Did the Bank of Israel Influence the Exchange Rate?

Avihay Sorezcky*

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* Research Department, Bank of Israel. http://www.boi.org.il
Avihay Sorezcky – Phone: 972-2-655-2651; E-mail: avihay.sorezcky@boi.org.il
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חטיבת המחקר, בנק ישראל ת״ד 780 ירושלים 91007
Research Department, Bank of Israel, POB 780, 91007 Jerusalem, Israel

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Abstract

In March 2008 the Bank of Israel started buying foreign currency, one of the aims of which was to affect the exchange rate. This study examines the effect on the NIS/US$ nominal exchange rate of the Bank's intervention in the foreign currency market. It does so by comparing the dynamic and static forecasts of the exchange rate, using an unrestricted VAR model estimated using the Bayesian method, with the actual exchange rate in the intervention period. Before performing the comparison the quality of the model's forecasts was examined, and it was found that the model produced good forecasts (given the actual values of the model's exogenous variables). In particular it was found that the forecasts were better than those obtained from the random walk model. This study found that the changes in the Bank of Israel's policy of intervention in the foreign currency market in March 2008, July 2008 and August 2009 resulted in shekel depreciation. The strongest estimated effect was recorded in the period after July 2008 when the scale of the purchases was increased, and the deviation of the actual exchange rate from its forecast level exceeded 10 percent. It was also found that the effect started to wane at the end of 2008, and that in the first half of 2009 the gap between the actual exchange rate and its expected level in the absence of Bank of Israel intervention narrowed, until it widened again when the Bank changed its intervention policy from one of fixed daily purchases to ad hoc purchases.

האם בנק ישראל השפיע על שער החליפין?

אביחי שורצקי

תקציר

בחודש מארס 2008 החל בנק ישראל ברכישות מט״ח, שאחת ממטרותיה הייתה השפעה על שער החליפין. במחקר זה נבחנה השפעת התערבותו של בנק ישראל בשוק המט״ח על שער החליפין הנומינלי שקל/דולר. זאת בדרך של השוואת תחזית, דינמית וסטטית, של שער החליפין, לפי מודל VAR לא מוגבל שנאמד בשיטה בייסיאנית, לשער החליפין בפועל בתקופת ההתערבות. קודם לביצוע ההשוואה נבחן טיב התחזיות של המודל האמור ונמצא כי הוא מניב תחזיות טובות (בהינתן הערכים בפועל של המשתנים האקסוגניים במודל). בפרט נמצא כי תחזיותיו טובות מהתוצאות המתקבלות ממודל של מהלך מקרי. מממצאי המחקר עולה כי תחילתן של רכישות המט״ח על ידי בנק ישראל במארס 2008, הרחבת היקפן ביולי 2008 והמעבר לרכישות מט״ח לא קבועות באוגוסט 2009, הביאו לפיחות בשער החליפין. ההשפעה הנאמדת החזקה ביותר על שער החליפין הייתה בתקופה שלאחר יולי 2008, עם הרחבת הרכישות – אז סטיית שער החליפין בפועל מערכו החזוי הייתה גבוהה מ-10%. עוד עולה מתוצאות העבודה, כי בסוף שנת 2008 החלה להצטמצם השפעת בנק ישראל על שער החליפין, ובמהלך המחצית הראשונה של שנת 2009 נסגר הפער בין רמת שער החליפין בפועל לרמתו הצפויה ללא התערבות בנק ישראל, עד שהוא נפתח שוב לאחר שינוי המדיניות של בנק ישראל בשוק המט״ח והמעבר לרכישות מט״ח לא קבועות.

1. Introduction

In early 2008, the Bank of Israel began to intervene in the foreign-exchange market by purchasing billions of US$ in order to influence the nominal NIS/US$ exchange rate. The purpose of this study is to estimate the effect of these purchases on the exchange rate.

It is no simple matter to estimate the effect of an economic policy generally, and that of a central bank's policy in the foreign-exchange market particularly, because the counterfactual cannot be observed. The approach that this study uses to examine the effect of the Bank of Israel's policy on the exchange rate is an attempt to estimate what the exchange rate would have been had the Bank of Israel not intervened in the foreign-exchange market and comparison of this rate with the actual exchange rate during the intervention period.[1] The main advantage of this approach is that it does not require the estimation of an exchange-rate equation during the intervention period, a task that encounters several econometric problems: (a) the possibility of simultaneity between the foreign-currency purchases and the exchange-rate level; (b) a tacit assumption in estimating an exchange-rate equation that includes the foreign-currency purchases as an explanatory variable, by which any level of purchases will affect the exchange rate in a similar and linear way.[2]

To estimate the effect of the Bank of Israel's foreign-currency purchases on the exchange rate, several tests based on comparing the non-intervention exchange-rate forecast with the actual exchange rate were performed. The principal model used to calculate the exchange-rate forecast was an unrestricted VAR model based on Azoulay and Ribon (2009) and estimated using the Bayesian method, much as in Segal (2010)—a BVAR model. The first test was the calculation of a dynamic exchange-rate forecast and comparison of the outcome with the actual exchange rate during the intervention period. In addition, we calculated a static forecast for the rate of depreciation during the intervention period (a forecast to one month ahead, based on coefficients estimated before the intervention began) and a confidence interval (CI) for the forecast. Finally, we calculated a dynamic exchange-rate forecast by applying structural macroeconomic models that had different exchange-rate equations, scopes, frequencies of data, and estimation methods.

To compare the actual exchange rate with its predicted level, one must first test the quality of the exchange-rate forecasts. To examine the BVAR-model-generated forecasts out of the sample period, we performed a dynamic simulation of the model (using actual values of the exogenous

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[1] A similar approach toward the examination of policy effectiveness was applied by the Council of Economic Advisers (2010) when it tested the effect of the United States government's Recovery and Reinvestment Act by comparing actual employment and growth rates with forecasts generated by an unrestricted VAR model.

[2] For further discussion, see Disyatat and Galati, 2007, and Galati et al., 2005.

variables) and calculated the RMSE value of the exchange-rate forecast to different forecasting horizons. The findings show that the BVAR model elicits good predictions of the NIS/US$ exchange rate, especially to a horizon of up to six months. It was found particularly successful in improving the exchange-rate forecasts that were obtained from a random-walk (RW) model. Then, testing the quality of the model-generated forecasts of the rate of depreciation to one month ahead, we found that for a 99 percent confidence interval, there was only one outlier among thirty-eight observations of the actual exchange rate, attesting to the validity of the CI. The results of our tests of forecast quality counter the mainstream literature, which deems it difficult to improve forecasts generated by an RW model to a short forecasting horizon.[3] A possible explanation of these results is our inclusion in the BVAR model of a variable that expresses the strength of the US$ abroad: since the strength of the US$ abroad is an exogenous variable to the Israeli economy and has a meaningful effect on the NIS/US$ exchange rate,[4] its inclusion in the model may be the factor that enhanced the forecasting of the NIS/US$ exchange rate.

By comparing the actual exchange rate during the intervention period with the level that the BVAR model predicted, we found that after the Bank of Israel made a policy change in regard to the foreign-exchange market (as it did in March 2008, July 2008, and August 2009),[5] the currency depreciated relative to its predicted level. In August 2008, after the Bank of Israel increased the size of its purchases in the foreign-exchange market, the forecast deviated from the actual exchange rate by 10.5 percent pursuant to steep depreciation that month, which the model had not foreseen. Afterwards, the spread between the actual exchange rate and its predicted non-intervention level began to narrow and was eliminated during the first half of 2009 (but reopened after the transition to ad hoc foreign-currency purchases). These results were preserved when the exchange-rate forecast generated by the BVAR model was subjected to sensitivity tests.

Calculating a static forecast for the rate of depreciation during the intervention period and a CI for the forecast, we found that the actual rate of depreciation overshot the upper bound of the CI five times, doing so to the greatest extent—2.5 percentage points—in August 2008. When the forecasts were subjected to sensitivity tests, the actual rate of depreciation again overshot the upper bound of the CI in August 2008. Additional findings of the static-forecast calculation according to all tests were the following: the rate of depreciation overshot the upper bound of the CI in June 2008 and undershot the lower bound in December 2008. After the Bank of Israel switched to ad hoc

[3] For further discussion, see Meese and Rogoff (1983a, and 1983b), Kilian and Taylor (2003), and Mark and Sul (2001).

[4] For further discussion of the effect of US$ strength on the NIS/US$ exchange rate, see Schreiber (2010).

[5] For a breakdown of the Bank of Israel's purchases, see Appendix A.

purchases of foreign currency in August 2009, the rate of exchange-rate change surpassed its predicted value in each subsequent month (until the end of the sample period, December 2009).

When we used structural economic models to generate the exchange-rate forecasts, we found that the forecasts elicited by these models fell short of the actual exchange rate during the intervention period—a finding that reinforces the outcomes of the test performed on the BVAR model.

Having found that a spread between the actual exchange rate and its predicted value opened after the Bank of Israel changed its policy in the foreign-exchange market—a spread that various factors and a range of models failed to explain—we infer that it was the changes in Bank of Israel policy in March 2008, July 2008, and August 2009 that induced the depreciation. The effect on the exchange rate was strongest in August 2008, after the Bank expanded its intervention. We also infer that the effect of the intervention began to diminish in late 2008 because in the first half of 2009 the actual exchange rate equaled the level predicted in the absence of intervention by the Bank.

The Bank of Israel's intervention in the foreign-exchange market, particularly in its last phase and in the general historical standpoint, has been examined in additional studies.[6] Gamrasni, Nathan, and Stein (2009) tested the effect of foreign-currency purchases by the Bank of Israel from the beginning of 2008 to the beginning of 2009 using a different approach from that adopted here, one similar to that of Kamil (2008). Examining the effect of the purchases by means of an equation that allows the purchases (and additional explanatory variables) to explain the rate of exchange-rate change,[7] they found that the Bank's foreign-currency purchases had a positive and significant effect on the rate of exchange-rate change, at a much higher level of intensity than we found. The reason for this, evidently, is that they estimated the coefficient of the effect of each US$ purchase on the exchange rate and calculated the cumulative effect by multiplying the sum of the purchases by this variable. Since the sum of the purchases was large during their review period, they found a powerful cumulative effect.

Pesach and Razin (1992) examined the effect on the actual exchange rate of the rules that guided foreign-currency policy in 1978–1990. During that time, Israel's foreign-exchange market was typified by depreciation limits, sometimes unstated and sometimes explicit. Pesach and Razin

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[6] The effectiveness of other countries' interventions in their foreign-exchange markets has also been investigated, including Japan (Galati et al., 2005, and Fatum and Hutchison, 2006), the Czech Republic (Disyatat and Galati, 2007), Colombia (Kamil, 2008), and Australia and Canada (Kearns and Rigobon, 2002, and Rogers and Siklos, 2003).

[7] In estimating the coefficient of the effect of the Bank of Israel's foreign-currency purchases in the period from March 2008 to July 2009, a difficulty comes to light because there is little variance in the sizes of the purchases. The approach proposed in this study surmounts the problem because the various estimations pertain to the period preceding the onset of the Bank's intervention in the foreign-exchange market, as we explain below.

(1992) proposed a frame of analysis that allowed exchange-rate developments originating in Israel's economic fundamentals to be separated from behavior tracing to the effects of exchange-rate policy. Their main conclusion was that in several periods that included critical turning points for the Israeli economy, the depreciation limit imposed an effective cap on exchange-rate volatility. They also found that the depreciation limits did not win full confidence, forcing policymakers to revise them in order to align them better with the fundamentals. The frame of analysis in Pesach and Razin (1992) is less suitable for the analysis of exchange-rate policy in the recent period investigated here because the nature of the intervention and the foreign-exchange market was different then than now.

The rest of this article is structured as follows: Section 2 describes the BVAR model, the main model used to calculate the exchange-rate forecast. Section 3 shows the results of the tests used to estimate the quality of the dynamic forecasts generated by the BVAR model. Section 4 offers a BVAR dynamic forecast of the exchange rate during the period of Bank of Israel intervention in the foreign-exchange market and compares the forecast with the actual exchange rate. Section 5 reports on the sensitivity tests applied to the findings of the BVAR dynamic forecast. Section 6 focuses on the static forecasts elicited by the BVAR model and compares them with the actual exchange rate during the intervention period; it also presents sensitivity tests of the results. Section 7 describes additional macroeconomic models that we used to calculate exchange-rate forecasts, tests the quality of the forecasts generated by these models, and presents the exchange-rate forecasts generated by these models for the intervention period. Section 8 concludes.

