Loan Pricing under Basel II in an Imperfectly Competitive Banking Market

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Abstract

The new Basel Capital Accord (Basel II), published in its final form in June 2006, established new and revised capital requirements for banks. In this paper we analyze and estimate the possible effects of the new rules on the pricing of bank loans. We do that for the two approaches for capital requirements (Internal and Standardized) available to banks and make a distinction between retail (mainly households) and corporate customers. Our loan equation is based on a model of a banking firm facing uncertainty operating in an imperfectly competitive loan market. We use Israeli economic data and data of a leading Israeli bank, including probability of default of its retail and corporate customers. The main results indicate that high quality corporates and retail customers will enjoy a reduction in loan interest rates in (large) banks which, most probably, will adopt the IRB approach. On the other hand high risk customers will benefit by shifting to (small) banks which, most probably, will that adopt the Standardized approach.

1. Introduction

In June 2006 the Basel Committee on banking supervision published its newly revised capital requirements known as the new Basel Capital Accord (Basel II). The purpose of the new Capital Accord is to more effectively match regulatory capital to the underlying risks faced by banks and thus improving the decisions of banks and the effectiveness of banking regulation. This is achieved by improving the risk sensitivity of the capital ratios, especially with respect to credit risk, and by encouraging improved risk management on the part of the banks[1].

The new Basel Capital Accord consists of three pillars, (See Basel (2006)): pillar 1 presents the calculation of the total minimum capital requirements for credit, market and operational risk; pillar 2 discusses the key principals of the process of supervisory review of capital adequacy; pillar 3 outlines the measures necessary for promoting market discipline in the banking market. In this paper we concentrate on the first pillar and examine the effect of the new Accord on the behavior of banks, specifically the pricing of loans.

Basel II allows banks to use two (groups) approaches for determining their capital requirements against credit risk: a) The Standardized approach, which refines the risk weights of the 1988 accord (Basel I) by the use of external ratings while leaving essentially unchanged the capital charges for loans to unrated companies. b) The Internal Rating Based (*IRB*) approach which allows banks to compute the capital charges for each exposure using their own estimates of probabilities of defaults (*PD*) and their Loss Given Defaults (*LGD*)[2].

Basel II represents a major change in banking regulation. As such it raises a series of important questions regarding its impact on the behavior of individual banks and on the banking system as a whole. Some of the important issues in this context are the effects of Basel II on banks' capital levels an lending policies. These include the effects on interest rate and the amounts of loans in different market segments: retail vs. corporate; domestic vs. emerging markets etc. The literature on these issues is rather limited, since the Basel II Capital Accord was published only recently. Cave, *et al* (2003) find a significant

[1] Under Basel I, capital requirements are only weakly related to credit risk faced by the bank and no reference is made to operational risk.

[2] Specifically, there are two proposed variants of the *IRB* approach; The foundation *IRB* (*FIRB*) approach in which the banks are expected to provide an estimate of the *PD*s of each borrower while a formula (to be presented later in the paper) gives the corresponding capital charge: an Advanced *IRB* (*AIRB*) in which the banks also provide their own estimate of the *LGD*. In particular, if banks choose the *IRB* approach, they have to provide their own estimate of the *LGD* for retail customers. All the terms appearing in the capital charge formula will be defined and presented later in the paper.

reduction in capital requirements for commercial credit under the *IRB* approach compared with the current rule. French (2004), using data for all FDIC-insured banks, finds a large percentage reduction in capital requirements under the *IRB* approach.[3]

Two recent papers deal with the pricing of loans under the new capital accord. Repullo and Suarez (2004) analyze the loan pricing implication of Basel II assuming a perfectly competitive market for business loans. Their model implies that low risk firms will have their loan rates reduced by banks using the *IRB* approach, while high risk firms will avoid increases in their loan rates by borrowing from banks adopting the Standardized approach of Basel II. Hasan and Zazzara (2006) propose a methodology for estimating risk-adjusted rates for the banks' corporate loans and Basel II capital requirements using *EVA* and *RAROC*.

We investigate the impact of the two possible approaches (*IRB* and the Standardized approach), using the *PD* distribution of the bank's loan customers. In this analysis we distinguish between households (retail customers) and corporates (wholesale customers). We analyze the different effects in the context of a model of a banking firm operating under uncertainty in an imperfectly competitive loan market. This particular structure was found to characterize most European banking systems in recent years See Claessens and Laeven (2004) and Berg and Kim (1998)[4].

In our loan pricing model the interest rate charged on loans has four components: the financial funding cost, risk premium to compensate for the risk of default by the borrower, a premium reflecting market power exercised by the bank, and the sensitivity of the cost of capital raised to changes in loans extended. Data on prices and quantities of retail and corporate lending are usually not directly available for individual banks, a limitation of numerous previous studies. We were able to obtain such data for one of the leading banks in Israel. This data enabled us to consider the effect of differential market power which the banks may be able to exercise on households relative to corporates.

This is timely paper that both academic researchers as well as practitioners would benefit from its findings. Lack of proper data limits bank researchers to know more about the possible scenarios under the Basel II environment and this paper sheds some concrete evidence on the subject matter.

