{\infty} \beta_{il,j} \Delta l_{t-j} + \sum_{j=1}^{\infty} \beta_{ii,j} i_{t-j} \\
& + \sum_{j=1}^{\infty} \beta_{i\pi,j} (\pi_{t-j} - d92aft \cdot \pi_{t-j}^T) + \sum_{j=0}^{\infty} \beta_{im,j} \Delta m_{t-j} + \beta_T d92aft \cdot \pi_t^T \\
& + \beta_{dm} d94q4aft + \beta_{i\epsilon y} \epsilon_{At} + \beta_{i\epsilon l} \epsilon_{lt} + e_{it}
\end{aligned} \tag{17}$$

The central bank's monetary policy, represented by the interest rate, shifted dramatically at the end of 1994, from a relatively expansionary policy, giving more weight to real activity and maintaining a competitive real exchange rate, to one which aims primarily at attaining the inflation target. Because this is a permanent one-time change in the behavioral characteristics of the central bank, a dummy for the period starting at the end of 1994, $d94q4aft$, was included in the interest-rate equation. The exogenous flow of immigrants is also included in the equation.

At the estimation stage no restrictions are imposed on the contemporaneous coefficients. Aggregate supply shocks and labor supply shocks are included in the equation. We do not distinguish, at this stage, between interest-rate shocks and aggregate demand (inflation) shocks, so that the estimation error, e_{it} , is not a structural shock but rather a linear combination of the interest rate and inflation structural shocks, ϵ_{it} and $\epsilon_{\pi t}$. The identification of these two shocks is performed after estimating the system by imposing a quantitative restriction on the central bank's reaction to contemporaneous inflation shocks (see section 4.2).

¹¹Although at the time, the announced inflation target was regarded more as a parameter required in order to set the slope of the exchange-rate band as the inflation differential between Israel and its trading partners (see Djivre and Tsiddon, 2002).

3.4 Aggregate demand

This equation describes (inverted) aggregate demand as a function of past and current shocks to all variables. As in the central bank’s reaction function, both supply shocks are identified, while the structural aggregate demand shock and the shock to monetary policy are not identified at the estimation stage.

$$\begin{aligned}
 \pi_t = & \sum_{j=1}^{\infty} \beta_{\pi l,j} \Delta l_{t-j} + \sum_{j=1}^{\infty} \beta_{\pi y,j} \Delta y_{t-j} + \sum_{j=1}^{\infty} \beta_{\pi i,j} i_{t-j} + \sum_{j=1}^{\infty} \beta_{\pi \pi,j} \pi_{t-j} \quad (18) \\
 & + \sum_{j=0}^{\infty} \beta_{\pi m,j} \Delta m_{t-j} + \beta_{s1\pi} d91q3aft + \beta_{s2\pi} d97q3aft + \beta_{d\pi} d98q4 \\
 & + \beta_{\pi 2} dumq2 + \beta_{\pi \varepsilon y} \varepsilon_{At} + \beta_{\pi \varepsilon l} \varepsilon_{lt} + e_{\pi t}
 \end{aligned}$$

In addition to the inclusion of the flow of immigrants in the equation, two “step dummies”, $d91q3aft$ and $d97q3aft$, are included due to the finding that the inflation rate may be characterized as a step trend-stationary process (see below). A dummy variable, $d98q4$, which has the value of 1 in the fourth quarter of 1998, stands for the exceptional rate of price increases in that quarter following extremely large local-currency depreciation at that time, due to the LTCM debt default and the Russian crisis, against the background of relatively low local interest rates. Because an exchange-rate equation is not included in the system, although the exchange rate plays a major part in nominal and real developments in Israel, this shock may be considered as exogenous to the system. A dummy variable for the second quarter each year, $dumq2$, is added in order to account for seasonality in the Consumer Price Index.

3.5 Immigration

As noted above, we assume the intensity of immigration to Israel during the 1990s is exogenous to economic and other conditions in Israel. The major driving force of this vast influx of immigrants was “push” factors from the former USSR, and to a lesser extent “pull” factors. We assume immigration is exogenous, although there are indicators that the prospects of employment in Israel played a role in potential immigrants’ decisions whether and when

to arrive. For our purposes, the immigration equation reduces simply to:

$$\Delta m = \varepsilon_{mt} \quad (19)$$

4 Data, estimation, and identification

4.1 Data and estimation

The model examines four major variables of the economy: output, labor, prices and interest rates, plus the immigration variable discussed above. The data we use is quarterly beginning in 1989 and continuing until the third quarter of 2002 (Figure 3). Data limitations which reflect the ongoing

structural change in the Israeli economy prevent us from estimating the system with a longer data set.