2. The BVAR model

The BVAR model, based on Azoulay and Ribon (2009), is an unrestricted VAR model[8] that includes five endogenous variables—inflation, rate of change in production, rate of change in exchange rate, Bank of Israel interest rate, and inflation expectations to one year ahead—and several exogenous variables representing the state of the U.S. economy, the security situation in Israel, and seasonality. The frequency of the data is monthly and the sample begins in January 2000. A later starting point enhances the results of the estimation because it uses the most relevant information. A sample of short duration, however, might degrade the estimation due to the paucity of degrees of freedom. To surmount this problem, the model was estimated using the Bayesian method, much as in Segal (2010). In the Bayesian estimation, the Theil and Goldberger (1961)

[8] It is a structural VAR model due to restrictions imposed on the simultaneous relations, and this, in order to obtain the response of the endogenous variables to shocks. Since this study uses the SVAR model for forecasting purposes only, there is no need to apply the restrictions to the simultaneous relations.

algorithm was used. The prior in the Bayesian estimation was formulated on the basis of the Minnesota Prior algorithm (Duan, Litterman, and Sims, 1984). Since the BVAR model has been described in detail in previous articles, it is presented here in general terms only.

2.1 The model equations

The VAR model may be written as:

$$Y_t = C + A(L)Y_{t-1} + B(L)X_t + \varepsilon_t,$$

where Y_t is the vector of endogenous variables that includes Consumer Price Index inflation (*DLCPI*), the rate of change in the Bank of Israel's composite index (*DLCI*),[9] the rate of change in the NIS/US$ exchange rate (*DLE*), the Bank of Israel interest rate (*IBOI*), and inflation expectations to one year ahead, as implied by the capital market (INF_EXP).

X_t is the vector of the exogenous variables: the Federal Reserve interest rate (*IFED*—included as a two-month moving average), the rate of change in the US$ price of imported goods (*DLPM*—weighted at 0.2 for consumption goods and 0.8 for capital goods and included as a two-month moving average), the rate of change in U.S. industrial production (*DLIPUS*—included at a two-month lag and a three-month moving average), the rate of change in the US$ cross-currency exchange rate against other foreign currencies (*DLCROSS*),[10] net foreign direct investment (*NET_DIRECT*—included as a two-month moving average; the series is published at quarterly frequency and was converted to monthly frequency),[11] a variable for Israel's security and political situation (*SECURITY*—the rate of relative change between inbound-tourist arrivals and departures from the U.S.; included as a two-month moving average), the midpoint of the Bank of Israel's inflation target (*TARGET*), and dummy variables for seasonality in April and September.

A graphic presentation of the data series and the descriptive statistics appears in Appendix B. The prior used in the Bayesian estimation is described in Appendix C. The results of the model estimation for sample period 01:2000–02:2008 (which, as we explain below, was used to calculate the exchange-rate forecast for the period of Bank of Israel intervention in the foreign-exchange market) are shown in Appendix D.

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[9] The Bank of Israel composite index is based on Marom, Menashe, and Suchoy (2003). The rate of change in the index is a proxy for the rate of change in product when the frequency of the data is monthly.

[10] The average rate of change in the US$ exchange rate against the EUR, the British pound, and the yen.

[11] Net foreign direct investment was unusually volatile in 2006 due to the sale of Iscar and the acquisitions of Teva. To spare the estimation outcomes and the forecasts from degradation, these transactions for sterilized from the net foreign direct investment series.

3. Estimating the quality of the dynamic exchange-rate forecasts generated by the BVAR model

Here we present the tests that assessed the quality of the exchange-rate forecasts generated by the BVAR model in order to determine whether the forecasts are reliable enough to sustain inferences about the effect of the Bank of Israel's intervention in the foreign-exchange market.

First we tested the quality of the model forecasts in the sample period—an essential condition for the reliability of the forecasts but not a sufficient one. Meese and Rogoff (1983a, 1983b) show that exchange-rate forecasting models may generate good forecasts within a sample period but underperform RW models out of period. Therefore, this section shows the tests that assessed exchange-rate forecast quality as generated by the BVAR model out of period as well.

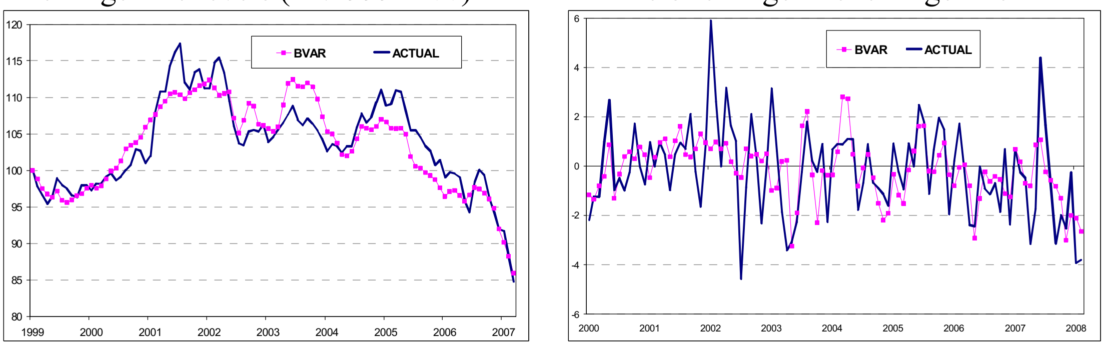
3.1 Forecast quality within the sample period

To test the forecasts within the sample period, a BVAR model was estimated for the 01:2000–02:2008 sample period (which ended one month before the Bank of Israel began to intervene in the foreign-exchange market). Then, a dynamic forecast for the endogenous variables in the model was calculated for the sample period, using the actual value of the exogenous variables. This is important in order to determine, at the level of impression, whether the model's exchange-rate forecast successfully explains rate fluctuations.

Figure 1 presents BVAR-generated forecasts for the sample period along with the actual exchange rate, in both rates of change and in level (as derived from the rates of change). The graph shows that the model delivers accurate forecasts within the sample period and successfully tracks exchange-rate fluctuations. Also, the graph of the level of the exchange rate shows that the model successfully tracks exchange-rate trends at times of both appreciation and depreciation. The maximum deviation of the model forecast from the actual exchange rate occurred in June 2002, at 6 percent.

Figure 1: Forecasts within Sample Period

Exchange-rate levels (12:1999=100)   Rate of change in exchange rate



3.2 Forecast quality out of period

This subsection reports on a check similar to that performed by Meese and Rogoff (1983a). By means of the BVAR model, dynamic simulations were performed for all endogenous variables, using actual values of the exogenous variables. The simulations were performed across a "rolling" sample period that began each month between January 2005 and February 2008, a time marked by bouts of significant depreciation *and* significant appreciation. The simulation period lasted eighteen months or until February 2008, a month before the Bank of Israel began to intervene in the foreign-exchange market. The results of the simulation elicited a forecast of the annual change in the exchange rate, with which a forecast of the exchange-rate level was calculated. Preceding the simulation, estimations were performed up to the starting point of the simulation, i.e., the forecast calculated is an out-of-period one.

The quality of out-of-period forecasts to different forecasting horizons was tested via the RMSE criterion, defined as follows:

$$RMSE = \left\{ \frac{\sum_{s=0}^{N_{k-1}} \left[F(t+s+k) - A(t+s+k) \right]^2}{N_k} \right\}^{\frac{1}{2}},$$

where:

k-1,3,6,9,12,15,18—forecasting horizon (in months);

N_k —number of forecasts to horizon *k* for which an RMSE value was calculated;

t—starting point of forecast;

$A(t)$—actual exchange rate in period *t*;

$F(t)$—predicted exchange rate in period *t*;

The RMSE value was also calculated for forecasts generated by "naïve" models—an RW model (which expects the exchange rate to remain unchanged in the future), an auto-regressive equation with three lags—AR (the number of lags chosen on the basis of an AIC criteria), and an equation in which the rate of change in the NIS/US$ rate is explained by the rate of change in the US$ cross-currency rate (CROSS). The RMSE values for the forecasts of the various models to the different forecast horizons are shown in Table 1. The numbers in parentheses next to the forecast horizon are the number of observations used to calculate the RMSE value (N_k). Values in boldface express the lowest RMSE value for each forecast horizon. Since the exchange rate at the starting point of each simulation is indexed and was set to 100, the RMSE values may be construed as a proxy for percent deviation.

Study of the table shows that the BVAR model delivers better results than RW-based forecasts to a forecast horizon of 1–15 months. Also, starting from a nine-month horizon, the forecasts produced by the CROSS model are the best. The longer the horizon, the worse the forecast quality.

The quality of BVAR-generated forecasts out of the sample period was also examined for estimations in which the sample period begins in January 2001 and additional periods for which simulations were performed. All checks of forecast quality out of the sample period showed that the forecast results generated by the BVAR model were superior to the RW forecasts to horizons of up to fifteen months. Several checks also found the BVAR-generated forecasts superior to those of the CROSS model to horizons exceeding nine months.

Meese and Rogoff (1983a), in their classic study, found that models based on macroeconomic fundamentals did not manage to improve forecasts generated by a RW model (which assumes that the exchange rate will remain unchanged). This study spawned a ramified literature about the exchange-rate forecasting power of economic models. Although several studies reinforced the findings of Meese and Rogoff (1983a) (e.g., Diebold et al., 1994, and Engel, 1994), the mainstream literature does state that exchange-rate models improved RW-generated forecasts to middle and long horizons whereas RW forecasts are better to a short horizon (e.g., Chinn and Meese, 1995; MacDonald and Taylor, 1994; Mark, 1995; Kilian and Taylor, 2003; and Mark and Sul, 2001).[12] Accordingly, the results presented above, showing that the BVAR model elicits better outcomes than those of RW even to a short horizon, clash with the mainstream literature. One possible explanation for this is that the literature focuses on the US$ exchange rate against currencies of other large economies (foremost Japan, UK, and Germany) while US$ exchange rates against currencies of small and open economies, such as Israel's, are heavily influenced by the US$ cross rate, which develops in a manner exogenous to a small economy. (For elaboration on the effects of US$ cross rates on the NIS/US$ exchange rate, see Schreiber, 2010.) Thus, the main reason for the superiority of BVAR-model forecasts over RW-model forecasts may be the inclusion of the US$ cross rate as an exogenous variable in the former.

The results of the tests that checked the quality of the out-of-period BVAR-model forecast show that the model generates good results to a forecasting horizon of up to six months. To this horizon, the RMSE value of the BVAR-model forecasts is the lowest. To horizons of 6–twelve months, although the BVAR-model forecasts sustained some degradation and were not as good as those generated by the CROSS model, they remained reasonable. To horizons beyond twelve

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[12] MacDonald and Marsh (1997) presented an exchange-rate model based on economic-fundamental variables and long-term relations, the forecasts of which surpassed those of the RW model to a short horizon as well.

months, the quality of forecasts generated by the BVAR model worsened considerably. Thus, it seems correct to use the BVAR-model forecasts to draw conclusions to horizons of up to twelve months.

Table 1: RMSE Values Obtained from Outcomes Generated by Different Models

Model / Horizon (N_k)	BVAR	AR	CROSS	RW
1 (38)	**1.53**	1.82	1.68	1.89
3 (36)	**2.76**	3.68	3.15	3.65
6 (33)	**3.97**	5.39	4.43	5.45
9 (30)	4.98	6.31	**4.93**	6.37
12 (27)	6.59	7.80	**6.06**	7.83
15 (24)	8.79	8.93	**6.89**	8.93
18 (21)	11.47	9.98	**7.78**	10.01

4. Comparing the actual exchange rate during the intervention period with the dynamic forecast generated by the BVAR model

After the quality of the exchange-rate forecasts generated by the BVAR model was checked in Section 3 and the model was found to elicit accurate forecasts, in this section we compare the forecasts of the model with the actual exchange rate during the period of Bank of Israel intervention in the foreign-exchange market. The Council of Economic Advisers (2010) took a similar approach toward the assessment of the effect of an economic policy, comparing actual growth and employment rates with rates predicted by an unrestricted VAR model. Wherever the forecast deviated from the actual growth and unemployment rates, the difference was attributed to the U.S. Administration's 2009 economic recovery program.

To calculate the exchange-rate forecasts, we estimated the BVAR model using a sample that ended in February 2008, a month before the foreign-currency purchases began. Then we performed a dynamic simulation out of the sample period for all endogenous variables in the model, using actual values of the exogenous variables. The dynamic simulation elicited a forecasting path for the rate of change in the exchange rate, from which the predicted exchange-rate level was calculated.

Figure 2 posits the actual exchange rate against that predicted by the BVAR model from the first month of Bank of Israel intervention in the foreign-exchange market (March 2008) to the end of 2009. (The forecast for the rate of exchange-rate change, from which the level of the exchange rate was predicted, is shown in Appendix E.) The graph shows the main points of policy change in the Bank of Israel's intervention regime. When the purchases began, more actual depreciation occurred than the extent predicted by the BVAR model. In August 2008, after the Bank of Israel broadened its intervention in the foreign-exchange market, the spread between the actual exchange rate and its predicted level widened considerably.[13] Since the BVAR model predicted depreciation from August 2008 onward, the spread remained almost unchanged for several months and began to narrow in late 2008. In June–September 2009, the actual exchange rate approximated the predicted rate; afterwards, the BVAR-generated forecast and the actual exchange rate pulled apart again.

