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Interest Rate Differentials in a Small Open Economy – Long Run Relationship, the Israeli Case

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Interest-Rate Differentials in a Small Open Economy—Long-Term Relationships, the Case of Israel*

In this paper we develop a model of uncovered interest-rate parity that assumes risk adverse individuals and takes into account not only the expected interest rate but also exchange-rate risk and the liquidity premium. We estimate the model after the opening of Israel's economy to capital flows, and show that as a long-term relationship, there is parity between the uncovered interest rate spread and the expectations on the change of the exchange rate as derived from the 'long-term' equilibrium relationship of relative purchasing power parity. The interest-rate differential between Israel and the US is also affected by changes in exchange-rate risks, as measured by the standard deviation of dollar options, and by a liquidity premium. In the period of disinflation—up to 2000—the effect of the expected change in the exchange rate on the interest-rate differential was dominant. From 2000 the contribution of the variables that measure the liquidity premium and the exchange-rate-risk premium are the dominant ones in the explanation of the development of the interest-rate differential. Deviations of the interest rate from that derived from the long-term equilibrium apparently lead to a reaction from the Bank of Israel, caused by the pass-through between these deviations and the changes in the exchange rate, that in turn cause deviations in inflation expectations. The process of converging to the long term is estimated to take about eight months.

1. INTRODUCTION

The trend towards globalization has proceeded at an ever faster pace over the last twenty years, and as international trade expanded, so did capital flows between countries. The growth of the global capital market under conditions of free capital movement and floating exchange rates raises the question of what are the factors that affect the long-term interest rate in a small, open economy. On the one hand, the generally accepted theory assumes that in a floating-exchange-rate regime the central bank is more capable of controlling the monetary aggregates, which increases its ability to achieve the inflation targets than under a fixed exchange rate. On the other hand, using the interest rate as an instrument to control the money supply and inflation can be seen as an attempt to influence the price of money in a perfect, competitive market in which the central bank of a small, open economy apparently cannot affect prices. Hence the assumption made in the traditional models—that factors related to the global capital market can be ignored in pursuing monetary policy—is likely to harm financial stability.

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The purpose of this paper is to examine the determination of short term interest rates in a small open economy, subject to long-run economic relationships. In economics the long run is defined as the period in which those basic relationships between variables derived from theories that assume flexible market prices apply. This contrasts with the short run, which might show rigidities and friction in the different markets. We assume, in line with the models of "overshooting" (Dornbusch, 1980), that the greater the deviation in values of economic variables in the short run from their basic (long-term) values, the larger and more severe will be the correction. Severe adjustments are likely to cause financial crises. As the main objective of the central bank's reaction function is dealing with short-term deviations from long-term equilibrium values (long-run targets), understanding long-term relationships is also important for directing short-term policy so as to avoid excessive deviations from long-term equilibrium values.

The point of departure for the paper is the existence in the long run of two classic behavioral equations: the first is the relative purchasing power parity (PPP) equation, which states that a change in the exchange rate is equal to the difference between the inflation rates in two economies. The second is the uncovered interest rates parity equation, according to which the difference between interest rates in two economies is equal to the expected depreciation of the domestic currency against the currency of the other economy. Most studies on the uncovered interest rates parity estimated for industrialized countries also examine the unbiasedness hypothesis that assumes risk-neutral individuals and a zero or constant risk premium. In this study we develop a spread equation[1] which assumes risk-averse individuals. Thus, in addition to expected depreciation, the various risk premiums that affect the spread must also be taken into account—i.e. exchange-rate risk premium and country-risk premium. Apart from these, we also directly add into the model a liquidity premium that derives from the difference in liquidity between the bond market in the US and that in Israel. In the *makam*[2] market several changes took place in the period under review, related to its degree of liquidity: progress was made towards the removal of the restrictions on the Bank of Israel's issue of *makam*, in a disinflation process which boosted the demand for local-currency (unindexed) bonds. We consider our model to be appropriate mainly for emerging markets in a disinflation period or exposed to exchange-rate and liquidity crises.

We first examined the purchasing power parity relationship for the years 1996–2005. We cannot reject the hypothesis that the change in the future NIS/$ exchange rate is related in the long run to the expected differences in inflation between Israel and the US. Hence, the expected difference in inflation can be used as an estimate of the change in the future exchange rate. The next stage was to use this estimate in the estimation of the equation for the spread between one-year *makam* and one-year US Treasury bills. The spread equation also included the implied volatility of dollar options, which reflects the exchange-rate risk premium, and also the liquidity index of

[1] The research literature on the subject deals with uncovered interest rate parity. In Israel the term normally used is yield, and that is the term used in this paper.
[2] Short-term bills issued by the Bank of Israel for purposes of monetary management.

the *makam* market. The results of the estimation show that we cannot reject the hypothesis that in the long run the yield on one-year *makam* is determined according to *expectations* regarding the fundamentals. This is in line with basic economic theory as well as the rational expectations approach. Statistically, a short-term shock causes a deviation of the spread for a duration of about 8 months.

The final step was to estimate the speed of the Bank of Israel's interest rate reaction to deviations from the long-term equilibrium that resulted from shocks reflected in the spread equation. This estimate does not directly examine the claim that the Bank of Israel monitored these deviations and reacted directly; it is a reduced form examination of the reaction function only. The initial findings indicate that a distinction can be made between two policy regimes: in the period of disinflation, the Bank of Israel's interest rate reacted within about eight months to deviations arising from the spread equation, whereas after the year 2000 the hypothesis that reaction was slower cannot be rejected.

This study is in line with many others that examined the long-term purchasing power parity relationships. Many studies refute purchasing power parity, while others can not reject it. In a summary of the research, Sarano and Taylor (2002) found that most of the studies carried out in the last few years support the existence of long-term purchasing power parity between industrialized economies. Nevertheless, further research is needed to explain the short-run dynamics and the processes of convergence to long-term equilibrium.

The literature on interest-rate parity is extensive. In a survey of this field, Froot and Thaler (1990) found that it was not possible to empirically accept uncovered interest-rate parity (UIP). One of the problems of the empirical tests is that the interest rates demonstrate a stochastic random walk process (with unit root), and therefore must be examined empirically by cointegration tests. Siklos and Granger (1997) claim that one should differentiate between different exchange-rate regimes and central bank monetary policies. In examining uncovered interest-rate parity between the US and Canada they show that when the same monetary policy prevails in two countries then one can find a cointegration relationship between the interest rates of the two economies. Kanioura and Turner (2005) claim that the Engle and Granger cointegration tests tend to reject cointegration for UIP. By using the F test they suggest that one can find cointegration between UK and US interest rates.

Another approach in the empirical literature on interest-rate parity focuses on estimating the relationship using longer-term interest rates than those estimated by earlier studies, while using various definitions of bonds (zero coupon and bonds with the same average term to maturity) and instrumental variables (Alexius, 2001). Chinn and Meredith (2004) also estimate a cointegration equation of long-term bond interest rates (with average terms to maturity of 5 years) and show that uncovered interest-rate parity cannot be rejected.

One of the major problems in finding a link between prices of financial assets (interest rates, exchange rates etc.) and fundamental variables in the economy is the fact that most assets exhibit random walk behavior, expressed statistically by a unit root I(1) as expected by finance theory, while economic variables are supposed to express equilibrium values (convergence). So for example, in a world of price stability, purchasing power parity will also decree stability in exchange rates (stationarity). On the other hand, the exchange rate is supposed to exhibit random walk behavior (unit root). In a new study, Engel and West (2005) attempted to overcome this problem. The solution to this paradox was not unique: the macroeconomic variables may have unit roots (there is no fast convergence to equilibrium), shocks may also have unit roots (that is, they do not behave according to the assumptions of the classic regression model), and the subjective discount rate nears unity. Even though the findings of this study are not strong, the authors do not reject the hypothesis that the fundamentals are linked to the exchange rate and call for further research along these lines. We hope that our paper supports the basic approach of Engel and West (2005).

In Chapter 2, a model is presented derived from the interest-rate parity equation for a small, open economy based on an assumption of individuals being risk averse. Chapter 3 presents the data used for our statistical estimation and Chapter 4 presents the results. In Chapter 5, we analyze empirically the Bank of Israel's response to deviations from the long-run equation as presented in Chapter 2. Chapter 6 presents the summary and conclusions.