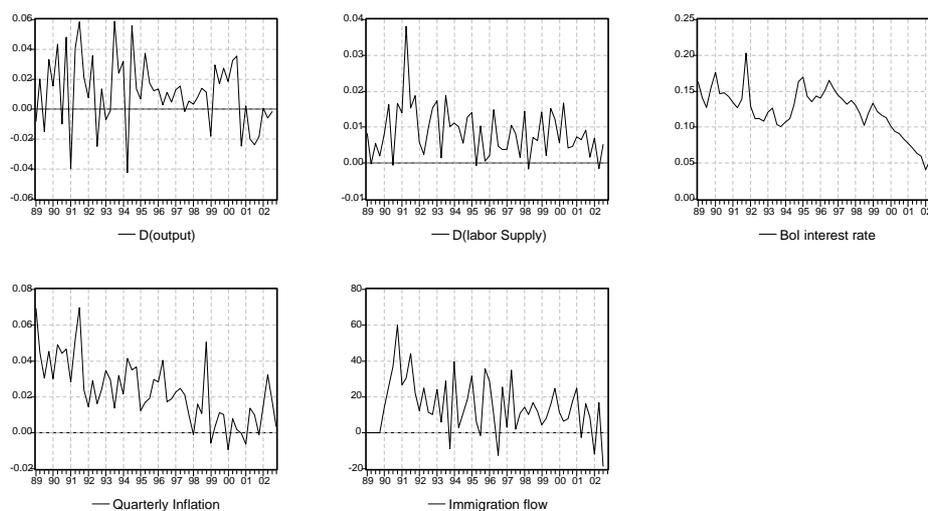


Figure 3: The VAR variables

The system of equations is estimated sequentially. We estimate each of the first two equations (Δy and Δl) separately, and estimate the i_t and π_t equations together as a SUR system. We use the covariance matrix of this system for the identification of the two structural shocks corresponding to aggregate demand and monetary policy.

The interest rate we use is the marginal rate on the discount window of the central bank. This interest rate has served as the main monetary instrument only since 1988. The price variable is the average quarterly rate of change in the Consumer Price Index. The GDP growth rate refers to the business sector and is seasonally adjusted (hereafter referred to as output). For the labor supply variable we use the (log of) the growth rate of the seasonally adjusted working force.

The short length of our sample limits the number of lags we can test for in the VAR system. The system was estimated initially with 3, 4, or 5 lags for all the equations. The main results and characteristics remain qualitatively the same, but as the response functions, especially for shocks to supply and the interest rate, are much more volatile in the 4- and 5-lag systems, therefore we have chosen to present the results of the 3-lag estimation. The short lag length may result in a less accurate description of the dynamics of the economy so that larger structural shocks may actually represent some of the dynamics not accounted for in the short lags.

Several exogenous variables, apart from the immigration variable, are included in the system and have been discussed above. We will elaborate here solely on the foreign workers variable included in the aggregate supply equation. Non-Israeli workers, who consisted initially of Palestinians from the West Bank and Gaza, and later on were joined by foreign workers, mostly from Eastern Europe and Asia, are a significant component of the local labor market, especially in the traditional low-skilled industries (construction, agriculture, and food services). In recent years, accompanying the surge in demand for housing, on the one hand, and security considerations preventing Palestinian workers from entering Israel, on the other, the government approved the entrance and employment of foreign workers, primarily to these sectors. These two groups of foreign workers have grown from about 9% of the employees in the business sector in 1990 to 16% in 2000¹². Assuming that the supply of foreign workers is perfectly elastic, we include foreign employees as a measure for foreign labor supply, to the output equation.

¹²In 2002 their rate declined slightly to about 14.5%.

4.1.1 Stationarity

We check for the stationarity of the variables in the system and find that both the growth of labor supply and business sector product (both in log difference terms), is stationary with a 5% significance level according to the Augmented Dickey-Fuller test with a constant and 3 lags or less.

Inflation rates after the stabilization program of 1985 may be characterized as evolving according to a “step” function (see Liviatan and Melnick, 1998). Inflation rates declined from about 20% at the end of 1991, to about 10% at the end of 1997, and then declined to 1-2% in 2000 and 2001¹³ (see Figure 3). We therefore check whether the inflation rate may be characterized statistically as a “step-stationary” process. In order to do so we use the procedure suggested by Perron (1990), which basically checks for the existence of a unit root in the series of residuals from a simple regression of inflation on dummy variables for the steps¹⁴. This test leads us to conclude that the inflation rate (during the 1990s) is a “step-stationary” process¹⁵. The nominal interest rate of the Bank of Israel is found to be stationary at a 5% significance level, with a constant and 2 or 3 lags (for a sample starting in 1989:1) but is found to be an I(1) process according to this test when 4 or more lags are included¹⁶. Because of the short sample used for the tests and because the period we look at is characterized by a disinflationary process, it is difficult to draw conclusions about the long-run nature of this series. Since we found that inflation is an I(0) process, and it is reasonable to assume that the real interest rate is also an I(0) process, we are inclined to assume the nominal interest rate is also an I(0) process. Accordingly we estimate our system for the following variables: the log difference of the labor supply, the log difference of business-sector product, the inflation rate, and the level of the Bank of Israel interest rate.

¹³Due to substantial local-currency depreciation in the first half of 2002, the inflation rate soared to about 6.5% in 2002.

¹⁴Because the critical values supplied by Perron (1990) refer to one break in the series, we check separately for each of the two breaks (fourth quarter of 1991 and fourth quarter of 1997) using subsets of the data.

¹⁵The stationarity of the inflation rate is not necessarily true for other economies. For example, Shapiro and Watson (1988) find that US inflation is an I(1) process.