Table 2 shows the rate of deviation of the BVAR-generated forecast from the actual exchange-rate level during the intervention period. The results show that six months after the onset of intervention (August 2008)—a horizon to which the BVAR model elicits good forecasts—the spread between the actual exchange rate and the predicted one widened considerably due to steep depreciation that the model did not capture. The deviation of the forecasts from the actual exchange rate peaked at 11.5 percent after nine months of purchases. Afterwards, the gap narrowed to 6 percent one year after the intervention began.

Importantly, during the period for which we checked the quality of the BVAR-generated forecasts out of the sample period (01:2005–02:2008), the forecasts overshot the actual exchange rate by quite a margin. However, the deviation recorded during the intervention period (08:2008–11:2008) exceeded every checked pre-intervention observation to a parallel forecasting horizon. This cannot be attributed to the steep exchange-rate fluctuations that occurred during the intervention period, since the term for which the quality of out-of-period forecasts was tested included several subperiods in which exchange-rate volatility was even greater. Furthermore, the deviation of the exchange rate from its predicted level in August-September 2008 was much greater than the RMSE value that was calculated in the testing of out-of-period forecasts to a parallel forecast horizon.

[13] In the second half of July 2008, after the Bank of Israel intensified its intervention in the foreign-exchange market, the NIS/US$ exchange rate depreciated considerably. Since the BVAR model is formulated for a monthly average of depreciation rates, depreciation was manifested in August 2008 due to end effects. A graph plotting the NIS/US$ exchange rate for June-Sept. 2008 at daily frequency appears in Appendix F.

Figure 2: BVAR-Generated Forecasts and Actual Exchange Rate during Intervention Period (02:2008=100)

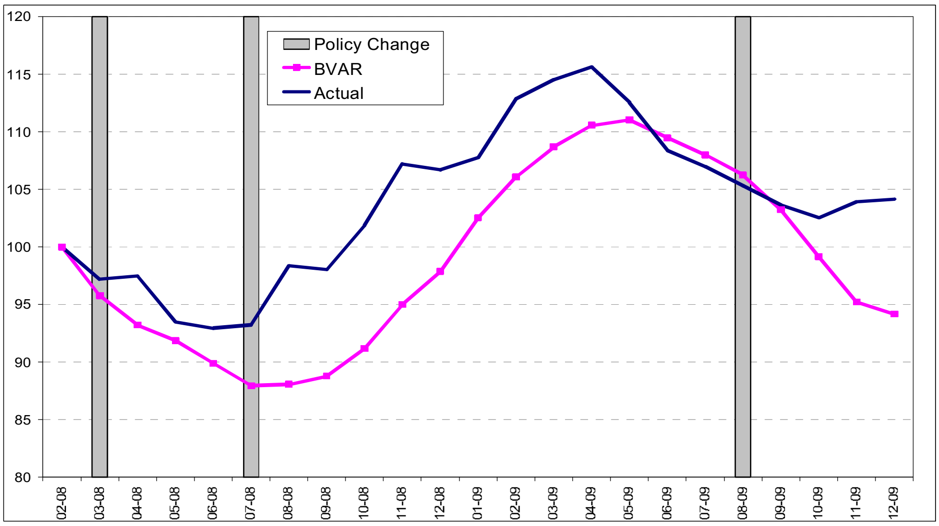


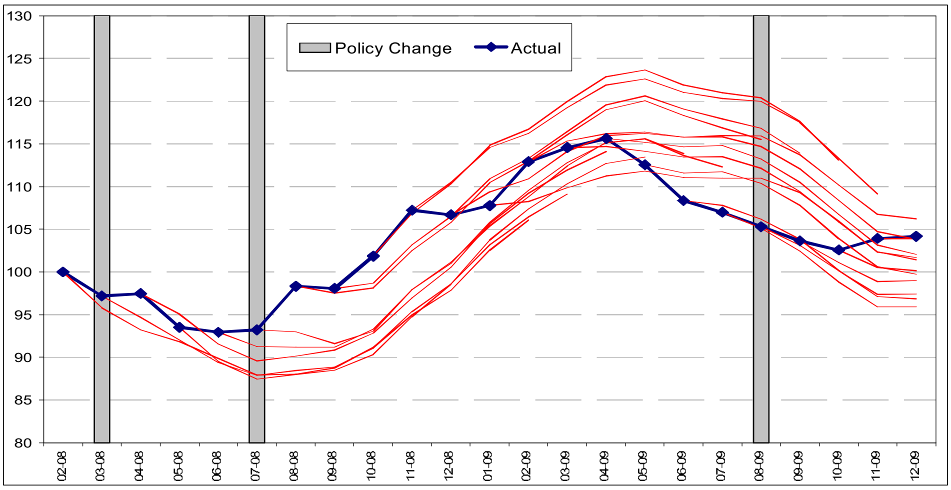
Table 2: Rate of Deviation of BVAR-Generated Forecasts from Actual Exchange Rate

Month	Horizon (in month)	Deviation
05:2008	3	-1.7
08:2008	6	-10.4
11:2008	9	-11.4
02:2009	12	-6.0

It is important to bear in mind that, according to the tests of BVAR-generated forecast quality, the forecasts generated by this model may be used up to a twelve-month horizon; therefore, the results in Figure 2 may be deemed reliable up to February 2009. To allow inferences about the effect of the Bank of Israel's intervention beyond this forecast horizon, simulations were calculated for a "rolling" sample period that began in each month between March 2008 and December 2009 and lasted twelve months (the maximum horizon found in the forecast quality tests), or until December 2009. All simulations were performed by using the coefficients obtained from the estimation of the model for the 01:2000–02:2008 sample period, i.e., before the Bank of Israel began to intervene in the foreign-exchange market.

The BVAR-model forecasts for the exchange rate, as calculated in the aforementioned simulations, are shown in Figure 3. It is evident that the results are consistent with those in Figure 2. After the Bank of Israel announced a policy change on intervention in the foreign-exchange market, the actual exchange rate pulled away from its predicted level, i.e., when the intervention began, the NIS depreciated more than the model predicted. In August, after the Bank intensified its intervention in the market, the spread widened. Similarly, after the Bank shifted to ad hoc purchases of foreign currency, a spread between the actual and predicted exchange rates reappeared. Finally, in December 2008 the spread began to narrow, as reflected in a higher exchange-rate forecast that the actual rate.

Figure 3: BVAR-Generated Forecasts for "Rolling" Sample Period and Actual Exchange Rate during Intervention Period (02:2008=100)



5. Sensitivity tests for the dynamic forecast during the intervention period, according to the BVAR model

The main reason for the deviation of the BVAR-generated forecast from the actual exchange rate seems to have been the Bank of Israel's intervention in the foreign-exchange market. Since the foreign-currency purchases did not create a structural shock in the BVAR model, one cannot rule out the possibility that additional factors affected the level of the exchange rate. This section checks for the existence of such factors and asks whether they influenced the spread between the actual and the predicted exchange rates.

We begin with global factors. Global shocks may affect the NIS/US$ exchange rate. However, since the actual values of the exogenous variables were used in the simulations, the effect of these shocks was already built into the forecasts and is not the source of the steeper depreciation than the predicted extent. Just the same, the period of Bank of Israel intervention in the foreign-exchange market was a time of severe global (and domestic) crisis that may have induced changes in the effect of exogenous factors of foreign origin on the Israeli economy. The main exogenous factor in which a change in effect on the NIS/US$ exchange rate may induce meaningful change in the BVAR-model forecasts is the US$ cross rate (which reflects the strength of the U.S. currency abroad). Therefore, the sensitivity of the BVAR-generated forecast to the cross exchange-rate coefficient was tested.

Additional tests were performed to see whether an increase in Israel's financial risk relative to the U.S., engendered by the crisis, was the main factor behind the deviation of the BVAR-generated forecast from the actual exchange rate. Finally, we asked whether the above-prediction rate of deprecation originates in errors in forecasting the additional endogenous variables in the model.

Below in this section, we describe at length the sensitivity tests performed and conclude by presenting their results.

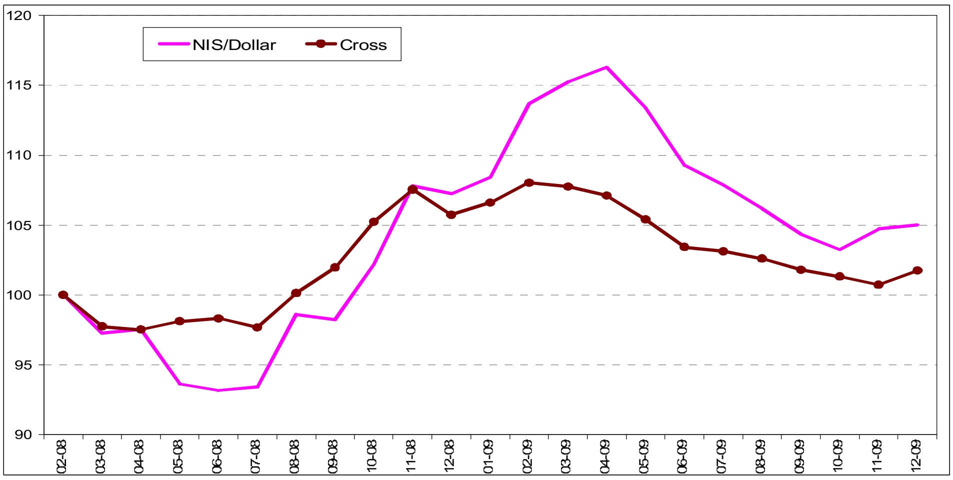
5.1 Sensitivity of the dynamic forecast during the intervention period to the US$ cross-rate coefficient

The BVAR model estimation in the 01:2000–02:2008 sample period, the sample used to calculate the dynamic forecast during the intervention, shows that the U.S. cross rate coefficient took on the value of 0.65—meaning that a 1 percent depreciation of the US$ abroad would be expected to raise the NIS/US$ exchange rate by 0.65 percent (Appendix D).

The Bank of Israel's intervention in the foreign-exchange market took place against the background of a grave global crisis, especially after the collapse of the Lehman Brothers investment bank in September 2008. Figure 4, showing the NIS/US$ exchange rate against the US$ cross rate, indicates that in the months following the Lehman Brothers collapse, the US$ appreciated strongly around the world, as it did against the NIS. Accordingly, the effect of the US$ cross exchange rate on the NIS/US$ exchange rate may have become stronger at the time of the crisis. In contrast, a study that looked into the effect of the global factor on the NIS/US$ exchange rate found that this factor actually became weaker in 2008 (Schreiber, 2010). Gamrasni, Nathan, and Stein (2009) estimated the effect of the strength of the US$ abroad on the NIS/US$ exchange rate during the period of Bank of Israel intervention in the foreign-exchange market, using daily data, and obtained a coefficient of 0.5.

To test the sensitivity of the BVAR-model forecast during the intervention period to the US$ cross-rate coefficient, we set up an exercise similar to that described in Section 4, using various values for the US$ cross-rate coefficient. For the purpose of the exercise, the BVAR model was estimated for a 01:2000–02:2008 sample period, and then the US$ cross-rate coefficient was calibrated in the NIS/US$ exchange-rate equation to values of 0.65 ± 0.2. Next, a dynamic simulation was performed for the endogenous variables in the model, using the values of the actual exogenous variables. The exchange-rate forecasts obtained from the simulations are shown at the end of this section, in Figure 6.

Figure 4: NIS/US$ Exchange Rate and US$ Cross Rate (02:2008=100)



5.2 Effect of an increase in financial risk on the dynamic forecast during the intervention period

The Bank of Israel's intervention in the foreign-exchange market coincided, as stated, with an acute crisis that took a turn for the worse in September 2008. The crisis elevated the risk of financial assets in Israel and abroad. The increase in risk was manifested in a steep widening of Israel's CDS (Credit Default Swap) spread. This upturn in sovereign risk might have induced an investor flight and, in turn, depreciation of the NIS. Since the BVAR model does not have a variable that represents financial risk, the financial-risk mechanism is not directly represented—a lacuna that may explain the deviation of the exchange-rate forecast from the actual rate during the period of Bank of Israel intervention in the foreign-exchange market. Importantly, however, the phenomenon of widening CDS spreads recurred in many countries. Therefore, if the mechanism described above has a meaningful effect on exchange rates, it may explain the appreciation of the US$ around the world. Since the variable reflecting US$ strength abroad was included in the BVAR model, it also expresses, indirectly, the effect of the upturn in financial risk on the exchange rate.

To test directly the effect of the increase in financial risk on the BVAR-generated forecasts during the intervention period, we added a variable expressing the risk to the model. The conventional data series that represents financial risk is the CDS spread, but data for this series are available only from the end of 2002. Therefore, the series chosen to capture financial risk was the rate of US$ depreciation against emerging-market currencies.[14] In Figure 5, which presents data on

[14] The US$ exchange rate against emerging-market currencies was calculated as the weighted average of the US$ exchange rates against the currencies of Brazil, China, India, South Korea, Mexico, Malaysia, the Philippines, Russia, Thailand, Turkey, Taiwan, and South Africa. Each country's weight was determined commensurate with its share in the MSCI emerging-markets index.