[3] Liebig, Porath, di Mavro and Wedow (2004), using German bank level data, find that Basel II should have a limited effect on lending to emerging markets.

[4] Berg and Kim (1998) study the oligopolistic behavior of multioutput banks which sell their outputs in two distinct markets: retail and corporate banking markets using Norwegian banking data.

The paper is organized as follows: Section 2 briefly summarizes the Basel II Capital Accord, outlining the Standardized approach and the Internal Rating Based (*IRB*) approach. Section 3 presents the model of a banking firm used for determining the interest rate on loans in equilibrium. Since we are using Israeli data, Section 4 is devoted to a description of the structure and other features of the Israeli banking system. Section 5 presents the empirical estimation (based on simultaneous equations, using Two Stage Least Squares regression analysis) of the possible impact of the new Capital Accord on the interest rates which the banks charge their two groups of customers: households and corporates. Section 6 summarizes the main results and presents their possible implications.

2. Basel II Capital Requirements: The Standardized approach and the Internal Rating Based (*IRB*) approach.

Basel II permits banks a choice between two methodologies for calculating their capital requirements for credit risk: a) The Standardized approach which measures credit risk, primarily on the basis of credit assessments by external rating agencies; b) An Internal Rating-Based approach *(IRB),* which enables banks to use their internal rating system to measure credit risk.

The Standardized approach revises the risk weights of the Basel I Accord (1988). Under the new approach, the range of weights of credit risk is expanded from the current range of 0% to 100% to a new range of 0% to 150%, where weights are determined by an external rating agency (for details see Table A1 in the appendix).

The Internal Rating-Based Approach *(IRB)* of Basel II focuses on the frequency of bank insolvencies arising from credit losses. According to this approach the total loss *(TS)* of a bank for a certain confidence interval is given by the Value-at-Risk *(VaR)* threshold. This total loss *(TS)* can be decomposed to an expected loss (*EL*) – which should be covered by loan loss provisions, and to an unexpected loss (*UL*) – which should be covered by capital that provides a buffer for protecting the debt holders against extreme events. Capital is therefore determined according to the difference between total loss and expected loss.

The *IRB* approach specifies the method of calculating the unexpected loss *(UL)* – to be covered by capital requirements for three types of asset classes (corporates, sovereigns and banks)[5]. The formula for calculating the capital requirements (*K*) as a percentage of

[5] For other exposures such as retail and equity (stocks) there are several adjustments that are made in

the bank's Exposure at Default *(EAD)* and the differentiation between unexpected loans *(UL)* and the expected loans *(EL)* are specified in part B of the appendix.

3. The Loan Pricing Model

The model of the optimal behavior of a commercial bank presented here assumes that the banks are risk neutral and that the banking industry is characterized by imperfect competition. This model is based on studies by Klein (1971) and Sealey (1980), which were applied and expanded in several studies of Israel's banking system (for example Barnea, Landskroner, Paroush, and Ruthenberg, (1999) and Paroush and Ruthenberg (2003)).

In our model, the commercial bank operates in the primary market, in which it raises deposits from the public and extends credit to it. The bank also operates in the secondary market in order to bridge between surpluses and deficits in its reserves, where this market involves transactions with other commercial banks (interbank deposits), with the central bank (monetary loans or deposits with the central bank), and in the financial markets (purchases and sales of Treasury securities, for example). In addition, the bank holds capital as required by the regulator, which serves as a cushion against unexpected losses (primarily from its credit portfolio).

We assume that the bank is risk neutral and its objective function is to maximize its expected profits with respect to its decision variables, amount of loans *(L)* and deposits *(D)*. The expected profits of the individual commercial bank in the short term, are:

$$E(\Pi_i) = (1 - PD)(1 + R_L) \cdot L_i(R_L, \tilde{\alpha}) - (1 + R_d) D_i(R_d, \tilde{\beta}) \qquad (1)$$
$$- (1 + R) \cdot Z - k_i \cdot K_i^*(L_i) - F_i$$

where,

PD = Probability of Default

$L(R_L, \tilde{\alpha})$ = the demand function for bank credit that relates (negatively) to the own interest rate (R_L), and to a shift parameter $\tilde{\alpha}$. The shift parameter may represent macro economic factors such as changes in *GDP* (the income effect) and conditions in the capital markets (substitution effect). Thus,

$$\frac{\partial L^d}{\partial R_L} < 0 \quad and \quad \frac{\partial L^d}{\partial (\text{income effect})} > 0 \quad \frac{\partial L^d}{\partial (\text{substitution effect})} < 0$$

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equation (1) through A^*, ρ (see footnotes 8 and 9).

It should be emphasized that the shift parameter may also capture the effect of the business cycle on the demand for loans. Namely, an increase in the level of economic activity (an expansion) leads to an increase in demand for loans and eventually, equilibrium, amount of loans extended. This is consistent with the hypothesis that bank capital requirements are procyclical under Basel II[6]. Given risk neutrality, we obtain the following relationship between R_L and the free-risk rate R_f:

$$R_L = \frac{(1+R_f)}{(1-PD)} - 1 \quad \text{and,} \quad \frac{\partial R_L}{\partial PD} > 0.$$

$D(R_d, \tilde{\beta})$ = the supply function of the public's deposits that are affected (positively) by the own interest rate (R_d) and a shift parameter $\tilde{\beta}$.