¹⁶The value of the Durbin-Watson statistic is about 1.5 when 2 or 3 lags are included, and is closer to 2 with 4 or more lags.

4.2 Identification

As stated, the structural shocks to the bank's reaction function, ε_{it} , and to the aggregate demand equation, $\varepsilon_{\pi t}$, are not identified in the estimation process. Instead, the structural shocks in each of these equations is a linear combination of the estimation errors.

$$\begin{aligned}\varepsilon_{\pi t} &= e_{\pi t} - \tau e_{it} \\ \varepsilon_{it} &= -\delta e_{\pi t} + e_{it}\end{aligned}\tag{20}$$

In order to identify the structural shocks we assume that their structural covariance matrix is diagonal. In addition, we make a quantitative assumption regarding $\beta_{i\pi,t}$ (hereafter, δ), which is the extent to which the central bank reacts to same-quarter shocks to inflation. $\beta_{\pi i,t}$ (hereafter, τ), which measures the contemporaneous effect of monetary policy on aggregate demand is then solved. Assuming $\delta = \delta_0$, (we choose $\delta_0 = 0.5$, see discussion below), and given the (symmetric) covariance matrix W of the estimated errors, we can solve for σ_1^2 , σ_2^2 and τ from the system:

$$\begin{array}{cc} \text{"} & \text{"} \\ \begin{array}{cc} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{array} & = \\ \text{"} & \text{"} \\ \begin{array}{cc} 1 & -\tau \\ -\delta & 1 \end{array} & \\ \text{"} & \text{"} \\ \begin{array}{cc} w_{11} & w_{12} \\ w_{12} & w_{22} \end{array} & \\ \text{"} & \text{"} \\ \begin{array}{cc} 1 & -\delta \\ -\tau & 1 \end{array} & \end{array}\tag{21}$$

get

$$\tau = \frac{-\delta_0 w_{11} + w_{12}}{-\delta_0 w_{12} + w_{22}}\tag{22}$$

$$\sigma_1^2 = w_{11} - \tau(2w_{12} - \tau w_{22})\tag{23}$$

$$\sigma_2^2 = w_{22} - \delta_0(2w_{12} - \delta_0 w_{11})\tag{24}$$

and identify the structural shocks to demand (prices) and monetary policy (the interest rate).

5 Results

The estimation results allow us to evaluate the contribution of each of the identified structural shocks to the evolution of the Israeli economy in the last decade. The system is analyzed using Impulse Response Functions and Variance Decomposition together with some other measurements of the characteristics of the estimation results.

5.1 Impulse response functions

Below we report the impulse response functions for each of the structural shocks. Since, because of data limitations, the lag length included in the system is very short (only 3 quarters), the impulse response functions converge relatively quickly to the initial condition of the economy and are characterized, for some of the exercises, by somewhat volatile dynamics. The interpretation of these characteristics of the system is limited. Alternative specifications of the system with longer lags for some of the equations¹⁷ have qualitatively the same results, but with a more volatile convergence pattern, especially in response to shocks to aggregate supply.

5.1.1 A labor supply shock

Labor supply shocks, which correspond to shocks to the long-run labor supply (l_t^* in equation (3)), result on impact in an expansion of the labor supply, and higher output only subsequently. Inflation rises and then falls as a result of the expansion of output supply and the rise in the interest rate. The interest rate declines after a few periods in reaction to output supply. Because the nominal interest rate declines more than the inflation rate, the real interest rate is lower. The slower rate of price changes brings aggregate supply down back to its initial level, together with the contraction of the labor supply. Output convergence to its initial equilibrium is prolonged relative to the labor supply, due to the lower real interest rate. Figure 4 illustrates the response of the system to the labor supply shock.

¹⁷The labor supply and interest rate equations with 5 lags fit the data better.

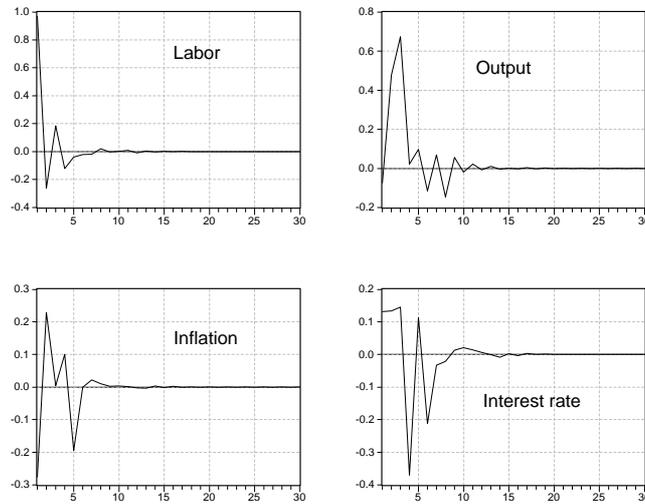


Figure 4: A one-time shock to the labor supply

5.1.2 A productivity shock

A productivity shock results in the expansion of aggregate supply, which is accompanied by a weaker and more volatile response of the labor supply. The inflation rate declines, and so does the interest rate after an initial rise. The long-run effect (the summation over time of the impulse response) on labor supply of a productivity shock is, as was assumed in the identifying assumptions, zero (Figure 5).