2 The Theory

In this section of our paper we derive the interest-rate parity equation for a small, open economy assuming individuals are risk averse and that local and foreign investors show different bias. We also assume differences in liquidity in the financial markets and between developing economies and financial centers.

2.1 Real yields on investments in one-year US Treasury bills and *makam*

We will split investors into two types:

Investor U: An American or Israeli who holds assets in dollars. This investor who invests in one-year US Treasury bills expects a real yield, r_{UU}, equal to the yield on one-year US Treasury bills discounted for the expected US inflation rate:

$$r_{UU} = T_U - \pi_U^e \tag{2.1}$$

This investor can invest in *makam* in Israel and expect a real yield, r_{UI}, equal to yield on *makam* discounted both for the expected depreciation in the NIS against the dollar as well as for the expected US inflation rate:

$$r_{UI} = T_I - e^e - \pi_U^e \tag{2.2}$$

Investor I: An Israeli who invests in *makam* and expects a real yield, r_{II}, equal to the yield on *makam* discounted for expected inflation in Israel:

$$r_{II} = T_I - \pi_I^e \tag{2.3}$$

This investor who invests in a one-year US Treasury bill expects a yield, r_{IU}, equal to the yield on a US Treasury bill plus the depreciation in the NIS against the dollar and discounted for expected inflation in Israel:

$$r_{IU} = T_U + e^e - \pi_I^e \tag{2.4}$$

2.2 Spread desired by the investor

2.2.1 Investors preferences and the utility function

Clearly the utility that the investor receives derives from each of these options is affected by additional factors. Among these factors we can include the uncertainty regarding future flows, the level of the asset's liquidity that determines the premium for its sale, the availability and exposure to information for the investor, the home bias and naturally the way in which the different variables appear in the investor's utility function. In an attempt to study the factors that influence the spread between US Treasury bills and one-year *makam*, we will analyze the expected yields as presented above while combining a framework of the CAPM model.

The utility to the investor is influenced positively by the yield and negatively by the risk associated with the investment, (Dornbusch (1988)):

$$U = u(\overset{(+)}{r}, \overset{(-)}{V}(r)),\ \ U_1' > 0, U_2' < 0$$

The actual yield that the investor will enjoy will be determined by the economic situation at the time of maturity. In order to create a conceptual framework that can be analyzed, we will use the assumption of rational expectations, which states that the expectations of the forecasted variables are the same as the forecasts, and that these follow a normal distribution:

$$\pi_I^e \sim N(\overline{\pi_I^e}, \sigma_{\pi_U^e}),\ e^e \sim N(\overline{e^e}, \sigma_e),\ \pi_U^e \sim N(\overline{\pi_U^e}, \sigma_{\pi_U^e})$$

The values inside the parentheses are parameters.

2.2.2 Calculating the spread desired by the investor whose assets are managed in dollars

The yield of the American investor investing in one-year US Treasury bills: $r_{UU} = T_U - \pi_U^e$

The yield of the American investor investing in one-year *makam* in Israel: $r_{UI} = T_I - e^e - \pi_U^e$

So the total yield for the investor is:

$r_U = (1-x) \cdot (T_U - \pi_U^e) + x \cdot (T_I - e^e - \pi_U^e)$
(Where x is the rate of investment in *makam*)

$$\Rightarrow E(r_U) = \overline{r_U} = (1-x) \cdot (T_U - \overline{\pi_U^e}) + x \cdot (T_I - \overline{e^e} - \overline{\pi_U^e} - L_I - \theta - H_U)$$

Let's assume that the liquidity in the US Treasury bill market is full (no financial loss is expected at the time of cashing in an asset due to lack of liquidity in the market) and that there is no country risk. In contrast, investing in bonds in Israel implies an expected loss at the time of asset realization, a loss that comes from the (relatively) low liquidity, L_I , and country risk, θ. (L_I, θ represent the expected loss on the day of realization for the lack of liquidity and the country risk). To these two factors we should add the home bias. The American investor sees the yield on the Israeli market on average as lower, because of his tendency to invest "at home". This factor is represented by H_U. For simplicity we will assume that liquidity, country risk and home bias are known and constant at the time of the decision (for the coming year, the period of investment under question).

$$\Rightarrow V(r_U) = V(\overline{\pi_U^e}) + x^2 \cdot V(\overline{e^e}) + (2x - x^2) \cdot \text{cov}(\overline{e^e}, \overline{\pi_U^e})$$

The investor maximizes utility U by choosing the optimal share of local (American) Treasury bills and Israeli *makam*:

$$U'_x = U'_1 \cdot \left[-(T_U - \pi_U^e) + (T_I - e^e - \pi_U^e - L_I - \theta - H_U)\right] + U'_2 \cdot \left[2x \cdot V(\overline{e^e}) + (2-2x) \cdot \text{cov}(\overline{e^e}, \overline{\pi_U^e})\right] = 0$$

Under the optimal x, the spread between *makam* and US Treasury bills for one year is:

$$\left(T_I - T_U\right)_U = \overline{e^e} + L_I + \theta + H_U - \frac{U'_2}{U'_1} \cdot 2x \cdot V(\overline{e^e}) - \frac{U'_2}{U'_1} \cdot (2-2x) \cdot \text{cov}(\overline{e^e}, \overline{\pi_U^e})$$

From empirical tests, we know that the covariance of inflation in the US and the expected change in the NIS/$ exchange rate is close to zero. Therefore the spread sought by the ‘dollar’ investor is:

$$\left(T_I - T_U\right)_U = \overline{e^e} + L_I + \theta + H_U - \frac{U_2'}{U_1'} \cdot 2x \cdot V(\overline{e^e}) \tag{2.5}$$

The higher the expected depreciation of the NIS, the liquidity premium of the Israeli *makam* market, the country risk and the American investor's home bias, the higher the spread between one-year *makam* and US Treasury bills. The uncertainty in the expected change in the NIS/$ exchange rate also makes a positive contribution to the gap ($U_2'/U_1' < 0$), which stems from the identical influences that the US inflation and the NIS depreciation have on the American investor's real yield.

2.2.3 Calculating the spread sought by the investor whose assets are managed in NIS

Recall that the yield of the Israeli investor investing in one-year US Treasury bills: is $r_{IU} = T_U + e^e - \pi_I^e$

The yield of the Israeli investor investing in one-year *makam* is: $r_{II} = T_I - \pi_I^e$

So the total yield for the Israeli investor is:

$r_I = (1-z) \cdot (T_I - \pi_I^e) + z \cdot (T_U + e^e - \pi_I^e)$
(Where z is the rate of investment in US Treasury bills)

$$\Rightarrow E(r_I) = \overline{r_I} = (1-z) \cdot (T_I - \overline{\pi_I^e} - L_I - \theta) + z \cdot (T_U + \overline{e^e} - \overline{\pi_I^e} - H_I)$$

Following the calculations above, we obtain a gap between the *makam* and treasury yield (see appendix B):

$$\left(T_I - T_U\right)_I = \overline{e^e} + L_I + 2 \cdot \frac{U_2'}{U_1'} \cdot (z-1) \cdot V(\overline{e^e}) + \theta - H_I \tag{2.6}$$

$U_2'/U_1' < 0, (z-1) < 0$

The effect of uncertainty in the exchange rate on the spread is positive; Perhaps it was expected that uncertainty in the exchange rate should have a negative effect on the extra yield sought from *makam* due to the effect this variable has on the utility of investing in US Treasury bills. The explanation for this stems from the effect that domestic inflation has on *makam* yields, the uncertainty of which has a negative effect on the utility of investing in Treasury bills.