Israel’s 5-year CDS spreads and US$ exchange rates against emerging-market currencies, one may see that the data series developed similarly as the crisis worsened in September 2008, so that the coefficient of correlation between the rates of change of the two series during the crisis stood at 0.65. The apparent reason for this is that the increase in the emerging markets’ financial risk, including Israel’s, caused these countries’ currencies to depreciate against the US$. Consequently, the US$ exchange rate against the emerging-market currencies reflects the financial-risk mechanism. Therefore, to include this mechanism in the BVAR model, the rate of change in the US$ cross-currency rate against emerging markets’ currencies was added to the model as an exogenous variable.

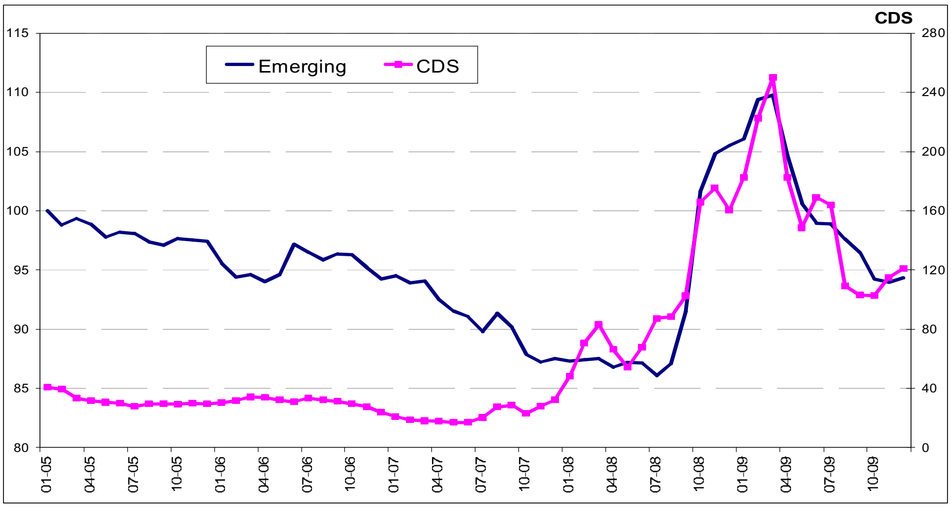
Importantly, before the crisis, there was a weak positive correlation (0.1 in 2005–2008) between the rates of NIS depreciation against the US$ and the US$ exchange rate against the emerging-market currencies. In contrast, there was a weak negative correlation (a coefficient of –0.25) between the rates of change in the NIS/US$ exchange rate and those in the CDS spreads. Accordingly, in the exchange-rate equations used in the BVAR model, the coefficient of the rate of US$ depreciation against the emerging markets’ currencies acquired a higher value than that obtained for the CDS spreads. Thus, the inclusion of the US$ exchange rate against the most advanced emerging markets’ currencies reinforced the effect of the financial-risk mechanism during the intervention period relative to the effect that would have been obtained had CDS spreads been used.

Further, in the past decade Israel transmogrified from an emerging market into a developed one, a process that climaxed in May 2010 with its admission to the OECD and inclusion in the MSCI index of developed countries. Therefore, the financial-risk mechanism probably would have had a milder effect on the Israeli economy than on the emerging-market class.

For the foregoing reasons, one may say that the inclusion of the rate of US$ depreciation against the emerging-market currencies as an exogenous variable in the BVAR model maximizes the consideration given to the effect of the crisis and the financial-risk mechanism on the NIS/US$ exchange rate during the period of Bank of Israel intervention in the foreign-exchange market.

A dynamic forecast of the exchange rate during the intervention period using the BVAR model, based on estimation of the model with the rate of change in the US$ cross rate against the emerging-market currencies as an exogenous variable, is shown in Figure 6.

Figure 5: Israel CDS Spreads and US$ Exchange Rate against Emerging-Market Currencies, 01:2005–12:2009



5.3 How using actual values of additional endogenous variables affects the dynamic forecast

The results of the exchange-rate forecast presented in Section 4 are based on a dynamic simulation for each endogenous variable in the BVAR model (exchange rate, rate of change in composite index, Bank of Israel rate, CPI inflation rate, and inflation expectations as implied by the capital market). The reason for performing the simulation on all endogenous variables in the model is that the Bank of Israel's foreign-currency purchases may have affected these additional economic endogenous variables via their effect on the exchange rate. It is possible, however, that a major deviation of the forecast of the endogenous variables from their actual values is what caused the exchange-rate forecast to deviate from its actual level. In particular, it may have been a deviation in the Bank of Israel interest-rate forecast that caused the exchange-rate forecast to swerve during the intervention period. At that time, the Bank of Israel, like many other central banks, was cutting its rate steeply in response to the acute global crisis. Thus, in April 2009 the Bank of Israel rate fell to a historical low of 0.5 percent. Rate-cutting, according to the UIP (uncovered interest-rate parity) theory, has a pro-depreciation effect. Therefore, a shock in monetary policy that is not captured by the BVAR model may explain the higher (depreciated) actual exchange rate relative to the predicted one.

To determine whether the deviation of the BVAR-model forecast from the actual exchange rate traces to a deviation of the forecast of additional endogenous variables, we performed a dynamic exchange-rate simulation that used actual values of the additional endogenous variables (and the exogenous variables). The exchange-rate forecast obtained in this manner is shown in Figure 6.

5.4 Outcomes of sensitivity tests

Figure 6 presents dynamic forecasts of the exchange rate during the intervention period in accordance with the sensitivity tests. The graph shows the forecasts with the rate of US$ depreciation against emerging-market currencies included in the BVAR model, with the value of the US$ cross-rate coefficient set at 0.85 (dlcross_coef+0.2) and 0.45 (dlcross_coef–0.2), and actual values of the endogenous variables used (actual_endogenous). The graph shows that the BVAR-model forecasts for the US$ cross-rate coefficient, according to the sensitivity tests, approximate the baseline forecast. The forecast obtained via use of the actual values of the additional endogenous variables is much lower than the baseline forecast.[15]

In contrast, the BVAR-model forecast including the US$ exchange rate against emerging-market currencies is different from the baseline forecast. The two forecasts approximated each other until August but a spread between the actual exchange rate and its predicted level developed when the intervention began and widened considerably in August 2008 (after the daily foreign-currency purchases became larger). From September 2008 onward, the forecasts deviated considerably: according to the emerging-market-currencies scenario, the spread between the actual and the predicted exchange rates closed by January 2009; in the baseline scenario, it took until June 2009 for this to happen.

By including the US$ exchange rate against emerging-market currencies, as noted, we found the strongest effect of the crisis and the financial-risk mechanism on the exchange rate during the intervention period. Therefore, the actual effect of these factors was probably weaker. Accordingly, the forecast based on the emerging-markets scenario serves as a lower bound for the spread between the actual exchange rates and its predicted level during the intervention period, with the probability that the spread closed after January 2009.

Table 3 shows the rate of forecast deviation, according to the sensitivity tests, from the actual exchange rate during the intervention period. It is evident that according to all tests, the spread was widest in August 2008, after the Bank of Israel intensified its intervention in the foreign-exchange market; the narrowest spread that month was 9.5 percent. Afterwards, according to the sensitivity tests for the cross-rate coefficient, the spread remained stable, and twelve months after the onset of intervention it began to narrow. According to the sensitivity test that included the US$ exchange rate against emerging-market currencies in the model, the spread between the actual exchange rates

[15] A forecast based on a dynamic simulation, in which the actual Bank of Israel rate was used and the additional endogenous variables were solved in the model, was also tested. The results of this forecast approximated those of the baseline forecast.

and its predicted level narrowed appreciably by November 2008 and was totally eliminated about a year after the intervention began.

Another finding illuminated by the sensitivity tests is that, in all scenarios, the actual value of the NIS slipped below its predicted value after the Bank of Israel changed its policy in August 2009 (to ad hoc foreign-currency purchases). Although this finding is consistent with the BVAR-model forecasts according to the baseline scenario, the quality tests for the BVAR-model forecasts demonstrate that these forecasts may be used only to a twelve-month horizon. Thus, one may not rely on the forecasts based on the sensitivity tests past February 2009.

Figure 6: BVAR-Model Forecast according to Sensitivity Tests and Actual Exchange Rate (02:2008=100)

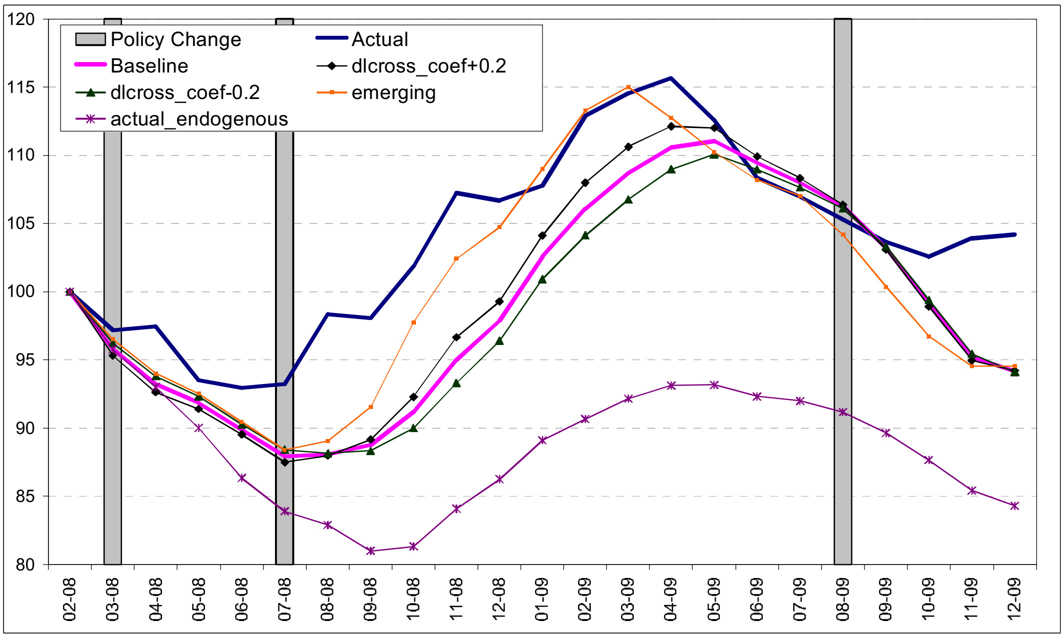


Table 3: Rate of Deviation of BVAR-Model Forecasts from Actual Exchange Rate according to Sensitivity Tests

Month	**Horizon (in months)**	**Deviation**				
		dlcross coef+0.2	dlcross coef-0.2	Emerging	Actual endogenous	**Range**
05:2008	3	–2.3	–1.3	–1.0	–3.7	(–3.7)–(–1.0)
08:2008	6	–10.5	–10.4	–9.5	–15.7	(–15.7)–(–9.5)
11:2008	9	–9.9	–13.0	–4.5	–21.6	(–21.6)–(–4.5)
02:2009	12	–4.3	–7.8	0.3	–19.7	(–19.7)–(0.3)

Comparing the dynamic exchange-rate forecast according to the BVAR model with the actual exchange rate during the intervention period, we found that whenever the Bank of Israel changed its policy on intervention in the foreign-exchange market, a spread developed between the predicted exchange rate and its actual level. The spread was widest in August 2008—after the Bank expanded its purchases—according to all sensitivity tests performed. Inferentially, the increment of NIS depreciation that exceeded the predicted extent traces to the Bank of Israel's intervention in the foreign-exchange market.

The spread between the actual exchange rate and its predicted level was eliminated several months later, although the sensitivity tests generated different outcomes as to how quickly this happened. The scenario that includes the financial-risk mechanism served as the lower bound of the celerity of this process. Thus, the spread between the actual exchange rate and its predicted level was probably eliminated during the first half of 2009.

6. Static exchange-rate forecast using the BVAR model

To test the effect of the Bank of Israel's intervention in specific months as opposed to its cumulative effect, we calculated a static forecast for the rate of exchange-rate change during the intervention period. Then we calculated a confidence interval (CI) for the forecast and compared the calculated rate of exchange-rate change with the actual one. This allowed us to determine exactly when the deviations of the actual exchange rate from the predicted rate were widest and whether the deviations took place attendant to announcements from the Bank of Israel about a change in its method of intervening in the foreign-exchange market. To weed out deviations of the actual rate of depreciation from the CI that do not originate in the Standard Deviation of the BVAR-model forecasts, the CI was calculated to a very high confidence level—99 percent. This check allowed us to determine whether aberrant deviations of the predicted depreciation rate from the actual depreciation rate may be explained by variance in the random errors of the model.

To validate this exercise, we first had to test the quality of the forecasts and the CI before the intervention period and check whether the actual rates of exchange-rate change before the purchases began falls within the CI of the forecast.