5.1.3 A demand shock

A shock to aggregate demand is apparent in an acceleration of the inflation rate. As we allowed a contemporaneous reaction of monetary policy to demand shocks to be only partial (a coefficient of 0.5), the interest rate is raised immediately, but only by a fraction of the change in the inflation rate, resulting in a drop in the real interest rate upon impact. In alternative settings, where the immediate reaction of monetary policy is only 0.1 or as large as 0.9, the reaction of the interest rate upon impact is smaller or larger, in accordance with the parameter, but in subsequent periods the route of all variables is very similar to the one obtained when the immediate reaction

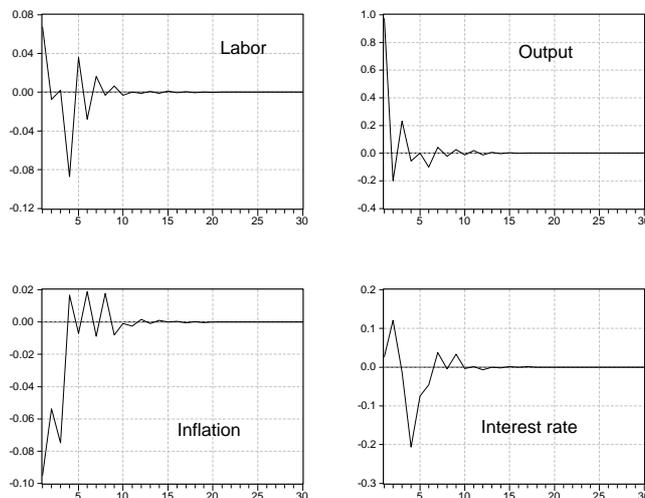


Figure 5: A one-time shock to productivity

is 0.5¹⁸. The convergence of the interest rate to its initial rate is slower than that of inflation, and therefore the real interest rate remains higher for several periods. Output expands in the first period in response to higher prices, and declines only afterwards, with some volatility, due to the rise in the interest rate, which implies a higher real interest rate, as inflation reverts to its initial rate. The impact on labor is volatile and mostly negative, after being positive in the first period. The response of the labor supply is much smaller than that of aggregate supply. In the long run, labor and output remain, by construction, unchanged (Figure 6).

5.1.4 A shock to monetary policy

As expected, a temporary shock to the monetary policy generates a short-run fall in the inflation rate. The response of the inflation rate is somewhat volatile, with a moderate rise in inflation in later periods. Still, on average

¹⁸The central bank sets the interest rate for a given month in the last week of the preceding month. At that time, the known data for the rate of inflation is lagged one month, meaning that the interest rate for t is set on the basis of price information until $t-2$. For quarterly data this means that on average the interest rate may be based only on information up to the first third of the current quarter. Assuming that the central bank does have some information about unpublished price data, and that it accommodates nominal interest in order to (at least) keep the real interest rate unchanged, we set $\beta_{i\pi,t} < 1$.

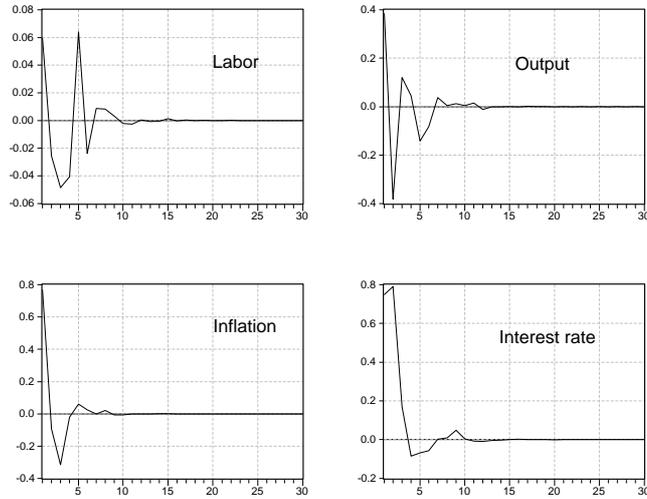


Figure 6: A one-time shock to aggregate demand

the reaction of inflation to the shock is negative. This result depends on the assumption we make concerning the immediate reaction of the central bank to an inflation shock, as this assumption determines the contemporaneous reaction of inflation to an interest rate shock ($\beta_{\pi i,t}$). For the choice of $\beta_{i\pi,t} = 0.5$, the contemporaneous impact of the shock to the interest rate on the inflation rate is solved at -0.11 . Assuming a larger coefficient (0.9) produces a steeper decline in inflation upon impact. A smaller coefficient (0.1) produces a decline in inflation only after two periods.