2.2.4 Market equilibrium

We assume that the rate of investors of type U is ρ, and the rate of investors of type I is $1-\rho$[3]. In equilibrium, in the *makam* market we should observe that the spread between one-year *makam* and one-year US Treasury bills equals the weighted average between the spread required by the two types of investors:.

$$T_I - T_U = \rho \cdot (T_I - T_U)_U + (1-\rho)\cdot (T_I - T_U)_I$$

$$\Rightarrow T_I - T_U = \overline{e^e} + V(\overline{e^e}) \cdot \underbrace{2 \cdot \frac{U_2'}{U_1'}((1-\rho)\cdot(z-1) - \rho \cdot x)}_{\alpha_2} + L_I + \underbrace{\theta - H_I(1-\rho) + H_U \rho}_{\alpha_0 + \varepsilon} \quad (2.7)$$

$$paar_t = \alpha_0 + \alpha_1 \cdot \overline{e^e} + \alpha_2 \cdot (\sigma_e)_{t-1} + \alpha_3 \cdot \bar{l}_{t-1} + \varepsilon_t \quad (2.8)$$

Equation 2.8 shows that the required spread between one-year *makam* and one-year US Treasury bills – *paar* - is a function of expected depreciation, expected inflation, uncertainty in the exchange rate[4], country risk, the difference in levels of liquidity between the US and Israel and the gap in home bias.

3 Empirical estimation

Equation 2.8 shows the theoretical relationship between the *makam* and US Treasury bills spread and economic variables, and represents the long-term relationship in which the spread is a linear function of risk premium, the expected change in the exchange rate, exchange rate risk and the liquidity premium. In this section we define the variables to be used in the estimation process, noting their sources.

3.1 The data for estimation

3.1.1 Expected depreciation

In the short run, the expected depreciation is affected by several variables. Finding a good estimate for future depreciation is a complicated task, which has occupied much research which still failed to point out any one particular variable which could serve as a good estimate (for example Fisher et al (1990), Hecht, Haim and Schreiber (2002) and others). Rational expectations, such as expected forecast or expectations derived from the capital market as well as adaptive expectations have also produced

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[3] Remember that this is not necessarily the actual component. The presence of type U investors in the market is likely to strongly affect the behavior of the rest of the market.

[4] Setting the coefficient of this variable as a constant is compelled by convenience. For the first: for the sample period, the rate of investment by nonresidents in *makam* as a proportion of all their assets (z) was negligible (tends to zero) while in contrast, the rate of investment by Israelis in US Treasury bills as a proportion of their assets invested in bonds (x) is also negligible (tends to zero). The second: the individual's utility function has a constant coefficient for risk aversion, meaning that in our case the value U_2'/U_1' is a constant.

relatively weak results (Schreiber and Benita (2005)). In this paper we chose to use expected depreciation as derived from relative-PPP. According to this approach, currency depreciation (or appreciation if the difference is negative) of country A vis-à-vis currency of country B is expressed as the difference between inflation in A and inflation in B. As we are interested in predicting depreciation, we will use the expected gaps in inflation as an estimate for expected depreciation.

PPP: Based on relative-PPP, we calculate the expected depreciation as the difference between forecasts for inflation in Israel and forecasts in the US. Expectations of inflation in Israel are calculated from the capital market by means of the spread between unindexed bonds and indexed bonds with average terms to maturity of one year. Expectations of inflation in the US are based on expectations as estimated by the University of Michigan. So the expected depreciation is calculated as follows:

$$\left(\overline{e^e} \middle| t = 2 \sim 13 \middle| t = 1\right)_t = \left(\pi_I^e\right)_t - \left(\pi_U^e\right)_t$$

3.1.2 Liquidity effect

Liquidity in the *makam* market has improved in recent years, so we cannot assume that it is constant. Therefore if we assume that liquidity in the US Treasury bills market is constant and higher then we can use a liquidity index for the *makam* bonds as a measure of the "liquidity gap" between Israel and the U.S.

Liquidity itself cannot be observed and so indices are needed to calculate its level. Black (1996) points out the difficulties in measuring liquidity. According to Black, different indices of liquidity are likely to result in conflicting measures. Still, the leading measure of liquidity is the bid-ask spread. For bonds, an additional acceptable measure is the spread between two bonds of the same length to maturity but with differing levels of liquidity (for example, Amihud (1991)). However in Israel none of these measures can be calculated for our sample, so instead we have chosen to use indices that measure the depth of the market, which according to Fleming (2003), who examined the behavior of several measures of depth and liquidity in the US Treasury bill market, exhibit a high degree of correlation with measures of liquidity. The major variables on which measures of depth are based are volatility in asset prices, turnover and turnover velocity. The central idea behind these measures is the relationship between volatility in asset price and turnover or speed of turnover. The deeper a market is, the weaker this relationship is, in other words, holding this measure constant, greater volatility needs to be accompanied by a high turnover.

Among the measures for depth, one is the ILLIQ index (Amihud (2002)) which is the absolute price change per dollar of daily trading volume. Another is the Kyle measure (Kyle (1985)), similar to the ILLIQ, which is used for large trades and which measures price change as a rate of the trade size. The Hui index takes the difference in maximum and minimum prices over the past five days divided by the minimum price, and divides this by the average turnover velocity during the same five-day period.

In this paper, the liquidity variable is one of the factors that could affect the utility of the individual considering investing in *makam* in Israel. It is reasonable that the investor would check out the long-term liquidity, not a daily measure as conveyed in the above measures. So for a long-term estimate of liquidity of the *makam* market and subject to the limitations of detailed trade data, we will use the combined measure of yield volatility implied in the *makam* and the turnover velocity based on the last 250 trading days (about a year):

$$L_\tau = \frac{\sigma(r_{\tau|\tau=0\sim-249}) / \bar{r}_{\tau|\tau=0\sim-249}}{\left(\sum_{s=0}^{-249} C_{\tau-s}\right) / \bar{O}_{\tau|\tau=0\sim-249}} \qquad (3.1)$$

Where τ is the business day index, σ notes the standard deviation, r represents the yield implied in the *makam*, C notes the daily turnover in the *makam*, and $\bar{O}_\tau$ is the average balance in the market in the past 250 days. As our sample is based on monthly data, we converted the daily index to a monthly one through a simple average accounting.

Liquidity in the *makam* market - L_t. We use the liquidity index in Equation 3.1 as an estimate of liquidity in the *makam* market. This index is based on the entire *makam* market and is calculated according to *makam* bills of all durations between one and 12 months. The preference for using a liquidity index based on the market in general and not only on one-year *makam* stems from two major reasons: data taken from the entire *makam* market as a whole naturally includes less statistical errors arising from errors in measurement etc.; and the liquidity of the *makam* market as a whole is more suitable as a description of the general state of liquidity.

3.1.3 Exchange rate risk

STD_GLUM: As an estimate for the uncertainty of the exchange rate we chose to use the standard deviation implied from the dollar option market. Alternatively we could have used the actual standard deviation of the exchange rate itself. The choice was based on our aim to incorporate the expectations of the capital market participants, expectations that could, in the short run, deviate from actual uncertainty. According to studies made in Israel (Benita and Schreiber, 2003) the implied standard deviation is characterized by a significantly autoregressive component, which weakens the possibility of forecasting the standard deviation of the actual exchange rate. We believe there is no disadvantage in this, as this suggests the existence of a unit root in the derived standard deviation variable that can be used to forecast the spread, which has similar stochastic properties.

3.1.4 Spreads

PAAR: The difference in yields of one-year *makam* and one-year US Treasury bills. Clearly *makam* yields are only partly correlated with the Bank of Israel interest rate, which allows us to use the difference between this yield and that of one-year US Treasury bills as a market indicator. Figure 5 shows the difference between the Bank of Israel interest rate and yields on one-year *makam*. Using this *makam* series is not comparable to using the Bank of Israel interest rate, as over time, the deviations from the x-axis are one directional (that is, the spread between the Bank of Israel interest rate and the interest on one-year *makam* does not demonstrate "white noise" properties).

3.1.5 Estimation method

In order to choose the method of estimation, the stochastic structure of the data series must be evaluated. As most of the financial variables follow a random walk process, a cointegration method should be used. Using cointegration tests (Johansen Test, Engel-Granger) we will check if the correlation shown in equation 2.8 exists in the Israeli economy. If it does, this would show that the equation holds true for the long term. The residuals of the long-term equations (which are stationary by construction owing to cointegration) are short-term deviations and could be used as estimates for short-term risk premiums for the Israeli economy[5].