$Z = [L-(1-r)D]$ is the activity of the bank in the secondary market, where r = the reserve requirement on public deposits. Z can be positive, negative or zero.

If $Z > 0$, the bank has a shortage of sources in the primary market, and will have to raise funds in the secondary market at interest rate R_W, e.g., discount-window borrowing or interbank borrowing.

If $Z < 0$, the bank has excess sources (funds) and buys assets in the secondary market, such as deposits with the central bank, Treasury securities, earning an interest rate R_b.

Given the activity in the secondary market, we define the interest rate, R, as follows:

$$R = R_b + I(R_w - R_b), \quad where \quad I = \begin{cases} 1, & Z > 0 \\ 0, & Z < 0 \end{cases}$$

F = the operating cost function of the bank, which we assume to be constant in the short term.

k = the cost of equity (required rate of return).

K^* = the required (regulatory) capital in monetary terms.

Taking the first derivative of $E(\Pi)$ in equation (1) with respect to L, assuming $Z > 0$, yields the following first order condition[7]:

$$\frac{\partial \Pi}{\partial L} = (1-PD)(1+R_L)\frac{\partial L(\cdot)}{\partial L} + L(\cdot)(1-PD)\frac{\partial (1+R_L)}{\partial L} - (1+R_w)\frac{\partial L(\cdot)}{\partial L} - k \cdot \frac{\partial K^*}{\partial L} = 0 \qquad (2)$$

[6] Gordy and Howells (2006) examine the procyclicality issue from the perspective of market discipline: how it affects banks' lending policies and the efficacy of policy options.

[7] The assumption here is that *EAD* is equal to the amount of the bank's outstanding loans (L), with the result that $\frac{\partial K^*}{\partial L} = K$.

Rearranging the terms and summing over all banks, assuming that the market structure is Cournot-oligopolistic, yields an equality between marginal revenue *(MR)* and marginal cost *(MC)* as follows:

$$\underbrace{(1-PD)(1+R_L)\left[1-\frac{H}{\eta}\right]}_{MR} = \underbrace{(1+R_w)+k\frac{\partial K^*}{\partial L}}_{MC} \qquad (2a)$$

where, $\eta = -\frac{\partial L}{\partial R_L}\frac{R_L}{L}$ is the elasticity of demand for loans;

$H = \sum_{i=1}^{n} S_i^2$ is the Herfindahl-Hirschman index of concentration in the loan market where, $S_i = (L_i/L)$ is the market share of bank *i* in the loan market.

Solving for $(1+R_L)$ yields;

$$(1+\mathrm{R_L}) = \theta + (1+\mathrm{R_f})\frac{\mathrm{H}}{\eta} + (1+\mathrm{R_w}) + \mathrm{k}\frac{\partial \mathrm{K}^*}{\partial \mathrm{L}} \qquad (3)$$

where, $\theta = R_L - R_f$ is the yield differential (i.e. the risk premium) which can also be written as $PD(1 + R_L)$ (see Paroush and Ruthenberg (2003)).

From (3) it follows that the interest rate on loans is determined by the risk premium *(θ)*; the industry's market power as determined by its concentration *(H)*; the market elasticity of demand for loans (η); the risk free rate (R_f) (such as the prime rate); the cost of raising funds in the secondary market – cost of debt *(R_w)*; and the multiple of the cost of capital (equity) raised (*k*) by the sensitivity of the required capital to changes in the amount of loans extended $\left(\frac{\partial K^*}{\partial L}\right)$.

<u>In general terms, the rate of interest on loans</u> (equation (3)) can be written as follows:

$(1 + R_L)$ = g (credit risk, market structure, cost of debt, cost of equity and the sensitivity of capital to loans extended)