The reaction of the labor supply and output is relatively volatile. Aggregate supply expands slightly upon impact, despite the increase in the interest rate, and contracts later. The reaction of labor supply to a temporary shift in monetary policy is similar. By construction, the monetary shock does not have a long run effect on the supply of either labor or business sector output. Monetary policy shocks seem to have a significant effect on inflation almost instantaneously. Although caution is advisable in interpreting the results, this finding is consistent with other findings for the Israeli economy (Djivre and Ribon, 2000a), and contrasts the findings for the US and other large relatively closed economies. This is apparently due to the rapid pass-through from interest rates to the exchange rate and from the exchange rate to prices. This is due in part to Israel's the hyperinflationary history, which

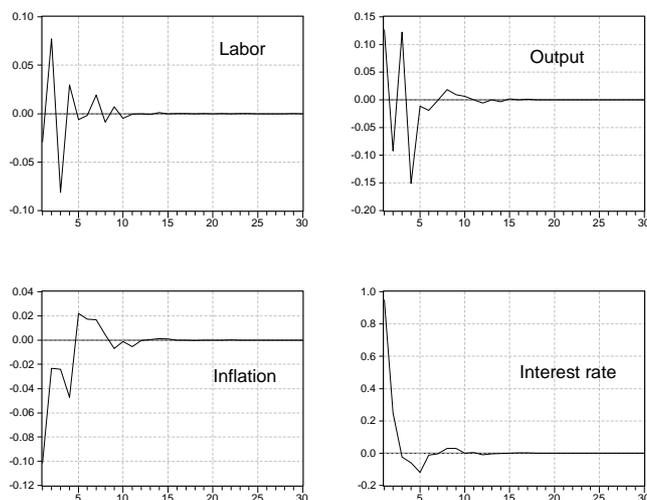


Figure 7: A one-time shock to the nominal interest rate

led to the creation of well established mechanisms linking the exchange rate with domestic prices, against the background of an administered exchange rate regime, and the fact that Israel is a small, open economy (Figure 7).

5.1.5 A shock to the flow of immigrants

An increase in the flow of immigrants is evident in an increase in the labor supply, which peaks only after some periods, and in an increase in output only two periods later¹⁹. Inflation accelerates (after a minor decline) as a result of the expansion of demand prior to the adjustment of supply, and the nominal interest rate that at first rises due to excess demand converges relatively quickly to its initial level. As output expands, inflation and the interest rate decline, before returning to their initial levels. (Figure 8).

5.2 Variance decomposition

In order to assess the relative importance of each of the shocks in explaining the variation in the variables of the system, we decompose the variance of the forecast errors for each of the equations to its five structural components.

¹⁹The shock to the flow of immigrants is in absolute terms, while the labor force and product variables are measured in log differences.

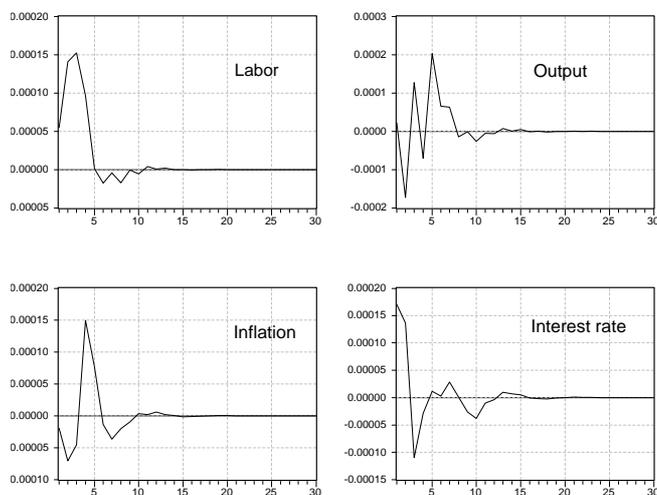


Figure 8: A one-time shock to the flow of immigrants

Four main findings are shown in Table 1. The first is that the variation of the forecast errors in the endogenous variables is generally due to their own variance. The share of variation which is attributed to the same variable's variations is about 90% in the short run and declines to about 60% to 80% in the long run. The second finding is that the disturbances in the monetary policy instrument account for only a small fraction of the forecast errors of the other variables for all horizons. This result is similar to those obtained for the US economy (Sims and Zha (1996) and Bernanke, Gertler and Watson (1997) for post-war data and Sims (1998) for the Great Depression) and for the G-7 (Kim (1999)). It is also consistent with the results of a previous study of the Israeli economy (Djivre and Ribon (2000b)). The third finding is that variation in the forecast of the monetary policy instrument is due, to a large extent, apart from the variance in the variable itself, to the variance in aggregate demand (expressed in the equation system as noises in the inflation rate). The fourth finding is that shocks to immigration play a substantial part in explaining forecasting errors in the labor supply, but not the variability of output supply and aggregate demand.

Table 1: Variance decomposition

Variability in the labor supply resulting from					
Qtr.	labor	productivity	demand	monetary policy	immigration
0	0.909	0.045	0.013	0.005	0.026
1	0.760	0.036	0.014	0.034	0.156
10	0.570	0.082	0.020	0.053	0.274
Variability in the (supply of) output resulting from					
Qtr.	labor	productivity	demand	monetary policy	immigration
0	0.000	0.957	0.032	0.010	0.001
1	0.018	0.893	0.052	0.014	0.023
10	0.054	0.800	0.051	0.029	0.064
Variability in the inflation (demand for output) resulting from					
Qtr.	labor	productivity	demand	monetary policy	immigration
0	0.035	0.046	0.885	0.032	0.002
1	0.062	0.051	0.833	0.032	0.022
10	0.060	0.070	0.723	0.033	0.114
Variability in the interest rate resulting from					
Qtr.	labor	productivity	demand	monetary policy	immigration
0	0.009	0.006	0.088	0.858	0.038
1	0.007	0.034	0.259	0.655	0.044
10	0.029	0.094	0.267	0.560	0.050

5.3 Analysis of the estimated structural shocks

In analyzing the Impulse Response Function in the previous section, we examined the response of the economy to a hypothetical one-time shock, given the estimated coefficients and the identification of the structural shocks. We did not look at the actual deviations of the data from its expected values, i.e., the realization of the structural shocks in the sample. This section describes the structural shocks as they are derived from the estimation of the system and the identifying assumptions. (Figure 9).