3.2 Data description

Most researchers dealing with uncovered interest-rate parity assume a fixed or zero risk premium and indeed this assumption is reasonable when estimating these equations for developed economies. In equation 2.8 we assume a fixed risk premium for the Israeli economy. But given the severe vicissitudes that have occurred in the economy, one could suggest this assumption is problematic, although international agencies Fitch and Standard & Poor's have maintained a fixed credit rating for Israel for the past 10 years. Only Moody's raised its credit rating in the second half of 2000 (Figure 1). One can also assume that the home bias remained at a basic level with no change in recent years. The two parameters *h* and θ (equation 2.7) remained fixed and therefore they can be expressed by the constant α_0 in equation 2.8.

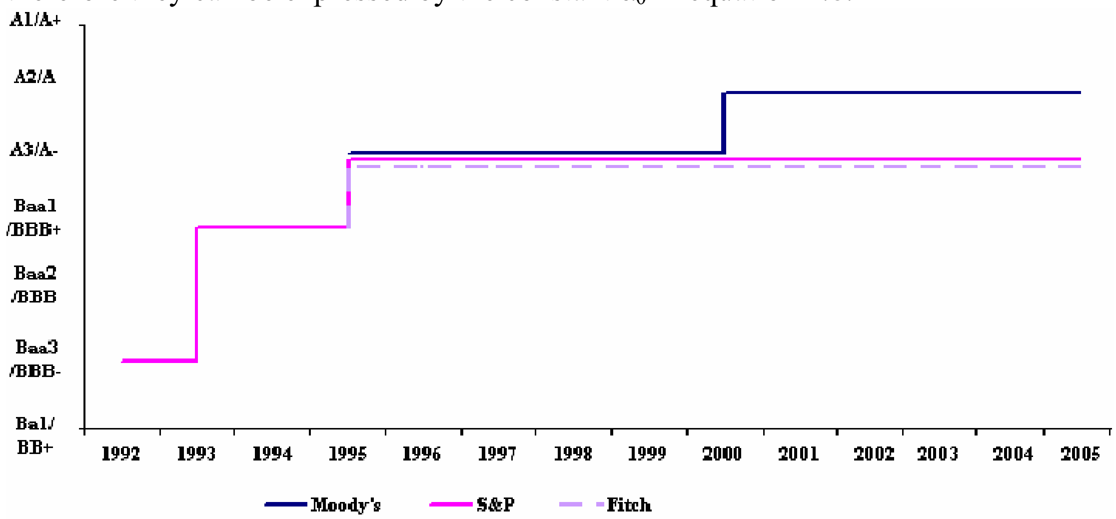

Figure 1: Israel's credit rating

Source: Ministry of Finance.

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[5] In the cointegration method the long-term correlation between the variables is tested, and therefore there is no endogenous consideration of the explanatory variables. In other words for an infinite sample the existence of endogeneity between the explanatory variables should not affect the estimation of the cointegration correlation.

In this study we used monthly data for the period 1996:01 to 2005:12 as our sample. Initial observation of the data reveals trends among the explanatory variables. Figure 2 shows that the downward trend in the spread is correlated with a decline in the trend of expected depreciation and a rise in liquidity in the *makam* market. On the other hand a rise in the spread in the crisis periods of 1998 and during the intifada, is correlated principally by a rise in uncertainty as expressed by the standard deviation implied from dollar options.

It is interesting to note that all exchange rate crises during the sample period (a rise in the standard deviation implied from dollar options) were characterized by liquidity crises, expressed in the deviations of the liquidity index from its trend line. This was the case in October 1998, October 2000 at the outbreak of the intifada and in March-April 2002 at the time of Operation Defensive Shield (and after the interest rate cut by then Governor of the Bank of Israel David Klein).

We also note that during the period reviewed two important changes occurred in the Bank of Israel's control of the *makam* market, which impacted the market level of liquidity; in August 1998 and in January 2002. These two changes were accompanied by a cut in the interest rate, which undermined financial stability, although in their wake the level of liquidity improved.

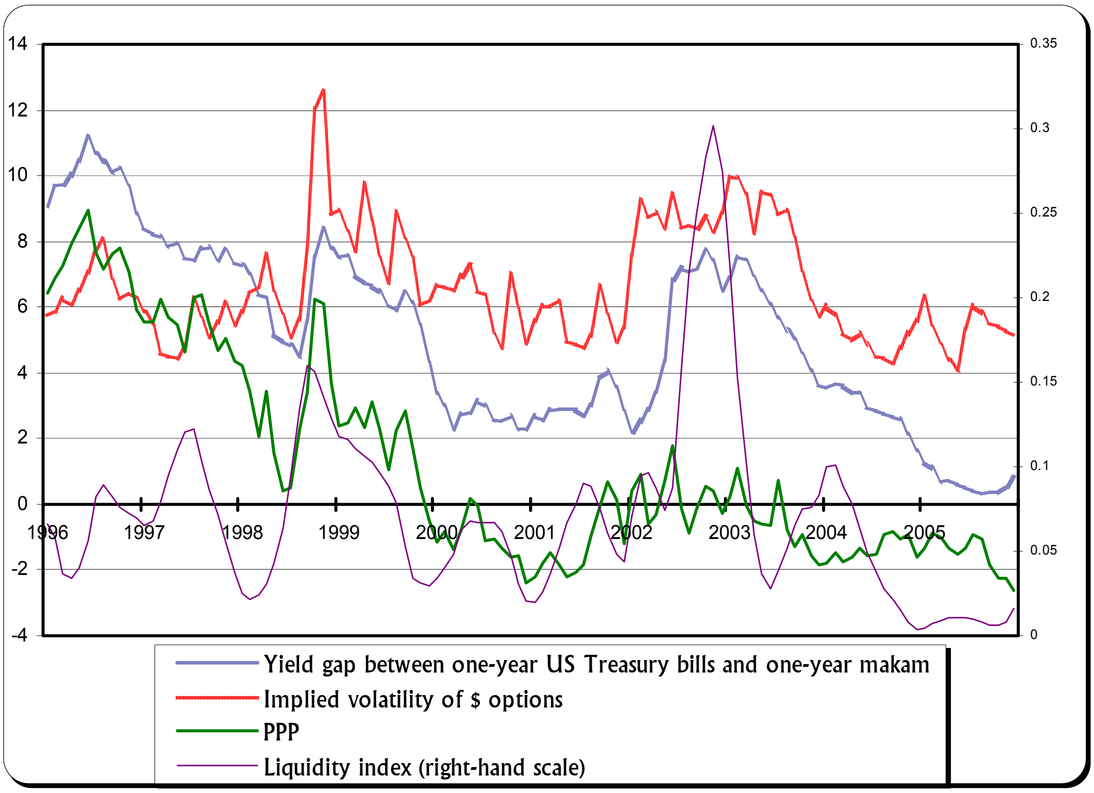

Figure 2: Variables in the Gap Equation during the Sample Period

4 Estimation Results

4.1 Equation for Expected Depreciation – PPP

The assumption of the model is that the expected change in the exchange rate is derived in the long-term from relative purchasing power parity (PPP). We test for cointegration in the equation:

$$\left(\frac{e_{t=12}}{e_{t=-1}} - 1\right) = \alpha_1 \cdot \underbrace{\left(\left(\pi_I^e\right)_t - \left(\pi_U^e\right)_t\right)}_{PPP_t} + \mu_t \qquad (4.1)$$

Before estimating the cointegration relationship we check for unit roots in the variables. Using the ADF test we learn that the PPP variable and the actual change in the exchange rate are not stationary, and that both have a unit root I(1). In the first stage, we estimated a simple OLS equation (equation 4.2) for the period 1996:01–2004:03.

$$\left[\frac{e_{t\ =\ 12}}{e_{t\ =\ 1}} - 1\right] = \underset{(0.21)}{1.009}\,.ppp_t \qquad (4.2)$$

In the second stage we check for cointegration, using two methods: Engel-Granger and the Johansen.

According to the Engel-Granger approach, the equation does show a cointegration relationship[6] at the 1-5 percent significance level, while the Johansen test rejected no cointegration at the 2.6 percent significance level.

These results imply that we can use the PPP relationship as an estimate of the expected change in the exchange rate. Figure 3 shows the change in the dollar exchange rate in the next 12 months together with the expected change as obtained from the PPP equation. We can see that the expected change in the exchange rate converges to the PPP equation in the long run.