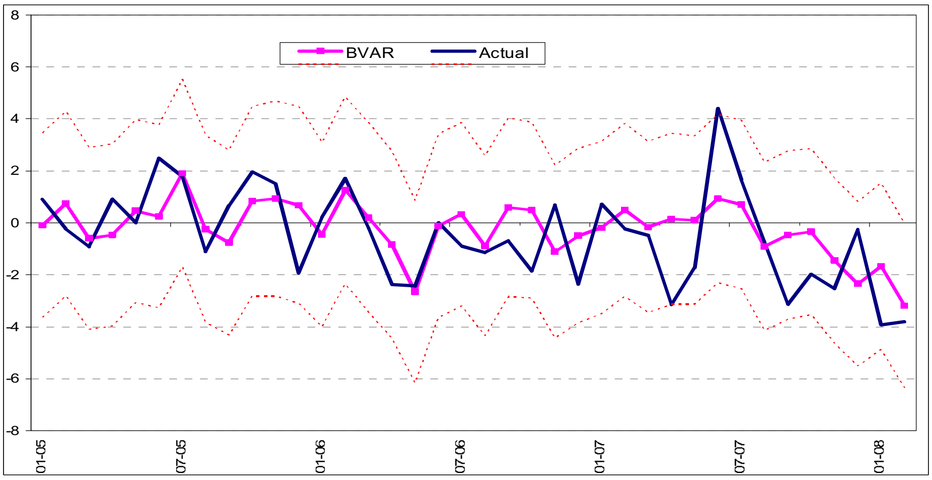
6.1 Forecast of rate of exchange-rate change to one month ahead before intervention period

To calculate the BVAR-model forecast for the rate of exchange-rate change, we estimated the model pertaining to a sample period that began in January 2000 and ended in each month between

December 2004 and January 2008. Then we simulated the model to one month out of the sample period and calculated the CI of the forecast to 99 percent.[16,17]

The BVAR-model forecast for the rate of exchange-rate change, the CI of the forecast, and the actual rate of depreciation in the 01:2005–02:2008 period are presented in Figure 7. The graph shows that the actual rate of exchange-rate change deviated from the forecast CI once, in June 2007, by 0.2 percentage point. At a 99 percent confidence level, one would expect the actual rate of depreciation to overstep the CI once every 100 months. Therefore, one such deviation during a period of thirty-eight months demonstrates the validity of the CI.

Figure 7: One-Month Forecast using BVAR Model and Confidence Interval before Onset of Intervention



6.2 Static forecast of rate of exchange-rate change during intervention period

One would expect to find the most appreciable effect of the Bank of Israel's intervention in the foreign-exchange market after the Bank's announcements about the onset of intervention or a policy change. To test the spot effect of this intervention, a static forecast of the rate of exchange-rate change was calculated on the basis of the results of the estimation for the 01:2000–02:2008 sample period (one month before the intervention began). The meaning of the calculated forecast is, given the realization of the variables up to period (t) and given the relations among the variables

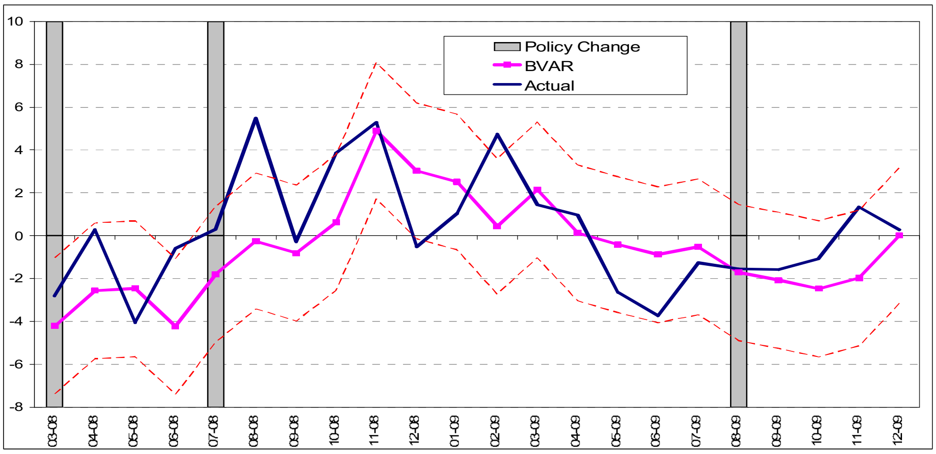
[16] The CI level for the forecast was calculated using the bootstrap method.

[17] The S.D. of the forecast originates in two sources of uncertainty: variance of random errors and variance of estimated parameters. For technical reasons, the CI was calculated only according to error variance. However, estimation of the VAR model using the OLS method and calculation of the CI according to both sources of the S.D. yield basically the same results.

before the intervention began, what the exchange rate in period ($t + 1$) according to the BVAR model should be.[18]

The static forecast for the rate of depreciation during the intervention period, the CI for the forecast, and the actual rate of exchange-rate change are shown in Figure 8. The rate of deviation of actual depreciation from the CI in months in which a deviation was recorded is shown in Table 4. Since the CI was calculated to a 99 percent confidence level, deviations of the actual rate of depreciation from the CI very probably do not trace to the Standard Deviation of the forecast. By studying the results, one may see that during the intervention period, the actual rate of depreciation overstepped the CI six times, five of which an upward direction. The largest deviation was recorded in August 2008, after the Bank of Israel announced the intensification of its intervention in the foreign-exchange market.[19] That month, depreciation occurred at a strength that was 2.6 percentage points above the upper bound of the CI—a much larger deviation than in any observation checked before the purchases began. Additional major deviations took place in June 2008 and February 2009, even though these months did not coincide with policy change. From August 2009 onward, after the Bank of Israel shifted to ad hoc purchases of foreign currency, the actual rate of depreciation overshot the predicted rate each month until December 2009. In November 2009, the actual rate of depreciation even overshot the upper bound of the CI, albeit mildly.

Figure 8: Static Forecast Based on BVAR Model and CI during Intervention Period



[18] We also produced a forecast of the rate of depreciation during the intervention period by updating the sample period and calculating a forecast to one month ahead; this procedure elicited similar results. However, calculating the forecast by updating the sample period is problematic because the estimations pertain to a sample period that includes a visceral intervention in the foreign-exchange market.

[19] In the second half of July 2008, after the foreign-currency purchases were increased in size, considerable depreciation occurred (as shown in Appendix F). Since the BVAR model was formulated for an average rate of exchange-rate change, the depreciation was manifested in August 2008 due to end effects.

Table 4: Deviation of Actual Depreciation from CI during Intervention Period

(Positive value=overshoot)

Month	Deviation (percentage points)
06:2008	0.5
08:2008	2.6
10:2008	0.1
12:2008	–0.4
02:2009	1.1
11:2009	0.1

6.3 Sensitivity tests for static forecast of rate of depreciation during intervention period

The Bank of Israel's intervention in the foreign-exchange market took place, as stated, against the background of a grave global crisis, foremost between September 2008 and March 2009. Table 4 shows that the actual rate of depreciation deviated from the CI four times during these months. The global crisis may have affected the NIS/US$ exchange rate via the financial-risk mechanism, as described in Section 5. Similarly, the effect of the strength of the US$ abroad on the NIS/US$ exchange rate may have changed during the crisis. To determine whether it is reasonable to "charge" the overstepping of the CI by actual depreciation rate to these scenarios, sensitivity tests similar to those described in Section 5 were performed. To test the effect of the financial-risk mechanism, the rate of US$ depreciation against emerging-market currencies was added to the model. The model was re-estimated for the 01:2000–02:2008 period and a static forecast and a CI for the intervention period were calculated. To test the sensitivity of the forecast to the US$ cross-rate coefficient in the exchange-rate equation, the coefficient was calibrated to the value obtained in the estimation, ± 0.2. (The cross-rate coefficient obtained in the estimation was 0.65.)

The results of the sensitivity tests are shown in Figures 9–11. One may see that the sensitivity tests for the cross-rate coefficient in the exchange-rate equation do not induce meaningful change in the predicted rate of exchange-rate change or in the deviations of the actual rate of depreciation from the CI. In contrast, when we added to the model the US$ exchange rate against the emerging-market currencies as an exogenous variable, we obtained differences relative to the baseline forecast. The inclusion of the financial-risk mechanism resulted in considerable narrowing of the CI overshoot that occurred in February 2009, and the rate of depreciation in October 2008 and November 2009 returned to the CI. However, even after the financial-risk mechanism was included in the model, the deviation of the rate of depreciation from the CI in August 2008 was almost unchanged. Similarly, the overshooting of the actual rate of depreciation from the CI and the undershooting of the same in December 2008 persisted in all sensitivity tests performed.

Figure 9: Insertion of Cross-Rate Coefficient to (0.2+0.65)

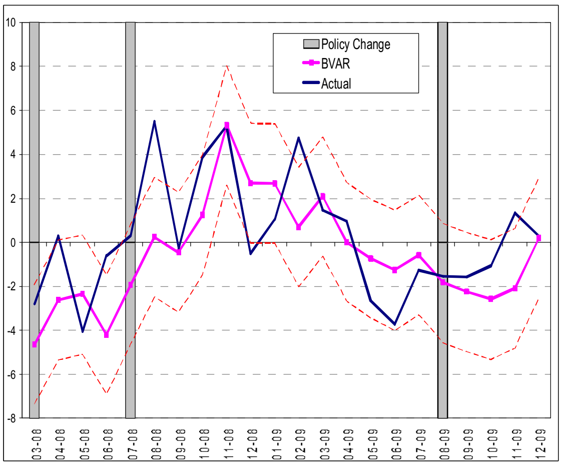


Figure 10: Insertion of Cross-Rate Coefficient to (–0.2)

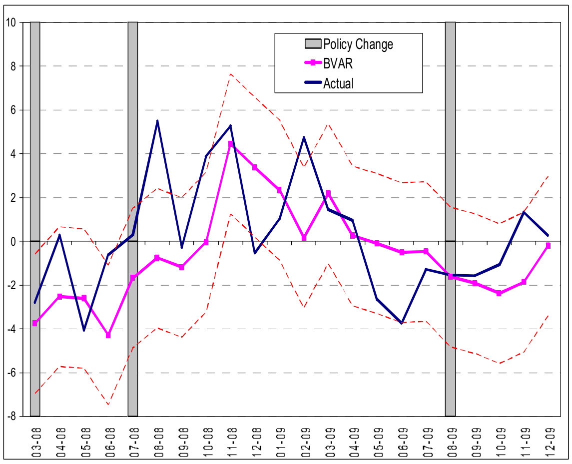
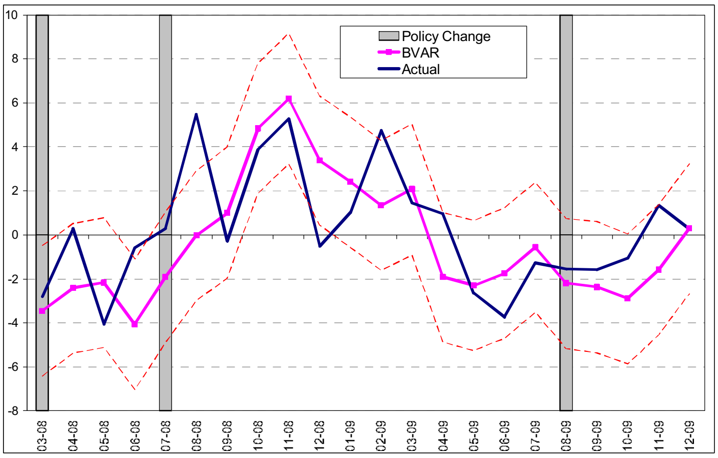


Figure 11: Addition of US$ Exchange Rate against Emerging-Market Currencies as Exogenous Variable in Model



The tests described above indicate that the rate of exchange-rate change deviated sharply from the predicted rate in August 2009—the largest deviation among all observations during the period of Bank of Israel intervention and also among all observations checked in the past. Furthermore, the deviation is not explained by any of the sensitivity tests performed. Given that this major deviation followed the expansion of the Bank of Israel's intervention in the foreign-exchange market and is not explained by additional factors, one may by inference trace the steep depreciation that month to the foreign-currency purchases.

In December 2008, the actual rate of depreciation undershot the CI according to the baseline forecast and according to all sensitivity tests performed. This deviation may attest to a decrease in the effect of the Bank of Israel's intervention and the elimination of the spread between the actual exchange rate and the rate that would prevail had no intervention taken place.

After the Bank of Israel shifted to ad hoc purchases of foreign currency in August 2009, the actual rate of depreciation was found to exceed the predicted one in every subsequent month according to all sensitivity tests performed.

7. Additional exchange-rate prediction models

This section presents NIS/US$ exchange-rate forecasts as calculated on the basis of additional models. The forecasts that these models—structural models—generated for the review period are superior to those based on a RW model (as shown below). However, the exchange-rate dynamic in these models is based on the UIP principle, which according to various studies does not stand up in the long run (Meredith and Chinn, 1998). Furthermore, the structural models lack elasticity to the sensitivity tests that were performed for the BVAR model and described above. The purpose of testing exchange-rate forecasts that are based on these models is to determine whether the result elicited by models that include structural relations among the variables is consistent with that generated by the BVAR model, according to which the actual exchange rate reflected depreciation relative to its predicted level during the intervention period. The models are differentiated in scope, level of complexity, and the mechanism used to determine the exchange rate. They also differ in frequency of data and estimation methods. The vast importance of using a range of models is that this rules out the possibility of attributing the findings to a characteristic or assumption of any particular model.