Note that the major shock to the Israeli economy in the first half of the 1990s - the influx of immigrants - is taken into account in the estimation by including the flow of immigrants as one of the system's variables. Therefore, only unexpected shocks to the rate of immigration or to its impact on the economy may be attributed to the estimated structural shocks.

Most apparent in the pattern of the labor supply shocks are the consecutive negative shocks in the mid 1990s - 1995 to 1998. During this period output slowed, and therefore had a moderating effect on the labor supply,

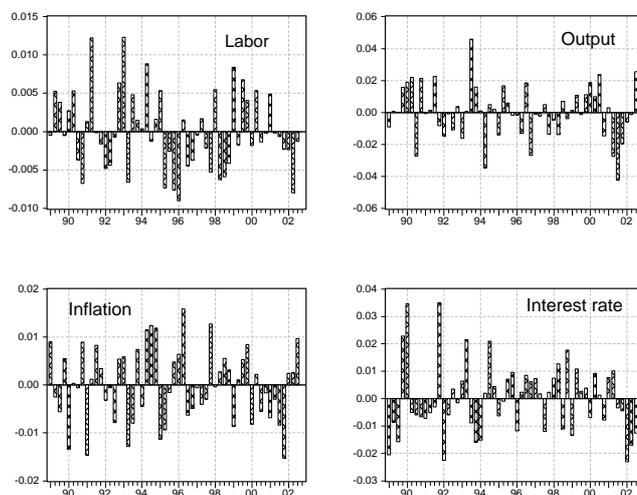


Figure 9: The identified structural shocks

although the actual drop in labor supply was larger than is explained by the slowdown in growth and other factors included in the system. One explanation for this may be the completion or reduction of the effective addition to the labor force as a result of immigration. In other words, a change in the age and education composition of immigrants during the 1990s may have reduced the effect (i.e. the coefficient) of new immigrants on the labor force. Figure 10, which shows a “dip” in the share of the labor force in the working-age population during those years supports this notion.

The residuals from the output equation do not show any significant pattern, except for the consecutive negative residuals towards the end of the sample. These represent Israel’s recession since the last quarter of 2000. The main exogenous reasons for this are the renewed Palestinian uprising and the global economic slowdown. As the output equation describes the supply side, these residuals may be interpreted as a slowdown in productivity. This is consistent with the decline in total productivity in 2001 (-1.6 percent, Bank of Israel Annual Report, 2001) and in most of the period since 1993.²⁰

As noted above, total productivity and labor productivity declined through most of the 1990s. The shocks referred to in this analysis do not represent this development as they refer only to unexpected shocks to productivity and

²⁰The figures are consistent with the data used in this paper. The updated figure (January 2003) is -3.4% for 2001, with declining productivity from 1993 through 2001.

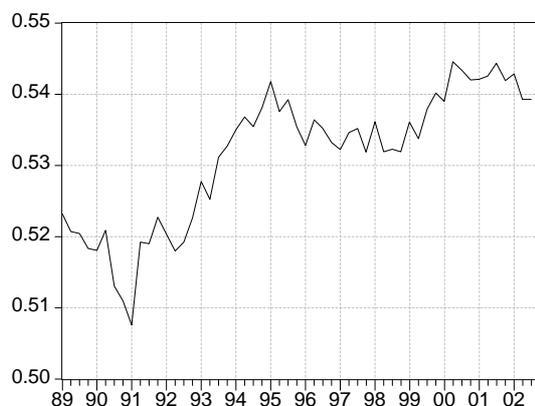


Figure 10: The share of the labor force in working-age population

add up to zero by construction. We find support for actual developments in our analysis by examining the contribution of labor and other factors to the average output growth. According to the estimation results, changes in the (Israeli) workforce contributed on average 1.5% (quarterly) to the 1.1% average business sector output growth rate during the sample period 1989-2002. Foreign workers contributed another 0.2%, and all the other factors, which may be attributed to labor productivity, contributed a negative -0.6%; this is consistent with the actual measured decline in labor productivity.

The residuals from the `inflation` equation represent shocks to demand. As mentioned earlier, Israel suffered from a recession during 2001, and this is evident in the residuals. Although the recession continued in 2002, sharp local-currency depreciation, which is not included in our system, explains the positive residuals in 2002. Although, for the sample as a whole the residuals from the inflation equation could have been expected to be correlated with changes in the exchange rate, the actual correlation was relatively low - only 0.22. Note, too, that the inflation equation includes 2 dummy variables for the “steps” of inflation during the 1990s. Therefore, any shocks that affected these steps are incorporated within the equation and are not evident in the residuals²¹.