4.1.1 Duration of Convergence in the Long Run

The inclusion of the error correction (EC) variable in the short-term differences regression (a VAR equation) ensures the convergence of short-term deviations to the long-term relationship. In other words, if there is indeed cointegration that testifies to a long-term correlation, then according to Engel and Granger, the EC variable entered into the short-term equation should be negative and significant.

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[6] The lags for the unit root test were chosen according to the Schwartz criterion.

When included in the short-term equation, the EC coefficient takes the value (-0.087821). In other words, a return to the long-term correlation is completed after about 12 months.

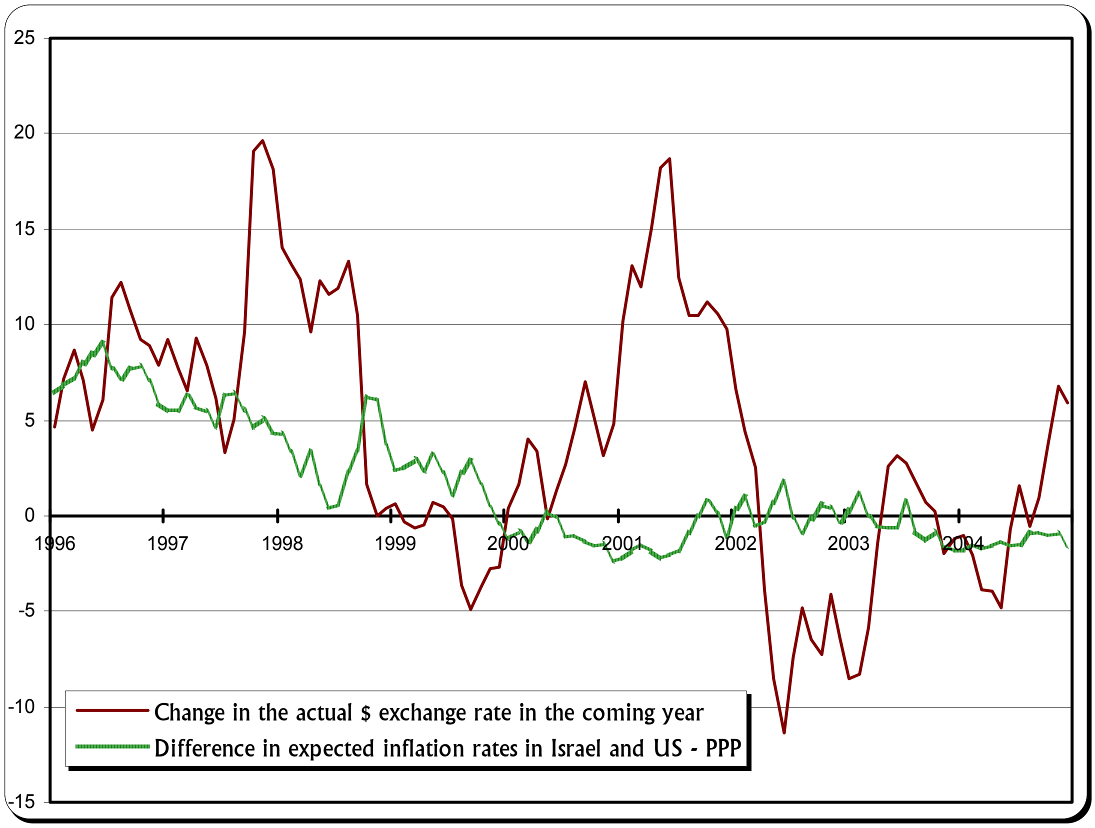

Figure 3: Expected Depreciation as Derived from PPP and Actual Depreciation

4.2 The Spread Equation

In equation 2.8, the spread is defined as the difference between the yield on one-year *makam* and one-year US Treasury bills. The explanatory variables are the expected depreciation (for which PPP is used), the variable of uncertainty in the exchange rate (for which the standard deviation implied in the prices of the NIS/$ options is used), and the liquidity gaps (for which the liquidity index as presented in equation 3.1 is used).

None of the variables in equation 2.8 are stationary, and all have a unit root I(1). This allows us to test for a long-term correlation between the variables using cointegration tests[7].

Engel and Granger tests for the period 1996:01–2006:04, show a cointegration relationship[8]. In equation 4.3 one can see the coefficients obtained for equation 2.8 through an OLS regression[9].

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[7] Despite the impression that inflation was eliminated in 2000, the variables are not stationary in the sub-sample of 2000-2005 either. See the statistical appendix.

[8] The ADF test for the residuals shows that we can not reject cointegration at the 0.5 percent level.

$$paar_t = \underset{(0.450)}{1.58} + \underset{(0.038)}{0.73} \cdot ppp_t + \underset{(0.064)}{0.17} \cdot \sigma_t^e + \underset{(4.714)}{18.88} \cdot L_t + u_t \qquad (4.3)$$

N=124

4.2.1 Different Variables' Contribution in Explaining the Spread

In this section we examine the contribution of the explanatory variables in explaining the spread. For clarification we split the period of estimation into two. One—from 1996 up to 2000—could be considered as a period of disinflation and during which there were still restrictions on capital movements in the Israeli economy. The second period—from 2000—could be considered a period of stability in terms of inflation and almost complete opening up of the economy to capital movements[10].

Table 1: Different variables' average effect on spread by sample period

	Average values of the variables in sample period					Average contribution to spread		
Period	**12-month *makam***	**Spread**	**PPP**	**Implied standard deviation**	**Liquidity index**	**PPP**	**Implied standard deviation**	**Liquidity index**
1996:01-1999:12	12.9	7.6	4.5	7.33	0.078	3.29	1.25	-1.47
2000:01-2005:12	6.5	3.4	-0.9	7.13	0.063	-0.66	1.21	-1.19
1996:01-2005:12	9.0	5.1	1.24	7.21	0.073	0.91	1.23	-1.38

Table 1 show that each of the variables affected the spread in the sample sub-periods. Firstly, the intercept obtained from this equation (see above) points to Israel's basic risk premium which, according to these results, stands at an average 1.6 percent throughout the period. This means that if all the variables were to have the value 0, this would be the spread required. This spread could be attributed to the country risk, etc[11].

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[9] Liquidity may be coordinated with inflation expectations, expressed through PPP. We therefore estimated this equation through a two-stage method, by which we considered the possibility that some of the change in liquidity is endogenous to the spread. After entering instrumental variables that capture, *inter alia*, the economic developments of the sample period, this method gives similar results to those presented in equation 4.3.

[10] Note that only in January 2005 were tax rates on investments in Israel and abroad brought into line, and there are still some restrictions for certain parties on investing in foreign securities.

[11] Israel's credit rating was, as stated, constant throughout the sample period, but despite this, when estimating the equation for the sub-periods and when forcing the exchange rate variable to take the value 1 (as derived from the theory), then a different risk premium is obtained: for the period 1996-2000, the premium is around 3 percent, and for 2000-2005 it drops to around 0.7 percent.

The contribution of the expected exchange rate (the inflation gap between Israel and the US) is mainly in the period of disinflation during which the inflation gap continually narrowed and with it the expected depreciation and the spread. In theory, when the inflation gap is zero (in long-term equilibrium), we would expect that its contribution to the gap would also be zero.

The standard deviation implied in the dollar options has a steady effect over the sample period. The exchange rate risk premium appears constant and, at around 1.25 percent, is not inconsiderable. The liquidity premium contributed to lowering the spread due to the improved liquidity in the *makam* market in the period studied. Apparently this contribution was also steady throughout the two sub-periods.

4.2.2 Duration of the Convergence to the Long Run

In order to check the time needed for the spread as measured in the markets to converge with the gap as derived from equation 2.8, we will estimate another error correction equation in which the explained variable is a change in the gap ($d(paar)=paar_t-paar_{t-1}$), and the explanatory variables are the changes in lag period of the explanatory variables in equation 2.8. We also add the error correction term u_{t-1}.

Our estimation results show that the error coefficient was significant and has a value of -0.157. From these results we infer that there is additional evidence for a long-term cointegration and that convergence to the long-term is about seven months (1/0.157). Despite these findings we note that in Figure 4 one can see that in the period from 1996 to the end of 2001, the spread's deviations were relatively small and short-lived. From 2001, these deviations seem larger and longer lasting. In the next section we will attempt to relate these facts to Bank of Israel policies.