Three additional models were invoked to generate exchange-rate forecasts: a monthly structural model (MSM) based on Ilek (2006) an "error-correction" (EC) model based on Barnea and Djivre (2004), and a quarterly structural model (QSM) based on Argov et al. (2006).

The MSM is composed of several structural equations based on neo-Keynesian principles. It has five main endogenous variables: exchange rate, Bank of Israel rate, output gap, inflation expectations to one year ahead, and core-inflation rate. The model was formulated for the NIS/US$ exchange rate and its exchange-rate equation was based on the UIP theory and the assumption that some of the public's expectations of exchange-rate developments are adaptive (based on past exchange-rate developments). Each equation in the model was estimated separately, using different methods. The exchange-rate equation was estimated using GMM for the 01:1998–07:2006 sample period.

The EC model includes several long-term equations of which the residuals serve as an error-correction component of the short-term equations. As for the short term, the EC model has several main endogenous variables, like the MSM, and was formulated for the real exchange rate. The real exchange-rate equation is based on the UIP theory and on an equation that describes the deficit on balance-of-payments current account. Therefore, at equilibrium and under a floating exchange-rate regime, capital inflow is equal to the current-account deficit. By using the real exchange rate, domestic inflation, and global inflation, one may calculate the NIS/US$ exchange rate by applying the PPP (purchasing power parity) principle. The model was estimated as a system of equations using the three-stage least-squares (3SLS) method and quarterly data. The sample period begins in Q4:1997.

The QSM is a small neo-Keynesian model that was formulated for the Israeli economy and is composed of four main equations—output gap, inflation, exchange rate, and Bank of Israel interest rate. Since the model was formulated for Israel's nominal effective exchange rate, the forecasts obtained by performing the simulations are for this exchange rate. By using the US$ effective exchange rate, which reflects the strength of the American currency abroad, one may derive an NIS/US$ exchange-rate forecast. The exchange-rate equation is based on the UIP principle and the assumption that exchange-rate expectations are rational with partial adjustment (a proposition similar to that of the MSM). The model was estimated by GMM, each equation separately, considering the Q3:1997–Q4:2005 sample period for the exchange-rate equation, and considering the Q1:1992–Q2:2006 period for the other equations.

7.1 Testing the quality of out-of-period model forecasts

This subsection presents the outcomes of the quality tests for forecasts out of the sample period of the structural models—MSM, EC, and QSM—and for the SVAR model, a model structured like the BVAR model but estimated using the OLS method equation by equation (much as in Azoulay and Ribon, 2009). Although the SVAR model and the BVAR are similarly structured, the use of different estimation methods yields slightly different results; therefore, the exchange-rate forecasts generated by this model should be reported here.

To estimate the quality of the out-of-period forecasts of the models presented above, a test similar to that performed for the BVAR model was invoked. For each model, a dynamic simulation was performed for all endogenous variables in the model, using the actual values of the exogenous variables. The simulations pertained to a "rolling" sample period. For the monthly models, the simulation began in each month between June 2006 and February 2008; for the quarterly models, the starting point was each quarter between Q3:2006 and Q1:2008.[20] The simulation period was twelve months long (or five quarters in the quarterly models) or up to one period before the onset of Bank of Israel intervention in the foreign-exchange market. The EC and SVAR models were estimated before each simulation and the endpoint of the estimation sample was one period before the beginning of the simulation. For the MSM and QSM models, the parameters shown in Ilek (2006) and Argov et al. (2006) were used.

The RMSE values obtained for the forecasts of the various models, together with the RMSE values for the forecasts according to RW, are shown in Table 5. (The members in parentheses denote the number of observations used in calculating the RMSE value.) The table shows that the results of the models to the various forecast horizons are superior to those obtained by RW. This finding, as stated, contrasts with the mainstream literature on model-generated exchange-rate forecasts.

Table 5: RMSE Values Obtained from Model Forecasts

Horizon-Month (N_k) \ Model	MSM	SVAR	RW
1 (21)	**2.01**	**2.01**	2.16
3 (19)	**3.61**	4.01	4.32
6 (16)	**3.75**	4.92	6.09
9 (13)	**2.70**	5.69	6.53
12 (10)	**2.45**	7.04	8.77

Horizon-Month (N_k) \ Model	EC	QSM	RW
1 (7)	**2.45**	3.58	4.39
2 (6)	**3.86**	5.48	6.57
3 (5)	**4.55**	6.89	7.17
4 (4)	**4.71**	7.70	9.39
5 (3)	**4.63**	8.22	11.06

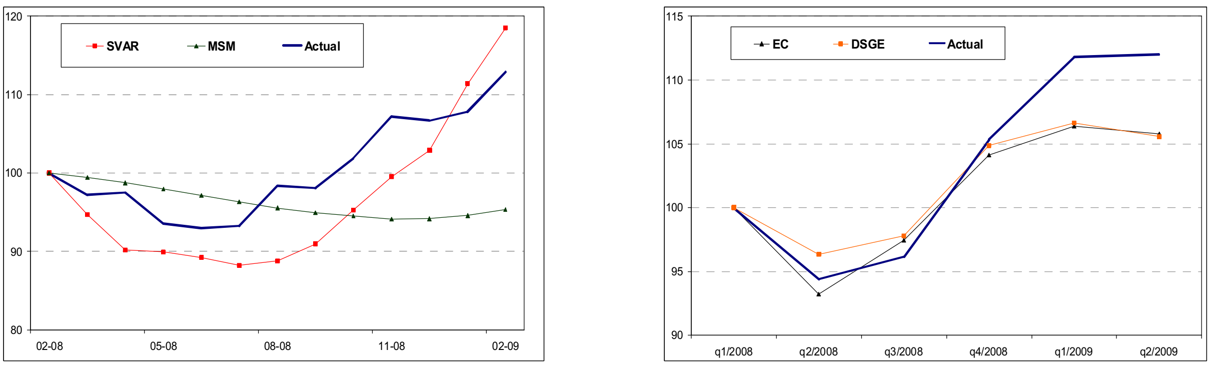
[20] As noted, the endpoint of the estimation sample period of the MSM and QSM models was the second half of 2006. Therefore, to test the quality of the forecast out of the sample period, the simulations were performed for the period starting in the second half of 2006.

7.2 Model-generated forecasts during the foreign-currency purchase period

The model-generated forecasts for the level of the NIS/US$ exchange rates during the period of Bank of Israel intervention in the foreign-exchange market[21] are shown in Figure 12. One may see that after nine months (three quarters) of foreign-currency purchases, the forecasts generated by all models undershot the actual exchange rate. Farther on, the forecasts of the structural models continued to undershoot the actual exchange rate consistently, whereas after eleven months of intervention the SVAR-generated forecast overshot the actual exchange rate. The models produced different exchange-rate forecasts due to differences among them and due to different exchange-rate development mechanisms. The forecasts generated by the quarterly models (EC and QSM) predicted NIS depreciation at first but also undershot the actual exchange rate after three quarters. The monthly models failed to capture the steep depreciation that occurred in August 2008 (similar to the BVAR model). In the middle of July 2008, as we recall, the Bank of Israel intensified its intervention in the foreign-exchange market. The combination of steep depreciation in August and the additional monthly models' failure to capture it reinforces the hypothesis that the depreciation was induced by the Bank of Israel's foreign-currency purchases.

Figure 12: Model-Generated Forecasts and Actual Exchange Rate during Intervention Period

02:2008=100 **q1:2008=100**



8. Summary and conclusions

This study examined the effect of the Bank of Israel's intervention in the foreign-exchange market on the nominal NIS/US$ exchange rate. To estimate the effect, several tests based on comparing exchange-rate forecasts with the actual exchange rate were performed. The principal advantage of this method is that it obviates the need for estimation during a sample period that includes Bank of

[21] The Bank of Israel's intervention in this market began at the end of March 2008, meaning that there was no intervention in most of the first quarter of that year. Accordingly, the first quarter was included in the non-intervention period.

Israel intervention in the foreign-exchange market—an estimation that encounters several econometric problems. The principal model used to calculate the exchange-rate forecast was an unrestricted VAR model using the Bayesian method. First, before comparing the model-generated forecast with the actual exchange rate, we tested the quality of the former and found that the model generates reasonably good forecasts both within the sample period and outside of it. In particular we found, in contrast to other studies, that its out-of-sample forecasts surpassed the quality of forecasts produced by a random-walk procedure. We also tested the quality of the model-generated forecasts on the rate of change in the exchange rate one month ahead and found that among thirty-eight observations, the actual rate of depreciation deviated from the confidence interval only once.

The first test performed to gauge the effects of the Bank of Israel's intervention on the exchange rate was the calculation of a dynamic forecast for the exchange rate and a comparison of the result with the actual exchange rate during the intervention period. The findings show that after points where the Bank of Israel changed its policy in the foreign-exchange market, the actual exchange rate reflected stronger depreciation than that predicted by the model. In particular, in August 2008, after the Bank of Israel strongly increased the size of its foreign-currency purchases, there was a steep depreciation that the model failed to predict, the actual exchange rate deviating from its predicted level by 10.5 percent. Farther on, the disparity between the actual and the predicted exchange rates began to narrow, and in the first half of 2009 the actual rate matched the predicted rate in the absence of intervention. These results also withstood sensitivity tests to the exchange-rate forecast according to the BVAR model.

The next test was the calculation of a static forecast and a confidence interval for the rate of exchange-rate change. The findings show that the actual exchange rate overshot the confidence interval five times during the period of Bank of Israel intervention in the foreign-exchange market. The largest deviation was in August 2008, after the Bank intensified its foreign-currency purchases—an outcome that also passed the various sensitivity tests. It was also found that after the Bank of Israel went over to ad hoc purchases of foreign currency, in August 2009, the actual rate of depreciation was consistently steeper than the rate predicted by the model.

Finally, exchange-rate forecasts were calculated on the basis of several structural models. The models were differentiated by the mechanism used to set the exchange rate, their scope, the frequency of their data, and their estimation methods. These calculations showed that the actual rate of depreciation surpassed the level predicted by the monthly models after six months of intervention, and did the same according to the quarterly models after three quarters of intervention.

The results of these tests imply that the onset of foreign-currency purchases by the Bank of Israel in March 2008, the changeover to larger purchases in July 2008, and the transition to ad hoc purchases in August 2009 caused the Israeli currency to depreciate. The most significant depreciation was posted in August 2008, after the size of the purchases was increased. The findings also demonstrate that the Bank's influence on the exchange rate began to wane at the end of 2008 and that during the first half of 2009 the actual exchange rate converged with the rate that would be expected in the absence of intervention.

Thus, the various tests in this study elicited a consistent outcome: the NIS depreciated relative to its predicted level during the Bank of Israel's intervention in the foreign-exchange market. This outcome, however, does not explicitly credit the undershooting of the exchange rate relative to its predicted level to the intervention. To make precise identification of the effects of the intervention on the exchange rate possible, it is necessary to formulate and estimate a structural model including a shock to the Bank of Israel's foreign-currency purchases.