²¹Among them a change in expectations due to the enhanced credibility of monetary policy and a shift in the fiscal stance to one which enables and facilitates a long-run reduction in the rate of inflation (see Dahan and Strawczynski (1997) and Djivre and Ribon (2000a)).

The interest rates shocks shown in Figure 9 may partially correspond to a change in the monetary policy regime in the middle of the sample period (although a dummy for this purpose was included in the interest rate equation). Israel's monetary policy in the early 1990s was expansionary, its main objectives being to maintain a real exchange rate high enough to support the exporting sectors of the economy. Inflation targets were adopted formally in 1992 and effectively a year or two later, resulting in tighter monetary policy. From 1992 onwards, the estimated shocks seem to be associated with a different regime from the one that existed previously. The exceptionally positive residuals at the end of 1989 and 1991 correspond with the Bank of Israel's response in the form of interest-rate hikes to the waves of demand for foreign exchange (capital export) at those times. For the period as a whole we did not find a positive correlation between changes in the exchange rate and the residuals of the interest rate equation, although, as stated, we omitted the exchange rate from the system of equations. The relatively large negative residuals at the beginning of 2002 are a result of the central bank's deviation from its course of moderate interest rate reductions, when it lowered the interest rate 2 percentage points at the beginning of the year as part of an agreement with the government²².

The shocks described above are the contemporaneous shocks to the dependent variable in each of the equations. But according to our specifications, the endogenous variables are affected by the contemporaneous shocks to all variables in the system. Therefore, unexpected deviations in the four major variables can be attributed to each of the structural shocks, and we can assess the relative importance of contemporaneous shocks in the economy to the deviation of the output, labor supply, inflation and the interest rate from their expected values. The findings are summarized in Table 2. The table shows the relative importance of each shock by looking at the weight over time (1989-2002) of the sum of absolute shocks to each of the variables relative to the sum of all absolute shocks.

Unexpected deviations in demand and the interest rate play a minor role in explaining the deviation of the labor supply and output from their expected values, given the information of the previous period. Unexpected changes in output (supply) are due mainly to unexpected changes in produc-

²²Developments in 2002 are described in greater detail in the Bank of Israel Inflation Report, no. 10 (July 2002).

equation	Shocks to				
	labor	productivity	demand	interest rate	immigration
Labor supply	0.59	0.14	0.07	0.05	0.15
Output	0.00	0.53	0.09	0.07	0.30
Inflation	0.10	0.09	0.66	0.11	0.02
Interest rate	0.09	0.06	0.17	0.55	0.14

Table 2: Relative weight of (absolute value of) shocks

tivity and immigration, and only to a smaller extent to shocks to demand (prices). Inflation in the 1990s is a demand-side phenomenon, but unexpected shifts in inflation were also affected by shocks to the interest rate, labor and output. Unexpected changes in the Bank of Israel's interest rates were caused mostly by variations in the policy itself and to a lesser extent by contemporaneous shocks to demand.

Performing the same analysis for 1995-2002 shows that the volatility of the interest rate explains less of the volatility in the labor supply and output than in the period as a whole. The contribution of labor-supply disturbances to uncertainty in forecasting the interest rate declines while the contribution of price volatility and the volatility in the interest rate itself increases. Looking at the first part of the period, 1989-1992, disturbances to the immigration flow explain more of the uncertainty in forecasting the labor supply, output and the interest rate. This is reasonable in view of the significant volume and significant changes in the flow of immigrants during that period.

5.4 Interpretation of the productivity shocks

In the model, and throughout the analysis we relate to shocks to the aggregate supply function as productivity shocks related to technological progress. This interpretation requires some additional support. The aggregate supply function we estimate does not take into account several factors other than technological progress which could affect the growth rate of business sector product. In the present specification these factors may be hidden in the residuals (see Figure 9). In general, this difficulty may arise as a result of measurement errors in the components of the production function - labor and capital. Below we try to obtain some indication as to whether these omitted factors are crucial to the results. The first type of mismeasure-

ment arises from ignoring the rate of capital utilization; the second type stems from mismeasuring the labor input, initially because the labor supply rather than actual employment is included in the aggregate supply function, and also because changes in effort and the quality of labor, namely in human capital, are not accounted for. The human capital component is particularly important in Israel because the changes in it were not limited to the those deriving from the expected trend of improvement in the education, but were largely influenced by the influx of immigrants. While in its first stages aggregate labor productivity may have declined because of the need to absorb new and not fully compatible employees into the working force, with time, the new comers to the labor market contributed to a higher average level of education, integrated and gave rise to higher labor productivity.

To check whether the residuals of the aggregate supply function are correlated with these factors or represent technological shocks, their correlation with several partial indicators for possible effects on measured productivity was assessed using a simple linear regression. The number of employees, of weekly hours per worker, and total working hours, all in the business sector, in levels and rates of change, and the unemployment rate were found not to have a significant effect on the residuals²³. For the above variables R^2 was lower than 0.06. In addition, an index computed at the Bank of Israel to estimate the utilization of capital in the manufacturing sector²⁴ did not have any significant correlation with the aggregate supply residuals.