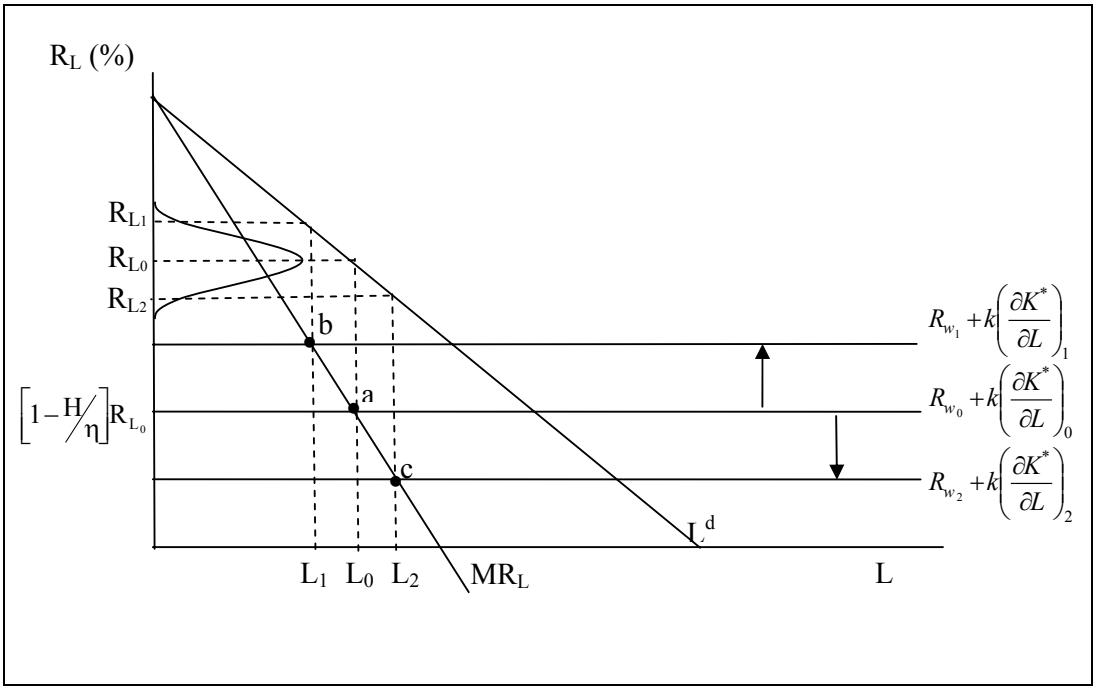
Figure 1 illustrates the sensitivity of bank loans and interest rates to capital charges and $\left(\frac{\partial K}{\partial L}\right)$ the cost of equity (*k*). As can be seen, the rate of interest on loans (R_L) ,after equating marginal revenue with marginal cost see equation (2A), may vary between R_{L1} and R_{L2}. We claim that the distribution of R_L under the new regime depends

(all else being equal) on the distribution of *PD's* of the bank's loans to its retail customers and to corporates.

As specified in the expected profits equation (*1*), the demand for loans is a function of the interest rate on loans *(R_L)* and a shift parameter ($\tilde{a}$). In general terms, we write the demand for loans as follows;

$$L^d = (R_L, \tilde{a}) \tag{4}$$

Figure 1: Determining the interest rate on loans (R_L) and the quantity of loans *(L)* in a non-competitive market in response to changes in capital requirements within the framework of the Basel II capital accord.



4. The structure of the Israeli Banking System

At the end of 2005 the Israeli banking system was comprised of five large banking groups, two small independent banks, and two branches of large foreign banks (HSBC and Citibank). The number of banking corporations operating in Israel was 29 (15 commercial banks, 5 mortgage banks, 2 foreign banks and 7 other financial institutions) compared with 63 banking corporations that operated at the end of 1980. The decrease in the number of banks during that period is the result of bankruptcies or mergers and acquisitions, principally between small and large banks[8].

The Israeli banking system is characterized by a high degree of concentration; the largest three banking groups account for close to 77% of the system's total assets, and the Herfindahl-Hirschman index of concentration (*H* index) is 0.228[9].

Banks in Israel provide what can be described as universal banking services. In addition to classic banking intermediation, the large commercial banks heading the banking groups have subsidiaries that engage in several activities complementary to commercial banking. These activities include mortgage banking, credit cards, overseas banking (via subsidiaries and branches), direct and indirect ownership of companies that operate in the financial and capital markets (such as trading in securities, management of investment companies and investment banking), and insurance companies. The activities described above enable the banking groups to utilize economies of scale and scope and to diversify their risks more effectively than small independent banks (see Landskroner, Ruthenberg and Zaken, (2005)).

The Israeli banks are active in three segments of intermediation: the unindexed local currency (nominal) segment (which accounts for approximately 40% of their total assets), the CPI-indexed segment, and the foreign currency segment (foreign-currency denominated and indexed). The share of the last two segments in the banks' total assets is approximately 30% each.

Another important feature of the Israeli banking system relates to capital adequacy. Although all banks meet the minimum capital adequacy requirement of 9%, the excess capital ratio above the minimum required in Israel is one of the lowest among developed countries[10].

[8] Commercial banks supply financial services via 992 branches and 1,370 ATMs (the number of which increased substantially during the last 20 years) and via internet banking.

[9] The high concentration level in Israel is also reflected in international comparison: The *H* Index for the Israeli banking system's total assets was 0.228 in 2005, vs. an overall mean of 0.163 for foreign banking systems and 0.187 for Israel's peer group.

[10] For an updated detailed analysis of the Israeli banking system, see the Annual Survey of Israel's Banking System (2005).

5. Empirical Estimation of Loan Pricing in the Israeli Banking System

In this section we estimate the loan and interest rate equations in the unindexed local currency segment for retail and corporate customers. The main reason for using data on the unindexed segment is its availability, particularly the ability to distinguish between rates and the amount of loans extended to retail customers versus corporates. The assumption here is that the activity of commercial banks in the unindexed segment provides a good approximation for their total activity as financial intermediaries.

Because of the simultaneity inherent in the analysis, as discussed above, the interest rate on loan-equation (3) was estimated simultaneously with the demand for loans (L^d) – equation (4), using the Two Stage Least Squares (2SLS) technique.

In general terms, the two equations comprising the system of equations are:

The interest rate on loans equation: $R_L = f$ (credit risk, market structure, cost of debt, cost of equity and the sensitivity of capital charges to loans extended).