4.2.3 Deviation from the Long-Term Correlation and its Effect on the Exchange Rate

The actual spread being greater than the predicted spread reflects a short-term deviation from equilibrium. In this situation we would expect that these deviations would affect the short-term exchange rate. In particular, we would expect that in a case of a positive deviation in the spread (in the next section we will suggest the Bank of Israel's possible contribution to this), the NIS would appreciate against the dollar. To test this conjecture, we estimated an equation in which the dependent variable is the monthly change in the $/NIS exchange rate. For the explanatory variables we entered the residuals from the long-term equation, a measure for serial correlation and an intercept.

$$\Delta e_t = \alpha_0 - \alpha_1 \cdot u_t + \alpha_2 \cdot AR(1) \qquad (4.4)$$

$$\Delta e_t = \underset{(0.002)}{0.003} - \underset{(0.001)}{0.007} \cdot u_t + \underset{(0.092)}{0.233} \cdot AR(1) \qquad (4.5)$$

$T = 122$ 1996:01 – 2006:04 $DW = 1.85$ $\overline{R^2} = 0.25$

$$\Delta e_t = \ln(e_t / e_{t-1})$$

Equation 4.5 shows that a positive deviation between the actual spread and the long-term spread has a downward effect on the exchange rate and vice versa. The of equation 4.5 is a reduced form one, though the negative coefficient for the deviation from the long-term spread is maintained in other specifications[12].

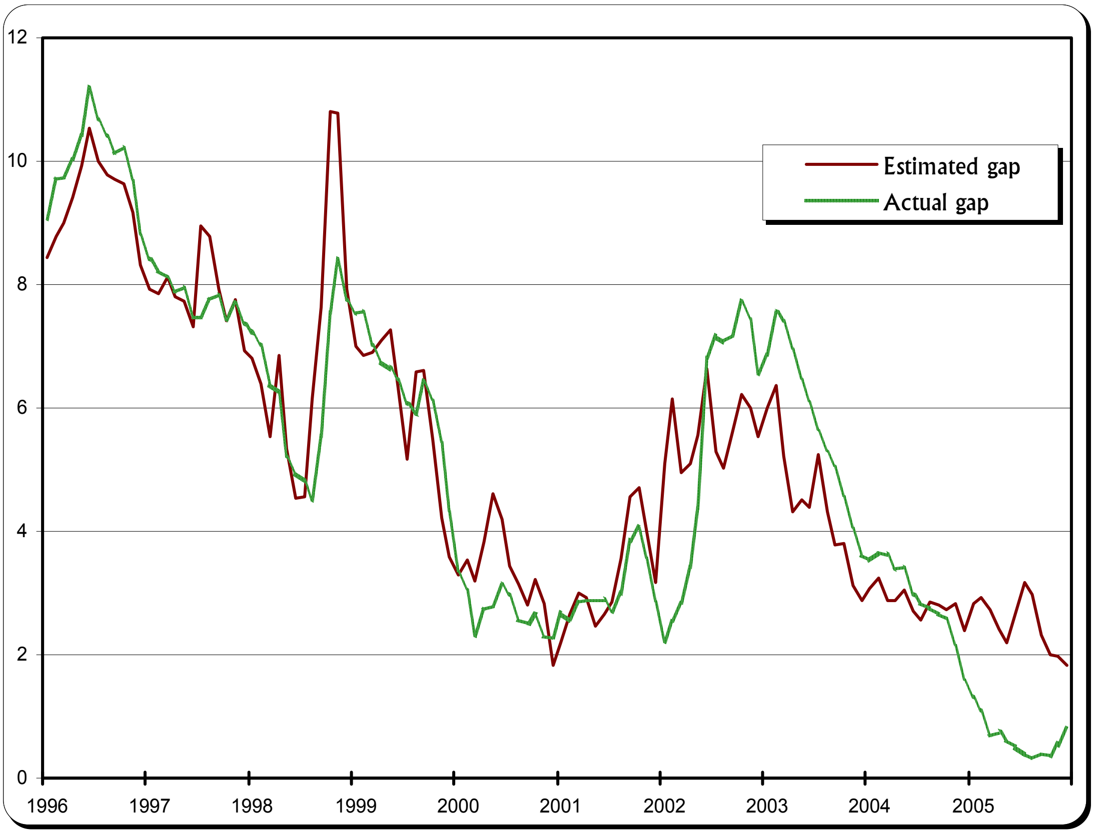

Figure 4: The estimated gap and actual gap (The months 5-12/05 are outside the sample period, and so for this period, the forecast for the model is taken as the estimated gap)

[12] The monthly change in the exchange rate is stationary and is therefore of the same level of integration as the deviation from the long-term correlation. See appendix.

4.2.4 Robustness checks and alternative specifications

ARCH estimation:

Since we are estimating spreads in market yields it is natural to test for the possibility of autoregressive conditional heteroskedasticity (ARCH). After estimating equation (2.8) we tested, using the ARCH-LM test, whether the residuals of the regression suffer from ARCH. We can not reject the hypothesis that there is an ARCH process in the residuals. We therefore estimated an ARCH model for equation (2.8). The results are reported below and are almost identical to the ones obtained using the OLS estimates.

$$paar_t = \underset{(0.648)}{1.58} + \underset{(0.029)}{0.73} \cdot ppp_t + \underset{(0.101)}{0.17} \cdot \sigma_t^e + \underset{(5.154)}{18.88} \cdot L_t + u_t \qquad (4.6)$$

Johansen cointegration test

Using the Johansen test allows us to add exogenous variables such as the changes carried out in the *makam* market. For our exogenous variables we entered two dummy variables: dum99 which takes the value 1 after January 1999; and dum02 which takes the value 1 after January 2002. The Johansen test was conducted with no lags, with an intercept and with no trend. The test showed that at the 1 percent significance level, a single cointegration relationship can not be rejected. The coefficients obtained in this method, apart from the intercept which is not significant, are similar to the coefficients that appear in equation 4.3 with the exception of the PPP variable which now has a unit coefficient, as predicted by the theory. We used this finding, in subsequent estimations and forecasts.

5 The Bank of Israel's Monetary Policy and Its Effect on the Spread

As the yield on *makam* for 12 months is affected, *inter alia*, by the short-term interest rate which is set by the Bank of Israel and also by the expected development of this interest rate, the spread in practice is likely to embody the Bank of Israel's monetary policy, both the policy as practiced and that of the future. As can be seen in Figure 5, there is a close link between the Bank of Israel interest rate and the yield on *makam* for 12 months, with the largest deviations related to the sharpest and unexpected, changes in the Bank of Israel interest rate, in particular the two rate reductions in 1998 and at the end of 2001.

In light of this correlation between the yield on *makam* and the Bank of Israel interest rate, we raise two issues: Does the Bank of Israel's monetary policy affect the long-term equilibrium of the interest rate spread? and what is the short-term interaction between the Bank of Israel interest rate and the spread?