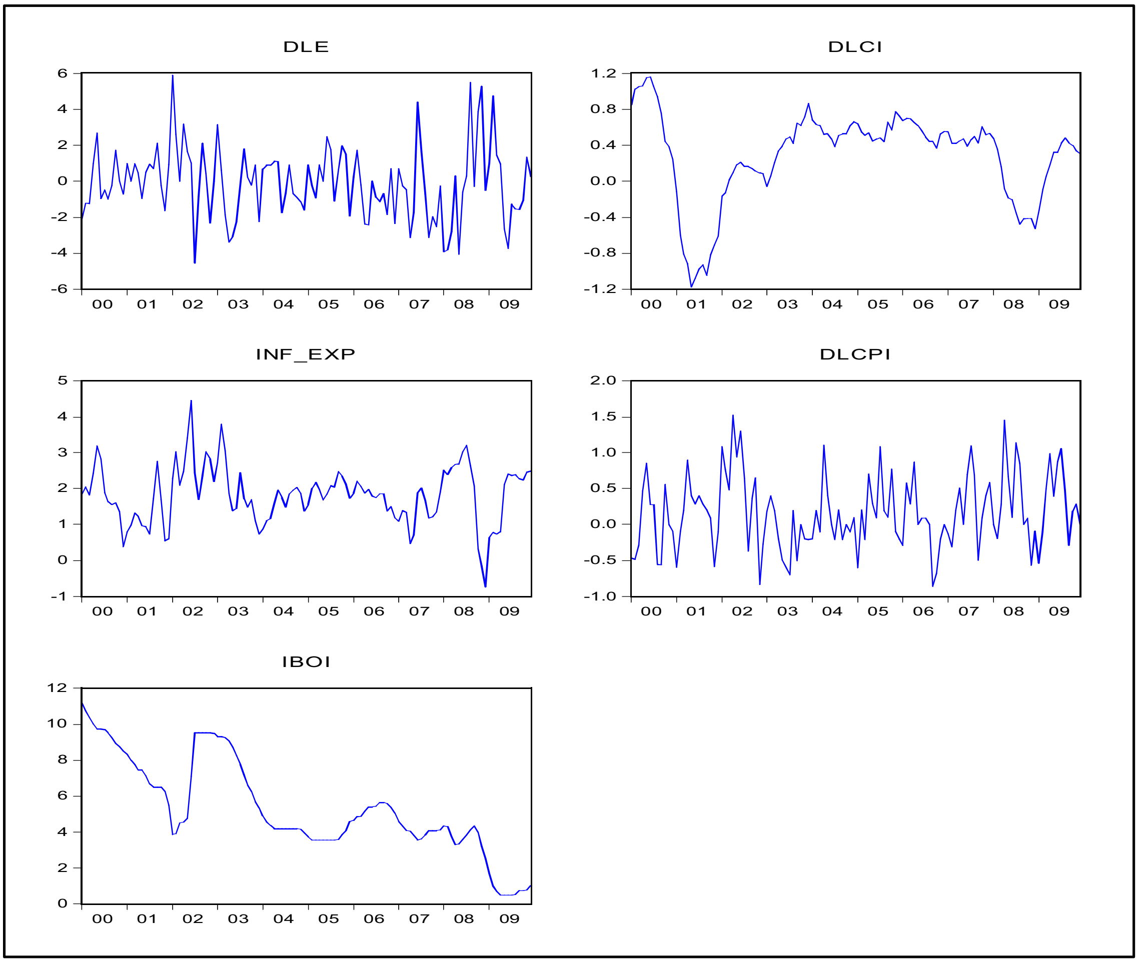
Appendices

A. Foreign-currency purchases by Bank of Israel

Date	Sum ($ millions)	Details
13–14/03/2008	600	
24/03/2008–09/07/2008	25 (daily avg.)	Part of a program designed to increase the foreign reserves to US$ 35–40 billion
10/07/2008–30/11/2008	100 (daily avg.)	Part of the program designed to increase the foreign reserves to US$ 35–40 billion
01/12/2008–25/03/2009	100 (daily avg.)	Part of the program designed to increase the foreign reserves; the reserve target was revised to US$ 40–44 billion
26/03/2009–10/08/2009	100 (daily avg.)	Continuation of daily foreign-currency purchases, with no new reserve targets set
11/08/2009		Change on foreign-currency purchasing policy—changeover to ad hoc purchases
08/2009	4073	Mainly ad hoc purchases
2009/09	1649	Ad hoc purchases
2009/10	1274	Ad hoc purchases
2009/11	0	
2009/12	132	Ad hoc purchases

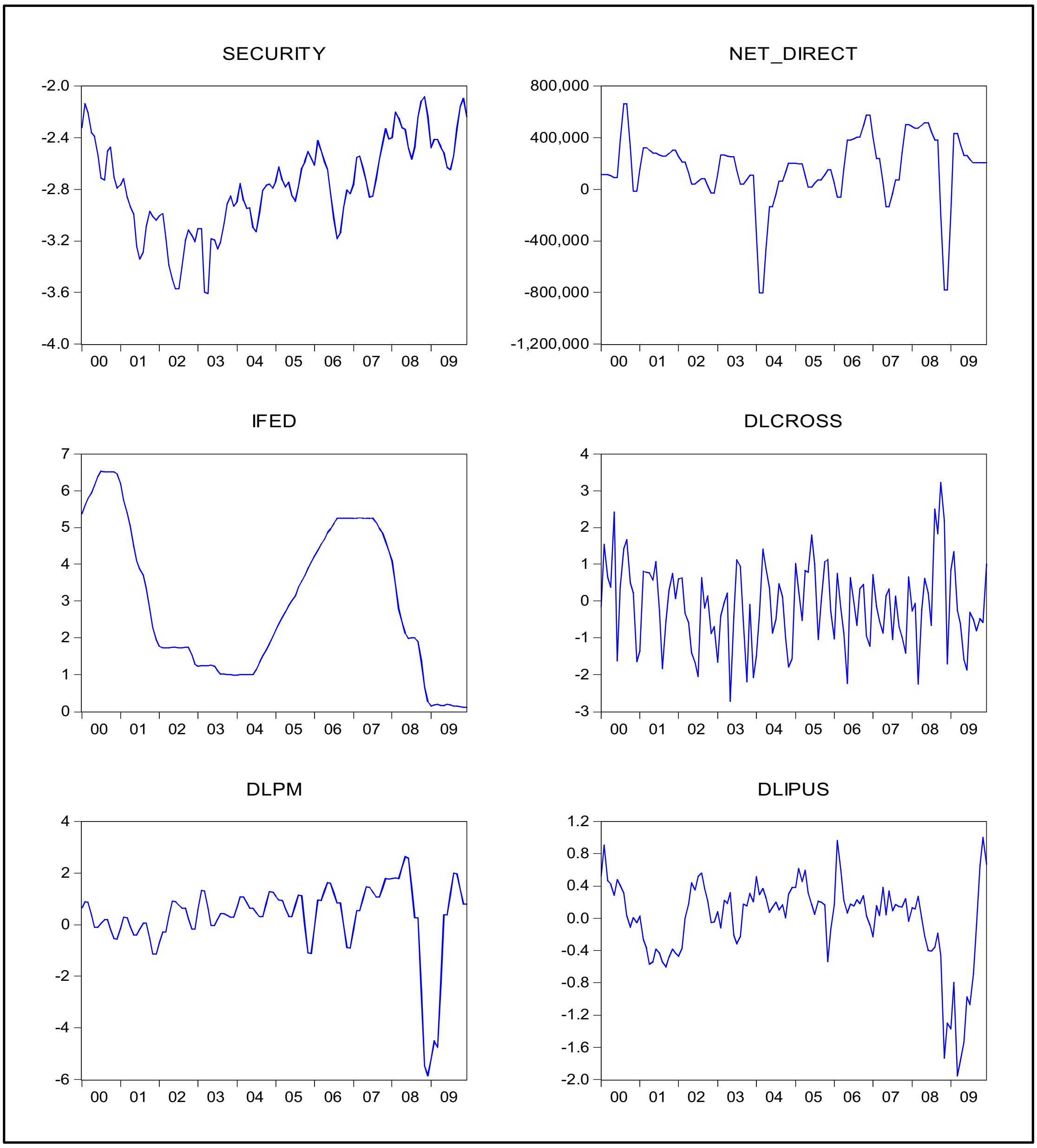
B. *Description of BVAR-model data in 01:2000–02:2009 period*

Endogenous variables:



	DLE	DLCI	INF_EXP	DLCPI
Mean	-0.08	0.28	1.82	0.17
Median	-0.22	0.43	1.86	0.10
Maximum	5.90	1.16	4.46	1.52
Minimum	-4.56	-1.18	-0.73	-0.86
Std. Dev.	2.00	0.50	0.79	0.51
Skewness	0.43	-1.05	-0.01	0.37
Kurtosis	3.62	3.74	3.96	2.73

Exogenous variables



	SECURITY	NET_DIRECT	IFED	DLCROSS	DLPM
Mean	–2.77	161305	2.98	–0.10	0.29
Median	–2.76	199041	2.42	–0.12	0.50
Maximum	–2.08	664679	6.54	3.22	2.64
Minimum	–3.61	–800728	0.12	–2.71	–5.86
Std. Dev.	0.36	265693	2.00	1.12	1.43
Skewness	–0.22	–1.42	0.25	0.11	–2.33
Kurtosis	2.53	6.70	1.69	2.96	10.00

C. *Choice of Prior for Bayesian estimation of BVAR model*

To formulate the prior for the Bayesian estimation, the Minnesota Prior Algorithm (Duan, Litterman, and Sims, 1984) was used. The original proposition according to this Prior is a random-walk model. Since the variables in the model estimated are stationary, we used a non-RW Prior, much as in Segal (2010).

The prior for the first moment of the first own lag in each equation in the model was chosen as follows:

DLCI	0.8
DLE	0.0
INF–EXP	0.5
DLCPI	0.0
IBOI	0.9

In accordance with the Minnesota Prior, the prior for the S.D. for the coefficient of variable *j* at lag *k* in Equation *i* was set as follows:

$$\sigma_{i,j,k} = \lambda \omega(i,j) k^{-\phi} \left(\frac{\hat{\sigma}_i}{\hat{\sigma}_j} \right),$$

where:

λ prior for S.D. of own-lag coefficient;

$\omega(i,j)$ prior for S.D. of coefficient of variable *j* in Equation *i*;

ø a parameter that affects the decline of the prior to the S.D. commensurate with increase in number of lags;

$\left(\frac{\hat{\sigma}_i}{\hat{\sigma}_j} \right)$ an expression that normalizes the various units of the variables.

The prior used in the estimation is the following:

$\lambda = 0.1,$

$\phi = 1,$

$$\omega(i,j) = \left\{ \begin{array}{ccccc} DLCI & DLE & INF\_EXP & DLCPI & IBOI \\ \hline 1 & 0.2 & 0.6 & 0.2 & 0.2 \\ 0.2 & 1 & 0.5 & 0.5 & 0.5 \\ 0.2 & 0.5 & 1 & 0.5 & 0.5 \\ 0.1 & 0.7 & 0.5 & 1 & 0.5 \\ 0.1 & 0.5 & 0.6 & 0.2 & 1 \end{array} \right\}.$$

When the value of $\omega(i,j)$ is high and outside the diagonal, variable *j* is more important than the additional variables in Equation *i*.

D. Results of BVAR model estimation for 01:2000–02: 2008 sample period

Exchange rate equation—DLE

Variable	Coefficient	t-statistic	t-probability
DLCI (t-1)	0.511	0.574	0.567
DLCI (t-2)	0.884	1.050	0.296
DLCI (t-3)	-0.463	-0.747	0.457
DLCI (t-4)	-0.502	-1.059	0.292
DLCI (t-5)	-0.188	-0.493	0.623
DLCI (t-6)	-0.256	-0.812	0.419
DLE (t-1)	0.233	2.026	0.046
DLE (t-2)	-0.005	-0.044	0.965
DLE (t-3)	0.038	0.370	0.712
DLE (t-4)	0.066	0.724	0.471
DLE (t-5)	0.031	0.378	0.706
DLE (t-6)	-0.173	-2.182	0.032
INF-EXP (t-1)	-0.133	-0.379	0.706
INF-EXP (t-2)	-0.434	-1.140	0.257
INF-EXP (t-3)	0.290	0.964	0.337
INF-EXP (t-4)	0.117	0.486	0.628
INF-EXP (t-5)	-0.190	-0.913	0.363
INF-EXP (t-6)	0.182	1.036	0.303
DLCPI (t-1)	-0.604	-1.616	0.109
DLCPI (t-2)	-0.680	-1.989	0.050
DLCPI (t-3)	0.088	0.312	0.756
DLCPI (t-4)	-0.131	-0.550	0.584
DLCPI (t-5)	-0.067	-0.305	0.761
DLCPI (t-6)	0.082	0.452	0.652
IBOI (t-1)	-0.453	-1.019	0.311
IBOI (t-2)	0.519	0.949	0.345
IBOI (t-3)	-0.174	-0.412	0.681
IBOI (t-4)	-0.123	-0.361	0.719
IBOI (t-5)	-0.013	-0.048	0.961
IBOI (t-6)	-0.065	-0.320	0.750
TARGET	1.325	2.154	0.034
DLIPUS	-0.865	-1.122	0.265
DLPM	0.150	0.505	0.615
DLCROSS	0.653	4.905	0.000
IFED	0.118	0.925	0.357
NET_DIRECT	0.000	-2.832	0.006
SECURITY	-2.181	-3.165	0.002
D4	-0.110	-0.215	0.830
D9	0.029	0.060	0.952
Constant	-6.999	-2.644	0.010
R-squared	0.58		
Adjusted R-squared	0.30		

Growth in composite index equation—DLCI

Variable	Coefficient	t-statistic	t-probability
DLCI (t-1)	0.945	9.530	0.000
DLCI (t-2)	0.094	0.743	0.460
DLCI (t-3)	0.075	0.629	0.531
DLCI (t-4)	-0.250	-2.333	0.022
DLCI (t-5)	-0.055	-0.553	0.582
DLCI (t-6)	0.041	0.551	0.583
DLE (t-1)	-0.002	-0.320	0.749
DLE (t-2)	-0.002	-0.346	0.730
DLE (t-3)	-0.002	-0.487	0.627
DLE (t-4)	0.000	-0.033	0.974
DLE (t-5)	-0.001	-0.404	0.687
DLE (t-6)	0.000	0.033	0.974
INF-EXP (t-1)	-0.002	-0.061	0.952
INF-EXP (t-2)	0.064	2.230	0.028
INF-EXP (t-3)	-0.011	-0.458	0.648
INF-EXP (t-4)	0.038	1.929	0.057
INF-EXP (t-5)	0.007	0.441	0.660
INF-EXP (t-6)	-0.006	-0.444	0.658
DLCPI (t-1)	0.030	1.289	0.200
DLCPI (t-2)	-0.005	-0.298	0.766
DLCPI (t-3)	-0.012	-1.037	0.302
DLCPI (t-4)	0.003	0.307	0.759
DLCPI (t-5)	0.000	0.036	0.971
DLCPI (t-6)	0.000	0.033	0.973
IBOI (t-1)	-0.040	-1.677	0.097
IBOI (t-2)	0.014	0.615	0.540
IBOI (t-3)	0.007	0.449	0.654
IBOI (t-4)	0.002	0.198	0.844
IBOI (t-5)	0.007	0.698	0.487
IBOI (t-6)	0.005	0.668	0.506
TARGET	-0.075	-1.793	0.076
DLIPUS	0.058	1.009	0.315
DLPM	-0.024	-1.154	0.251
DLCROSS	0.008	0.815	0.417
IFED	0.002	0.226	0.821
NET_DIRECT	0.000	-0.606	0.546
SECURITY	0.069	1.359	0.177
D4	0.027	0.697	0.488
D9	0.036	1.011	0.315
constant	0.269	1.430	0.156
R-squared	0.97		
Adjusted R-squared	0.95		