The demand for loans equation: $L^d = g$ (interest rate on loans, the income effect (economic activity) and the substitution effect).

All of the variables in the estimated equations were calculated after a logarithmic transformation was performed, with the exception of interest rates, yields and other variables that had negative values during the time of analysis, on which we performed a $ln(1+x)$ transformation. The sample period of the study is September 1998 – May 2006, the frequency of the data is monthly and the bank-specific data were obtained from one of the largest banks in Israel.

Since Basel II distinguishes between corporate customers and retail customers, we ran the system of equations separately for the two populations. Table 1 lists and defines the variables used in these equations while Table 2 summarizes the regression results for both samples.

able 1: Definitions, notations and the expected effects of the Independent variables

	Variable	Measure	Notation	Expected effect
Dependent variable	Demand for loans	For corporates: average amount of loans to corporates.	*Lc*	
		For retail customers: average amount of loans to retail customers.	*LR*	
Independent variables	Interest rate on loans	For corporates: Interest income plus management fees divided by the average amount of loans.	*RLC*	*Negative*
		For retail customers: Interest income plus management fees divided by the average amount of loans.	*RLR*	
	Income effect	For corporates and retail customers: Percentage change in Gross Domestic Product.	$\%\Delta GDP$	*Positive*
	Substitution effect	For corporates and retail customers: Standard deviation of expected inflation during 24 month period.	σ_P	*Negative*
		For corporates and retail customers: Percentage change in funds (bonds and stocks) raised on the Tel Aviv stock exchange.	$\%\Delta F$	*Negative*
Dependent variable	Interest rate on loans	For corporates: interest income plus management fees divided by the average amount of loans.	*RLC*	
		For retail customers: Interest income plus management fees divided by the average amount of loans.	*RLR*	
Independent variables	Risk	For corporates: the ratio of loan loss provisions to the average amount of loans.	*LLPC*	*Positive*
		For retail customers: the ratio of loan loss provisions to the average amount of loans.	*LLPR*	
	Structure	For corporates and retail customers: Market share of total assets in the unindexed segment.	*MS*	*Positive*
	Cost of debt (secondary-market)	Yield to maturity on a 1-year Treasury Bill.	*TB*	*Positive*
	Cost of equity sensitivity	The multiple of the cost of equity (k), by $\left(\frac{\partial K^*}{\partial L}\right)$ assumed to be 9%.	$k \bullet \left[\frac{\partial K^*}{\partial L}\right]$	*Positive*

Table 2: Regression Results of simultaneous equation system (using 2SLS) of loan rates (R_L) and demand for loans (L^d) for corporates and retail customers. Monthly data, Sep 1998 - May 2006.

a. Loan Rate Equation (R_L)

Independent variables	corporates	retail customers
Intercept	-0.12	-0.06
	(-2.24)**	(-1.20)
Loan loss provisions	1.08	
$ln\ (1+LLP_C)_{t-3}$	(1.87)*	
Loan loss provisions		0.82
$ln(1+LLP_R)_{t-1}$		(1.84)*
Market share	0.39	0.40
$ln(1+MS)_t$	(1.85)*	(2.12)**
Cost of debt (secondary market)	1.35	1.10
$ln(1+TB)_t$	(8.99)***	(14.42)***
Cost of equity sensitivity	0.11	0.07
$(ln(1+k)+ ln(1.09))_t$	(1.63)*	(1.97)**
AR(1)	0.78	0.52
	(4.67)***	(5.46)***
D.W	2.25	2.11
$\overline{R}^2$	0.95	0.93

Continue

b. Demand for Loans Equation (L^d)

Independent variables	corporates	retail customers
Intercept	17.20	15.61
	(62.87)***	(61.10)***
Interest rate on loans	-2.27	
$ln(1+R_{LC})_t$	(-1.62)*	
Interest rate on loans		-1.06
$ln(1+R_{LR})_t$		(-1.88)*
Changes in Gross Domestic Product	0.41	
$ln(1+\%\Delta GDP)_{t-5}$	(1.68)*	
Changes in Gross Domestic Product		1.47
$ln(1+\%\Delta GDP)_{t-3}$		(1.78)*
Standard deviation of expected	-0.11	
Inflation $ln(1+\sigma_p)_{t-5}$	(-1.78)*	
Standard deviation of expected		-0.09
Inflation $ln(1+\sigma_p)_{t-2}$		(-2.02)**
Change in funds raised	0.0003	
$ln(1+\%\Delta F)_{t-3}$	(0.25)	
AR(1)	0.91	0.80
	(14.80)***	(10.68)***
D.W	1.52	1.72
$\overline{R}^2$	0.98	0.77

The *t* statistics appear in parentheses under the coefficient.