In order to account for the change in human capital we used data from Flug, Kasir and Ribon (2000) and calculated the difference between the increase in the number of employees with 13 or more years of schooling and the increase in the number of participants in the labor force and employees with 8 or less years of schooling as an indicator of the change in the composition of human capital²⁵. These indicators were not significant in explaining the aggregate supply residuals either. Table 3 shows changes in the intensity of human capital (as measured by years of schooling²⁶) in Israel in the last decade; the basic test above does not find any significant effect

²³The log difference of employment and of total working hours were significant in 10%.

²⁴Using electricity consumption in the business sector.

²⁵Data until 1999.

²⁶This trend is evident both when examining the entire Israeli workforce, as is shown in the table, or just the veteran work force (excluding immigrants who arrived in or after 1989).

of these changes on the identified productivity residuals however.

Years of schooling	1987	1990	1994	1997	1998
0-8	0.192	0.163	0.113	0.087	0.078
9-12	0.476	0.496	0.484	0.466	0.458
13+	0.322	0.341	0.403	0.447	0.464

Table 3: Composition of Israeli labor supply by years of schooling. Source: Flug, Kasir and Ribon (2000).

Some other indirect evidence supports the assumption that the source of at least some of the productivity shocks is technological progress. Flug, Kasir and Ribon (2000) and Gandal, Hanson and Slaughter (2000) show that the increase in the share of employees with a high level of education in total employment in the last decade in Israel is mostly within rather than between industries. In other words, the change in the composition of labor does not reflect a change in the composition of demand for different (high-tech or low-tech) products, but rather a skill-biased technological change, which is evident in all industries.

An attempt to link the supply side “productivity” shocks we have identified with changes in productivity in the US, as a proxy for technological progress did not yield significant results, although there is some similarity in the general trend of the (4-quarter moving average, lagged one quarter) labor productivity in the non-farm business sector in the US and the shocks from the model (also in moving averages), as may be seen in Figure 11²⁷.

Although the above exercises are very partial and crude, they lend some support to the view that technological shocks are a major component of the disturbances we identified in the aggregate supply function.

6 Concluding remarks

This paper studies the different forces that affected the business cycles in Israel in the last decade. The two major developments during those years were: 1: the vast influx of immigrants into the country, mostly in the first half of the decade, which resulted in a significant increase in the supply of labor together with a change in its composition, and 2: significant structural

²⁷The correlation between the moving average of US labor productivity lagged 1 and 2 quarters, and RES_Y is about 0.35.

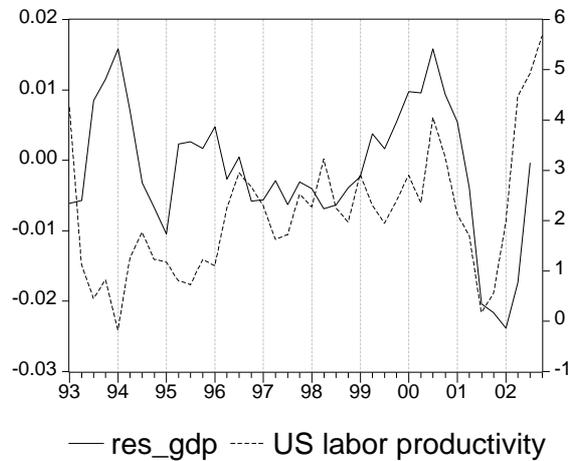


Figure 11: 4-qtr. moving average of US labor productivity in the non-farm business sector, lagged one period, and 4-qtr. moving average of aggregate supply residuals (RES-GDP)

changes in the real side of the economy - a shift to more advanced technologies and industries - alongside with the liberalization of the financial markets and a disinflationary process. These developments were shadowed by both positive and negative developments in the peace process and Israel's geopolitical situation. Using the structural VAR methodology with both long-run and short-run restrictions, we learn that variations in the (supply of) business sector product were mostly due to shocks to productivity, which we believe by and large represent shocks to technology, but may also correspond with changes in human capital as well as measurement errors, and to a much lesser extent are a result of shocks to the labor supply, aggregate demand or monetary policy. (Unexpected) changes in the intensity of immigration play a significant role in explaining the variation in the labor supply and help to explain shocks to aggregate supply. Shocks to immigration have an immediate effect on the labor supply and only later (after 6 quarters) output expands.

According to the Impulse Response Functions exercise we conducted, monetary policy reacts to the different shocks in the expected direction. In most cases the nominal interest rate reverts to its initial state more slowly than the inflation rate does, so that the real interest rate remains higher

than its original level for a few additional periods. We also find that the relative weight of actual shocks to monetary policy in explaining deviations in the output supply and labor supply is minor, as was also found in other studies of Israel and other countries. However, it may still be the case that the permanent shift to a disinflationary monetary policy in the mid-1990s, affected output for a relatively long period. This possibility is not explored here, since the methodology we use analyzes only the effect of temporary shocks on output, assuming these shocks do not have a long-run effect on aggregate demand. The system is characterized by very rapid convergence back to the baseline after a shock to one of the variables. This result is consistent with other findings for the Israeli economy that show that the transmission of monetary policy is faster than in the US and other countries. It may also be a result of the limited number of lags in our estimated model because of constraints imposed by the short sample relevant for this study.

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