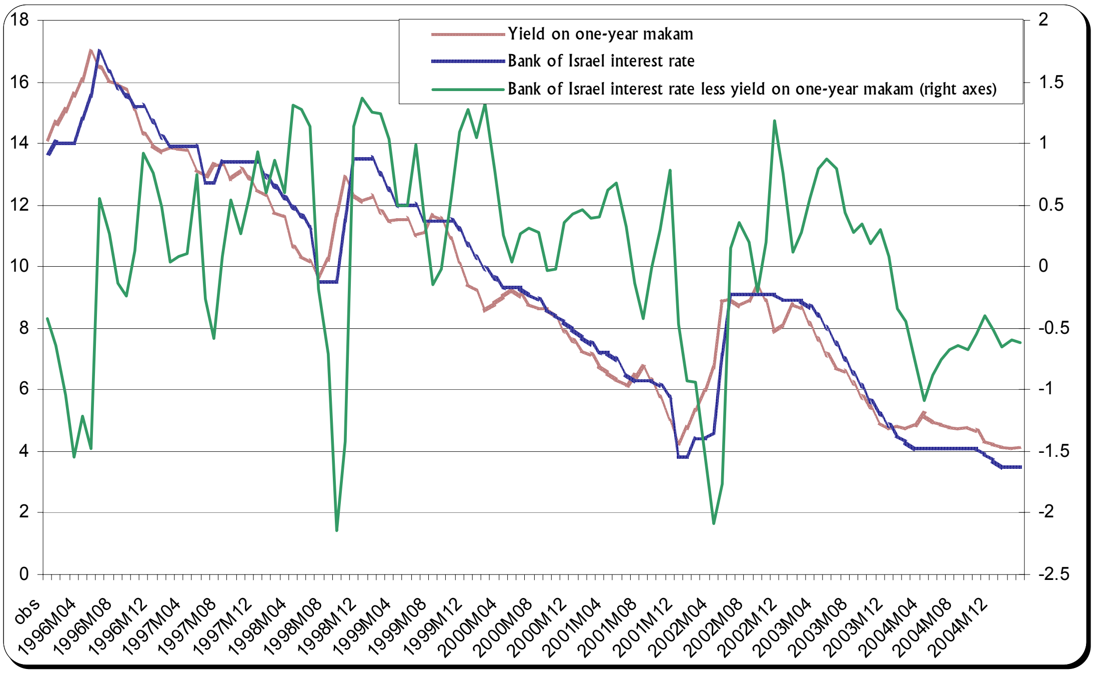

Figure 5: The difference between Bank of Israel interest rate and yield on one-year *makam*

5.1 Monetary Policy and the Long-Term Equilibrium of the Spread

The long-term correlations that we used in this paper are theoretically derived from the economic equilibrium conditions which seem to be unrelated to a central bank's policy. Has the central bank no influence on the long term? The cornerstone of the model we have used is purchasing power parity. Under a regime of a floating exchange rate, the exchange rate is determined in the long run endogenously by the difference between the expected local inflation rate and the expected rate abroad. The role of monetary policy (in line with fiscal policy) is to set inflationary expectations. When the public has faith in a central bank, then it affixes its expectations of inflation to within the declared inflation target range. Only then does the central bank pin down the spread between the two economies. In this case, the spread is affected only by changes in the risk premium, the liquidity premium and random shocks. Paradoxically, in long-term equilibrium with a credible inflation target, the central bank has no need to react to random deviations in the exchange rate or spread as the public believes that in the long run the spread will be maintained at its equilibrium level.

The conceptual framework presented above allows the analysis of the relationship between the Bank of Israel’s policy and the spread in the period studied. The major variable that indicates credibility and the policy's long-term goals is the depreciation as derived from purchasing power parity, a variable that is derived from inflation expectations which the monetary policy is supposed to affect.

As mentioned, Israel has experienced a period of disinflation when inflation expectations were on a downward trend, and therefore the trend of depreciation was also downward, and so too the derived spread. During this period, which followed many years of inflation, an aggressive monetary policy was required in order to make the policy credible. However the unexpected cut in the interest rate in 1998 undermined the credibility of the policy and this was expressed in a rise in the spread which resulted from the rise in pace of the depreciation as derived from the purchasing power parity equation; in other words, the difference in inflation expectations between Israel and the US grew (see Figure 3).

The behavior of the purchasing power parity (Figure 3) shows that from 2000, the goal of disinflation was achieved and was regarded as credible by the public. In this case, according to the above analysis, the central bank could have ignored the random deviations of the nominal variables and could have reacted moderately to the deviations of the spread from the long-term spread. However in practice the spread between expected inflation in Israel and the US became negative. Once the goal had been achieved, the interest rate was cut unexpectedly at the end of 2001. This time, unlike the interest rate cut in 1998, the public believed that the central bank had not changed its inflation target. As proof: the (long-term) purchasing power parity variable reacted at first only slightly in relation to the actual depreciation (Figure 3) and the gap in inflation expectations between Israel and the US fell to zero (which is consistent with long-term equilibrium.) The deterioration of the intifada and the fears of losing fiscal control (the lowering of Israel's credit rating) led to a rapid depreciation and fears of loss of confidence in the monetary policy, which was expressed, in line with the model, in a rise in the pace of depreciation as derived from purchasing power parity. The raise in interest rates following the depreciation restored the credibility of monetary policy, and as proof: the depreciation as derived from the purchasing power parity has remained at zero since the end of 2003 and even dropped below zero, which testifies to Israel's central bank's maintaining a lower inflation target than that of the US.

The spread between Israel and the US also increased between 2002 and 2004 mainly due to the rise in risk implied in the exchange rate. We emphasize that in the long-term analysis there is no correlation between exchange rate movements (standard deviation) and credibility of the monetary policy as measured by changes in rate of depreciation derived from the purchasing power parity (level of depreciation). In the long-term equilibrium, under complete credibility, the central bank has no need to take into account changes in the short-term exchange rate. The lack of response of the central bank's interest rate to these movements naturally allows a higher standard deviation. Low standard deviations are the outcome of "insurance" provided by the Bank of Israel that reacts when there are large movements upward on the exchange rate.

5.2 The Monetary Policy and the Short-term Spread

In the previous section we assumed that the central bank's credibility is expressed in the expectations of depreciation as derived from purchasing power parity. Earning this credibility is dependent on showing that, over time, the bank is committed to its declared inflation target. One of the most important indications in the short run and throughout the period of earning credibility, is the reaction of the central bank's interest rate to deviations in the interest rate from that which is consistent with the long-term spread. In this section, we will attempt to test the statistical correlation between the deviation in the actual interest rate spread from that predicted by the model and the Bank of Israel's interest rate policy. We must stress that in this section we do not intend to estimate a reaction function for the central bank. Also, as will be claimed later, the Bank of Israel may not have considered the spread directly at all in its deliberations, but may only have taken account of the variables whose behavior is derived from this spread, such as the exchange rate or the expected inflation. However as the residuals of the spread equation as derived from the cointegration equations, by definition, support the classic regression assumptions, and are particularly not correlated with the explanatory variables, it is possible to test their partial effect by an OLS model, as omitting other variables will not distort this partial estimate.

In order to examine this question, we will estimate an equation in which the dependent variable is the change in the Bank of Israel interest rate. The explanatory variables will be the deviations of the actual spread from those estimated. We also use the lagged change in interest rate which should represent the persistence of the interest rate policy.

$$\Delta i_t = -\underset{(0.043)}{0.197} \cdot u_{t-1} + \underset{(0.080)}{0.467} \cdot \Delta i_{t-1} \qquad (5.1)$$

$$T = 110 \qquad 1996{:}01 - 2005{:}04 \qquad DW = 1.96 \qquad \overline{R}^2 = 0.30$$

From the results of estimating this equation (shown in equation 5.1) we find that in the sample period, the Bank of Israel tended to lower the interest rate when the actual spread was above the long-term level. It therefore seems that the Bank of Israel's behavior took account of the long-term correlation[13]. We must also remember that deviations from the spread affected short-term exchange rate developments (equation 4.5). Therefore, perhaps the Bank of Israel was influenced by a pass-through effect of exchange-rate deviations on inflation expectations and therefore it is possible that its reaction to a deviation was only indirect. In order to estimate the path of influence of the deviation in spreads on central bank behavior, we will estimate an equation in which the dependent variable is the change in expected inflation and the change in the exchange rate as an explanatory variable. The results can be seen in equation (5.2)

[13] Despite the limits of this equation in comparison to the reaction function obtained for the central bank (Taylor (1993), CGG (1997); and for the Bank of Israel, Bafman and Bar Efrat (2002), Melnik (2005) et al.) the significant coefficient of the deviations from the long-term correlation point to a direction of influence that this variable has on the Bank of Israel interest rate. Further studies on the reaction function also point to a significant coefficient with the same sign for this variable.

The change in the exchange rate has a strong effect on inflation expectations. The change in the exchange rate is affected by the deviation of the actual spread from the predicted one (equation 5.1). Therefore the residuals of the spread equation affect the rate of depreciation, depreciation affects inflation expectations. And these affect monetary policy directly.

$$\Delta\pi_t^e = -\underset{(0.059)}{0.161} + \underset{(0.033)}{0.318} \cdot \Delta e_t \qquad (5.2)$$

T = 111 1996:01 – 2005:04 DW = 1.72 $\overline{R^2} = 0.46$

In light of the long-term analysis in the previous section, the findings obtained from equation 5.2 show that short-term deviations in the spread, which cause short-term depreciation, affect inflation expectations.