*** Indicates significance at the 1% level

** Indicates significance at the 5% level

* Indicates significance at the 10% level

The main findings are as follows:

Corporates;

All the independent variables in the demand for loans equation with the exception of the substitution (contestability) variable (defined as funds raised on the Tel Aviv Stock Exchange) obtained their expected signs and were statistically significant:

a) As expected, the change in Gross Domestic Product *(GDP)* which represents the income effect was found to have a positive impact on the demand for loans. This finding suggests that during periods of growth in the economy, the demand for loans by corporates increases while during periods of recession their demand for loans declines.

b) The substitution effect was decomposed into substitution within the banking system, and substitution (contestability) facing the entire banking system. The substitution within the banking system is estimated as inflationary uncertainty (measured by the standard deviation of monthly inflation)[11]and as expected, has a negative impact on the banks' demand for loans. In this respect we assume that the demand for indexed loans is a substitute for unindexed local currency loans. With regard to contestability facing the entire banking system from substitutes for bank loans, we used the variable: funds (equity and bonds) raised by corporates on the TASE (Tel Aviv Stock Exchange). This variable was found to be statistically insignificant. We can therefore conclude that during the period examined the stock market did not constitute a competitive threat to the banking system[12].

c) The interest rate charged on unindexed loans obtained a negative sign, as expected, and was found to be statistically significant.

With respect to the interest rate equation, which is the main focus of this paper, all of the explanatory variables obtained their expected signs and were statistically significant.

The explanatory variables in the interest rate equation include:

a) Loan-loss provisions for corporates as a percent of loans extended. This variable represents the risk component in the interest rate equation (that is, a proxy for θ in equation (3)), and as expected, was found to have a significant positive effect on the interest rate.

b) The market share of the individual bank in total assets in the unindexed segment. This variable represents the structure in the unindexed loan market (a proxy for H in equation (3)) as expected it was found to have a positive and significant impact on the interest rate.

[11] The standard deviation of inflation was calculated using monthly inflation during the previous 12 months.

[12] It should be noted that in recent years (since the beginning of 2003) there has been a significant increase in the amount of funds raised by corporates in the TASE as well as in the amount of funds raised through other non-banks sources. However, this period is probably too short to have a significant effect in our regression analysis.

c) The yield to maturity on a 1-year Treasury Bill. This variable represents the cost of debt in secondary market (R_w in equation (3)) and as expected, was found to have a positive impact on interest rate.

d) The cost of equity sensitivity, namely the multiple of the cost of equity *(k)* by the sensitivity of capital charges to the amount of loans extended ($\frac{\partial K^*}{\partial L}$), was as expected found to have a positive and a significant impact on the interest rate.

Although the bank's economic capital is composed of 2/3 core equity capital (tier 1) and 1/3 subordinated debt (tier 2), we assumed that the bank's cost of capital is based on the cost of equity capital. For measurement purposes we applied the *CAPM* model, whereby the expected (required) return on equity of bank *i* (its cost of equity) is written as:

$k_i = E(R_i) = R_f + \beta_i(R_M - R_0)$.

where:

R_f = The risk free rate represented by the average annual yield to maturity on a Treasury Bill with 360 days maturity.

R_M = The market yield, represented by the average annual yield on the TA (Tel Aviv) 100 index measured during a 5 year period[13].

β_i = The beta (β_i) of bank *i*. This was estimated by a series of *OLS* regression equations of the monthly stock return of bank *i* (R_i) on the monthly return of the TA-100 index (R_M), over a 24 month moving window: $R_i = \alpha_0 + \beta_i R_M + e_i$.

After adding to the loan regression equation the variable *AR(1)* (Autoregressive Error Process of the first order), there was no evidence of a serial correlation, as reflected by the values of the Durbin-Watson statistics. The adjusted *R* squares $\left(\overline{R}_s^{\,2}\right)$ were relatively high in the interest rate and the demand for loans regression equations (0.95 and 0.98 respectively).

Retail customers:

Similar equations were run for retail customers (mostly households). The results are also reported in Table 2 and the variables used are defined in Table 1. The regression results in respect of retail customers are for the most part encouraging, in the sense that all the independent variables obtained their expected signs and were statistically significant. However, there are several exceptions in these equations compared to those for corporates:

1) In the loan demand equation the variable representing the substitution effect includes only the substitution within the banking system that is represented by the standard deviation of monthly inflation. The reason for the exclusion of a variable that represents the substitution

[13] The TA-100 Index is one of the TASE's leading indices, published since 1992. The index consists of the 100 stocks with the highest market capitalization in Israel.

outside the banking system is that in Israel households, in contrast to corporates, do not have good substitutes outside of the banking system[14].

2) In the interest rate equation, the risk variable is measured by the loan loss provisions to retail customers.

The adjusted *R* squares $\left(\overline{R}_s^{\,2}\right)$ were relatively high in both equations (0.93 and 0.77 in the interest rate and in the loan demand regression equations respectively). After introducing *AR(1)* variables there was no evidence of serial correlation in either of the equations.

Out-of sample-prediction

Based on the regression results (reported in Table 2), we performed a simulation (that is, out-of-sample prediction) with regard to the interest rates which the bank would charge its corporate and the retail customers when the Basel II capital accord is implemented. The simulation is performed with respect to the two approaches available to banks: the Standardized approach and the Internal rating based (IRB) approach.

With regard to **corporates**, the simulations are presented in figure 2. For the sake of convenience, we plotted both approaches on the same diagram therefore, the horizontal axis covers both *PD's* (for the *IRB* approach) and credit ratings (for the Standardized approach).