Inflation expectations equation—INF_EXP

Variable	Coefficient	t-statistic	t-probability
DLCI (t-1)	0.190	0.659	0.511
DLCI (t-2)	0.231	0.849	0.398
DLCI (t-3)	-0.053	-0.267	0.790
DLCI (t-4)	-0.178	-1.167	0.246
DLCI (t-5)	-0.054	-0.442	0.660
DLCI (t-6)	-0.080	-0.787	0.433
DLE (t-1)	0.044	1.202	0.232
DLE (t-2)	0.010	0.321	0.749
DLE (t-3)	-0.017	-0.635	0.527
DLE (t-4)	0.004	0.165	0.869
DLE (t-5)	0.006	0.304	0.762
DLE (t-6)	-0.006	-0.368	0.714
INF-EXP (t-1)	0.749	6.277	0.000
INF-EXP (t-2)	-0.447	-3.029	0.003
INF-EXP (t-3)	0.257	1.972	0.051
INF-EXP (t-4)	0.117	1.058	0.293
INF-EXP (t-5)	-0.094	-0.962	0.338
INF-EXP (t-6)	0.055	0.676	0.501
DLCPI (t-1)	0.135	1.123	0.264
DLCPI (t-2)	0.013	0.121	0.904
DLCPI (t-3)	-0.034	-0.378	0.706
DLCPI (t-4)	0.057	0.744	0.459
DLCPI (t-5)	0.031	0.448	0.655
DLCPI (t-6)	0.045	0.762	0.448
IBOI (t-1)	-0.176	-1.231	0.221
IBOI (t-2)	0.237	1.351	0.180
IBOI (t-3)	-0.027	-0.201	0.841
IBOI (t-4)	-0.019	-0.171	0.865
IBOI (t-5)	-0.012	-0.132	0.895
IBOI (t-6)	-0.027	-0.406	0.685
TARGET	0.162	0.828	0.410
DLIPUS	-0.193	-0.781	0.437
DLPM	0.229	2.376	0.019
DLCROSS	0.054	1.268	0.208
IFED	-0.033	-0.797	0.427
NET_DIRECT	0.000	0.547	0.586
SECURITY	-0.214	-0.959	0.340
D4	0.168	1.031	0.305
D9	0.026	0.166	0.868
constant	-0.233	-0.271	0.787
R-squared	0.72		
Adjusted R-squared	0.52		

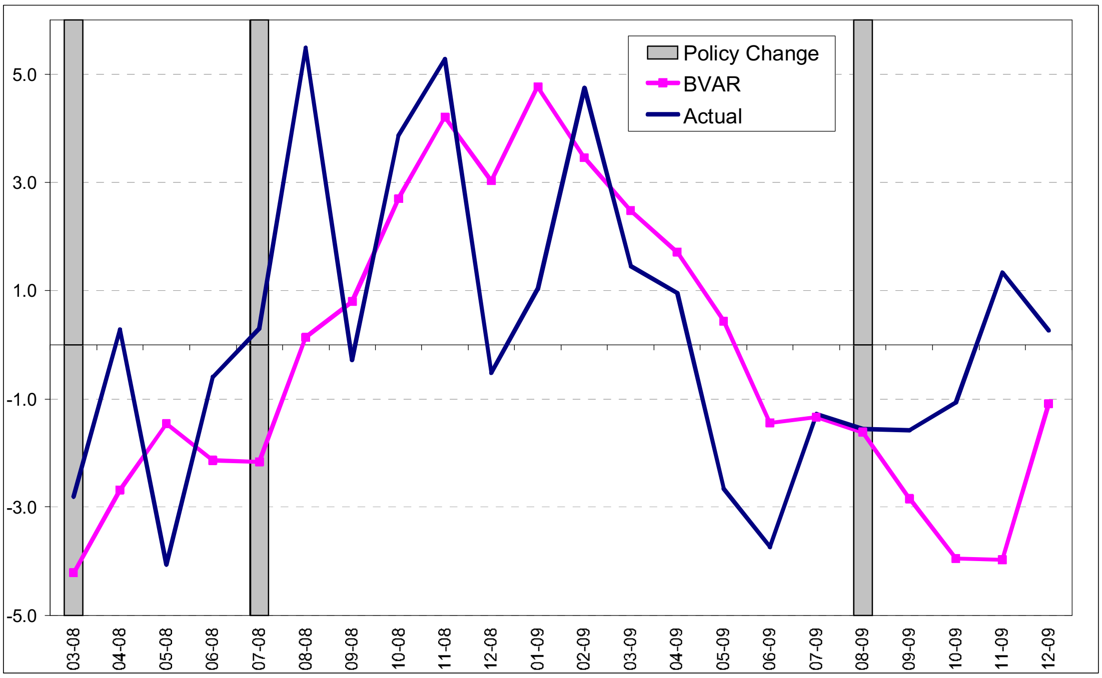
Inflation equation—DLCPI

Variable	Coefficient	t-statistic	t-probability
DLCI (t-1)	0.061	0.413	0.681
DLCI (t-2)	-0.021	-0.186	0.853
DLCI (t-3)	-0.034	-0.421	0.675
DLCI (t-4)	-0.044	-0.715	0.477
DLCI (t-5)	-0.019	-0.388	0.699
DLCI (t-6)	-0.025	-0.603	0.548
DLE (t-1)	0.098	3.508	0.001
DLE (t-2)	-0.018	-0.722	0.472
DLE (t-3)	-0.003	-0.117	0.907
DLE (t-4)	0.017	0.866	0.388
DLE (t-5)	0.013	0.743	0.459
DLE (t-6)	-0.001	-0.069	0.945
INF-EXP (t-1)	0.186	2.148	0.034
INF-EXP (t-2)	-0.170	-1.840	0.069
INF-EXP (t-3)	0.069	0.955	0.342
INF-EXP (t-4)	0.010	0.165	0.870
INF-EXP (t-5)	-0.067	-1.345	0.182
INF-EXP (t-6)	0.010	0.240	0.810
DLCPI (t-1)	-0.036	-0.381	0.704
DLCPI (t-2)	-0.008	-0.080	0.936
DLCPI (t-3)	0.038	0.456	0.650
DLCPI (t-4)	-0.064	-0.837	0.405
DLCPI (t-5)	0.055	0.694	0.489
DLCPI (t-6)	-0.032	-0.476	0.635
IBOI (t-1)	-0.021	-0.196	0.845
IBOI (t-2)	0.031	0.233	0.816
IBOI (t-3)	0.006	0.055	0.956
IBOI (t-4)	-0.097	-1.177	0.242
IBOI (t-5)	-0.046	-0.678	0.499
IBOI (t-6)	0.049	0.996	0.322
TARGET	0.318	2.052	0.043
DLIPUS	-0.167	-0.886	0.378
DLPM	0.192	2.641	0.010
DLCROSS	0.018	0.569	0.571
IFED	0.030	0.977	0.331
NET_DIRECT	0.000	-1.293	0.199
SECURITY	-0.186	-1.098	0.275
D4	0.744	5.928	0.000
D9	-0.447	-3.619	0.000
constant	-0.835	-1.272	0.206
R-squared	0.67		
Adjusted R-squared	0.45		

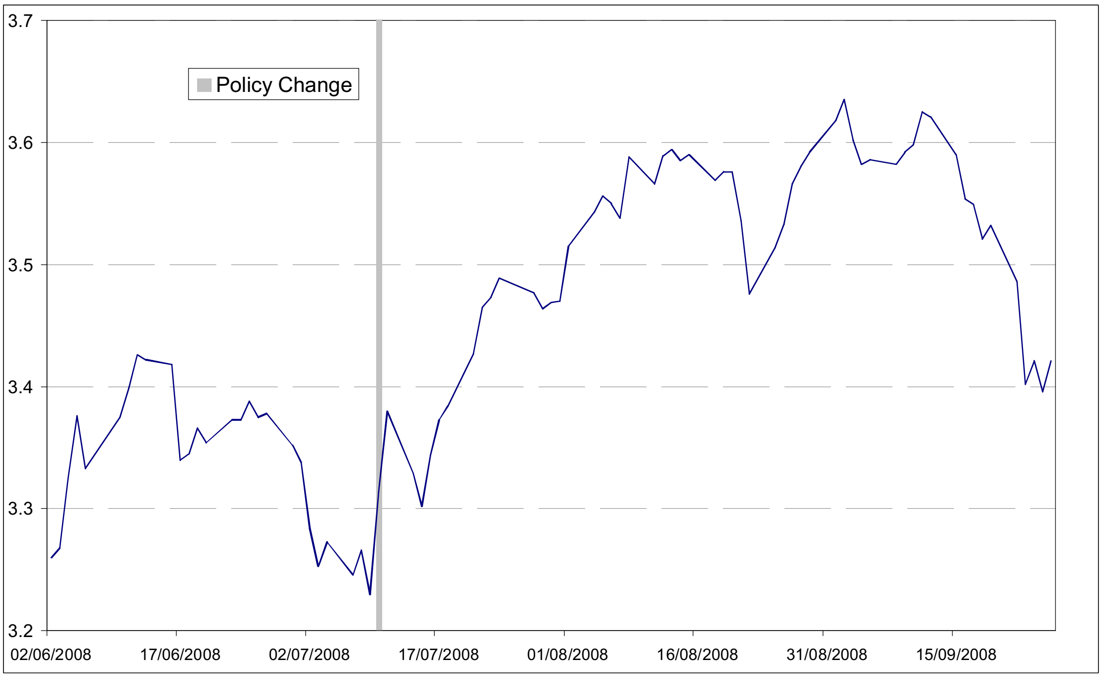
Bank of Israel interest equation—IBOI

Variable	Coefficient	t-statistic	t-probability
DLCI (t-1)	0.001	0.010	0.992
DLCI (t-2)	0.026	0.302	0.763
DLCI (t-3)	0.020	0.328	0.744
DLCI (t-4)	0.015	0.330	0.742
DLCI (t-5)	0.021	0.563	0.575
DLCI (t-6)	0.005	0.160	0.874
DLE (t-1)	0.005	0.249	0.804
DLE (t-2)	-0.004	-0.209	0.835
DLE (t-3)	0.009	0.586	0.559
DLE (t-4)	0.005	0.399	0.691
DLE (t-5)	0.024	2.301	0.024
DLE (t-6)	0.006	0.649	0.518
INF-EXP (t-1)	0.344	5.472	0.000
INF-EXP (t-2)	-0.033	-0.452	0.652
INF-EXP (t-3)	-0.009	-0.149	0.882
INF-EXP (t-4)	-0.058	-1.218	0.226
INF-EXP (t-5)	0.046	1.125	0.264
INF-EXP (t-6)	-0.005	-0.155	0.877
DLCPI (t-1)	-0.009	-0.157	0.876
DLCPI (t-2)	0.045	1.173	0.244
DLCPI (t-3)	0.003	0.093	0.926
DLCPI (t-4)	0.004	0.204	0.839
DLCPI (t-5)	0.008	0.428	0.670
DLCPI (t-6)	0.001	0.034	0.973
IBOI (t-1)	1.220	13.724	0.000
IBOI (t-2)	-0.385	-2.985	0.004
IBOI (t-3)	0.215	1.889	0.062
IBOI (t-4)	-0.097	-0.996	0.322
IBOI (t-5)	-0.143	-1.703	0.092
IBOI (t-6)	0.104	1.946	0.055
TARGET	0.168	1.658	0.101
DLIPUS	-0.035	-0.265	0.792
DLPM	0.043	0.867	0.388
DLCROSS	-0.076	-3.209	0.002
IFED	0.053	2.366	0.020
NET_DIRECT	0.000	-1.095	0.276
SECURITY	-0.315	-2.611	0.010
D4	-0.033	-0.367	0.715
D9	0.023	0.267	0.790
constant	-1.561	-3.447	0.001
R-squared	0.99		
Adjusted R-squared	0.99		

E. *BVAR model forecast for rate of depreciation during intervention period and actual rate*



F. *NIS/US$ exchange rate, daily observations, 06–09:2008*



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