In part of the sample period, the deviation was larger and remained so for some time. This could point to an inconsistency in monetary policy over the two sub-periods. Or even more explicitly: In figure 4 in the previous section, one can see that after the sharp reduction in the interest rate at the beginning of 2002, the actual spread deviated from the long-term predicted spread. Moreover, with the shock to the financial markets and the restrictive monetary policy that followed it, the situation turned completely around, and the actual spread was higher than the long-term spread for the next two years. One therefore finds that between 2002 and 2004 interest rate policy did not react to this long deviation. As a result, during this time, the exchange rate appreciated and inflation fell to below the inflation target[14].

In order to express this in the estimated equation, we added a dummy variable (D_2001) to equation (5.1) which has a value of 1 from 2001 until the end of sample period 12/2005. Equation (5.3) shows the results of this estimation.

$$\Delta i_t = -\underset{(0.077)}{0.379} \cdot u_{t-1} + \underset{(0.092)}{0.256} \cdot D\_2001 \cdot u_{t-1} + \underset{(0.077)}{0.457} \cdot \Delta i_{t-1} \qquad (5.3)$$

T = 110 DW = 1.99 $\overline{R^2} = 0.35$

From the results shown in equation 5.3 we see that the error correction coefficient for the first period is larger than the absolute value of the coefficient for the period after 2001. This finding is consistent with the analysis in the previous section in which it was claimed that most of the credibility had been built up in the period up to 2001. This means that in the period of disinflation, the Bank of Israel interest rate responded faster to deviations from the long-term deviation, i.e. the Bank of Israel's interest rate policy responded faster to the effect of a deviation in gap expressed through the exchange rate or/and inflation expectations. A possible explanation to the slower response of the policy in the period after 2001 is related to the temporary loss of

[14] Sussman (2004) showed that in this period, which is identified with the governorship of David Klein, the interest rate policy did not react to changes in inflation expectations as it had done previously.

credibility in 2002. Following this the Bank of Israel chose, for some time, to peg the actual interest rate spread higher than the long-term spread. Therefore an appreciation occurred that did not risk stability and strengthened credibility (not overshooting the inflation target). In this case, apparently, there was felt to be no need to respond to deviations as in the period in which the actual spread was lower than that estimated.

6 Summary and Policy Recommendations

In this paper we have shown that after opening up the Israeli economy to capital movements and allowing a freely floating exchange rate (at least for the latter part of the sample period), the one-year yield on NIS assets was set by long-term factors popular in macroeconomic literature on the open economy. The influential factors are expectations of depreciation, uncertainty in the foreign exchange market and a measure of liquidity in the *makam* market. Given these findings it is seen that achieving long-term stability is linked to achieving full credibility in meeting inflation targets. Only then, the central component influencing the spread—the expected depreciation—will be affected by the monetary policy targets. The empirical test for achieving this goal is the reduction of the exchange-rate pass-through on expected inflation to almost zero. Until this is achieved, and continuing the work of Sussman and Spivak (2004), the Bank of Israel should take into account the variables that set the spread when setting the interest rate targets of the Israeli economy in order to strengthen credibility. We predict that with achieving this credibility the volatility of the exchange rate will rise but its affect on expected inflation will fall. In the final stage, having achieved full credibility, the Bank of Israel interest rate can be divorced from that of the US as the interest rate gaps between the two economies, which will affect capital movements and the short-term exchange rate, will not be expressed in inflation expectations which set the long-term exchange rate.

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Appendix 1: Stationary Tests

Variable	Period	P-value	Method (with/without intersect)[15]	Conclusion
D_E_Y (annual change in exchange rate)	4/96-3/04	0.3	with	I(1)
D_E_Y (annual change in exchange rate)	1/00-3/04	0.53	with	I(1)
D_E_Y (annual change in exchange rate)	1/96-12/99	0.33	with	I(1)
D_E (monthly change in exchange rate)	1/96-12/05	0.00	with	I(0)
D_E (monthly change in exchange rate)	1/00-12/05	0.00	with	I(0)
D_E (monthly change in exchange rate)	1/96-12/99	0.00	with	I(0)
Liquidity	1/96-12/05	0.42	with	I(1)
Liquidity	1/00-12/05	0.23	with	I(1)
Liquidity	1/96-12/99	0.20	with	I(1)
Implied standard deviation	1/96-12/05	0.07	with[16]	I(1)
Implied standard deviation	1/00-12/05	0.34	with	I(1)
Implied standard	1/96-12/99	0.11	with	I(1)

[15] The Schwartz criteria was used in the selection of lag length in the unit root test.
[16] At the 5 percent significance level the variable exhibits I(1), without intersect, and with a Pv value of the unit root test of 0.43.

deviation				
PPP	1/96-12/05	0.38	with	I(1)
PPP	1/00-12/05	0.32	with	I(1)
PPP	3/96-12/99	0.63	with	I(1)
Spread	1/96-12/05	0.38	with	I(1)
Spread	1/00-12/05	0.57	with	I(1)
Spread	1/96-12/99	0.66	with	I(1)
Paar-ppp	1/96-12/05	0.20	with	I(1)
Paar-ppp	1/00-12/05	0.42	with	I(1)
Paar-ppp	2/96-12/99	0.15	with	I(1)
Δi	1/96-12/05	0.00	with	I(0)
Δi	1/00-12/05	0.01	with	I(0)
Δi	2/96-12/99	0.00	with	I(0)

Appendix B: calculating the spread between *makam* and treasury yield

Due to the lack of complete liquidity in the Israeli *makam* market, asset realization is likely to entail, as mentioned, a loss represented by the liquidity index in the *makam* market in Israel, L_I. Investing in Israel also entails country risk, θ. The home bias of the Israeli investor is shown as H_I and is lower than the expected mean yield from investing in the US[17].

$$\Rightarrow V(\overline{r_I}) = V(\overline{\pi_I^e}) + z^2 \cdot V(\overline{e^e}) - 2z \cdot \mathrm{cov}(\overline{e^e}, \overline{\pi_I^e})$$

The investor maximizes utility U by choosing the optimal share of US Treasury bills and *makam*:

$$U'_x = U'_1 \cdot \left[-(T_I - \overline{\pi_I^e} - L_I - \theta) + (T_U + \overline{e^e} - \overline{\pi_I^e} - H_I) \right] + U'_2 \cdot \left[2z \cdot V(\overline{e^e}) - 2 \cdot \mathrm{cov}(\overline{e^e}, \overline{\pi_I^e}) \right]$$

Under the optimal z that the investor chooses, the spread between *makam* and US Treasury bills for one year that he desires is:

$$\left(T_I - T_U\right)_I = \overline{e^e} + L_I + \theta - H_I + 2 \cdot \frac{U'_2}{U'_1} \cdot z \cdot V(\overline{e^e}) - 2 \cdot \frac{U'_2}{U'_1} \cdot \mathrm{cov}(\overline{e^e}, \overline{\pi_I^e})$$

According to relative purchasing power parity (PPP), we can assume that the expected depreciation is equal to differences in inflation, i.e. $\overline{e^e} + \overline{\pi_U^e} = \overline{\pi_I^e}$ and therefore $\mathrm{cov}(\overline{e^e}, \overline{\pi_I^e}) = \mathrm{cov}(\overline{e^e}, \overline{e^e} - \overline{\pi_U^e}) = V(\overline{e^e}) - \mathrm{cov}(\overline{\pi_U^e}, \overline{e^e})$. As claimed above, the covariance of inflation in the US and the expected depreciation is close to zero. This means that we can assume that $\mathrm{cov}(\overline{e^e}, \overline{\pi_I^e}) = V(\overline{e^e})$ and thus, the spread can be written as:

$$\left(T_I - T_U\right)_I = \overline{e^e} + L_I + 2 \cdot \frac{U'_2}{U'_1} \cdot (z-1) \cdot V(\overline{e^e}) + \theta - H_I \qquad (2.6)$$

[17] Level of non-preference for investing in any one country differs from country to country, and so one should look at the relationship between home bias and lack of preference of the foreign country. The home bias represented here represents this relationship.