The simulation was performed as follows:

Firstly, we assume that the independent variables (loan loss provisions [*LLP*], market share [*MS*], Treasury Bills [*TB*] and cost of equity [*k*]), that appear in equation (3) and in Table 2, obtain their average values which prevailed during the period June 2003 – May 2006[15]. The variable $\ell n\,(1+\frac{\partial K^{*}}{\partial L})$, on the other hand, is assumed to be equal to zero, meaning that the *PD's* of customers is assumed to equal to zero. This assumption is necessary in order to derive the expected loan rates as a positive function of *PD's*. Based on the above assumptions, the intercepts of the expected loan rates paths are obtained by multiplying the average values of the independent variables by their respective estimated coefficients as they appear in table 2. The two intercepts obtained are equal to 6.22% using the *IRB* approach and 6.42% for the Standardized approach.

Secondly, after obtaining the two intercepts we assumed that from then onwards, loan rates are likely to be affected by the capital required according to the *IRB* approach based on equation (A1) in the appendix and the Standardized approach based on the weights reported in Table A1.

[14] To verify this assertion we included the variable bonds and stocks raised in the TASE (i.e %ΔF) in the demand for loans by retail customers' equation. This however proved to be insignificant.

[15] It should be emphasized that this period was characterized by a growth in the Israeli economy after few years of recession, and we assume that during the next three years the economy will continue to grow.

As can be seen, the average actual effective loan rate for corporates for the period June 2003-May 2006, was 7.49%. The break-even point (the intersection of the actual rate with the expected rate) yields a *PD* of 5.3% for the *IRB* approach and a *PD* of 10% for the Standardized approach.

The diagram shows that all corporate customers with *PD's* lower than 9.4% (which is the intersection of the expected rate of the *IRB* and the Standardized approach), approximately 95% of corporate customers will be charged a rate of interest lower than the average prevailing during the last three year period.[16] This lower rate will be charged by banks adopting the *IRB* approach. On the other hand, with banks adopting the Standardized approach, the reduction in the loan rates will be available to customers with a *PD* higher than 9.4%.

From the above analysis we can therefore conclude that high quality (low risk) customers will enjoy a reduction in loan rates only at banks that adopt the *IRB* approach as opposed to the Standardized approach. On the other hand, the low quality (high risk) customers, those with *PD's* higher than 9.4%, will be better off obtaining loans from banks which adopt the Standardized approach[17]. These results are similar to those obtained by Repullo and Suarez (2004) however, our model differs from theirs in that we consider an imperfectly competitive banking market.

We performed the same type of analysis for **retail** customers (Figure 3).

The results are similar to the ones obtained for corporates although the values of the *PD's* in equilibrium are different. It is possible to conclude from the Figure that retail customers with *PD's* lower than 13.4% will prefer banks that adopt an *IRB* approach while very risky customers (with *PD's* higher than 13.4%) will prefer banks that adopt the Standardized approach.[18] It can be concluded from the above analysis that nearly all retail customers will prefer banks that adopt an *IRB* approach[19].

[16] The average *PD* for small / medium corporates was found to be 1.61% for other non-G10 Group 1 countries by Basel quantitative impact study (BIS 2006a).

[17] That is we may expect a shift in the demand for loans between banks according to the quality of the borrowers depending on the approach adopted by the banks.

[18] The average *PD* for other retail customers was found to be 2.77% for other non-G10 Group 1 countries by the Basel quantitative impact study (BIS 2006a).

[19] It should be emphasized that the actual loan rates charged to retail customers are higher than those charged to corporates (for example, during the period 3.2006-5.2006 it was 11.43% vs. 7.49% respectively). This difference in the rates is reflected in the higher market power banks exercise on retail customers as opposed to corporates.

Figure 2: The actual loan rate (6.2003-5.2006) against the expected loan rate (based on Regression equations 3 and 4) according to a Standardized approach and an *IRB* approach of Basel II, effective annual terms, Corporates ; 09/1998-05/2006

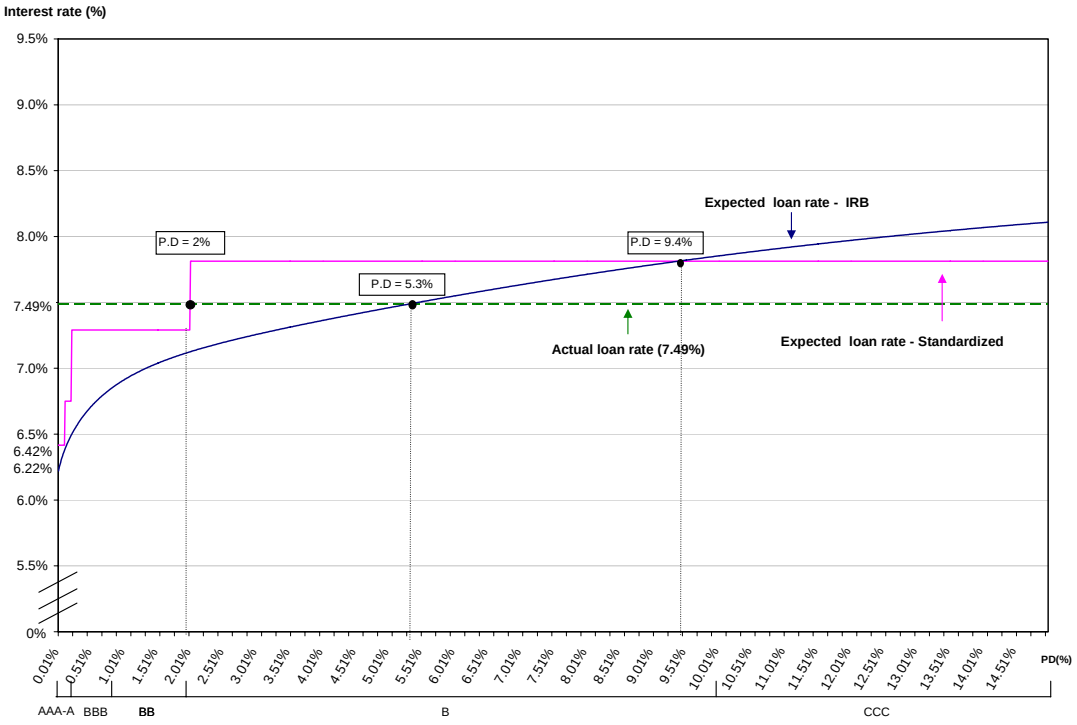
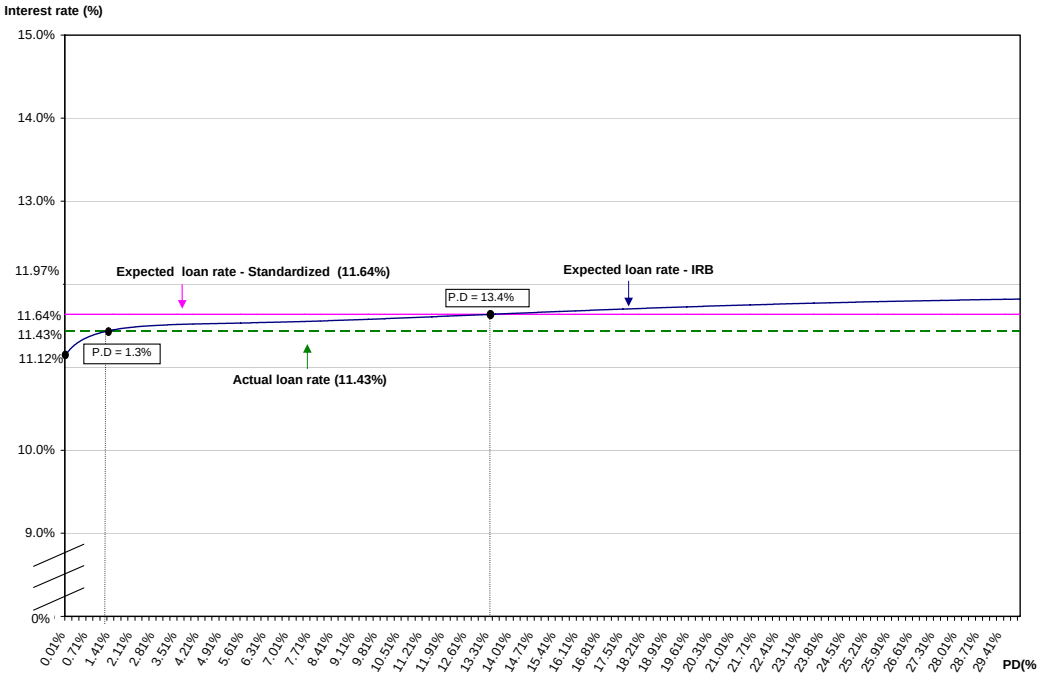


Figure 3: The actual loan rate (6.2003-5.2006) against the expected loan rate (based on Regression equations 3 and 4) according to a Standardized approach and an *IRB* approach of Basel II, effective annual terms, Retail ; 09/1998-05/2006



6. Summary and conclusions

In this paper we derive a loan rate equation for a commercial bank, assuming that the bank is risk neutral and operates in a market characterized by imperfect competition. Based on the data of a leading bank in Israel and the *PD's* of its customers, by means of simultaneous equations regression analysis (using Two-Stage-Least-Squares technique), we estimated the impact of the Basel II capital accord on the loan rates which banks will charge their corporate and retail customers under the Standardized and the Internal based approaches (*IRB*).

The results show categorically that high quality (low risk) corporate customers will enjoy a reduction in loan rates if they obtain loans from banks that adopt an *IRB* model. On the other hand, low quality (high risk) corporate customers will enjoy a reduction in loan rates only if they obtain loans from banks that adopt the standardized approach.

With respect to retail customers, almost all these customers will enjoy a loan rate reduction if they obtain loans from banks that adopt the *IRB* approach.

These results have a direct implication on the risk distribution among banks. In particular, the large and high quality banks, which are expected to adopt the *IRB* approach, will tend to serve the less risky customers while the small and low quality banks, which are expected to adopt the Standardized approach, will thus tend to serve the more risky customers.

Appendix:

Table A1: Risk weights for capital allocation according to the Standardized approach of Basel II (percent)

Credit Assessment / Claims on		AAA to AA-	A+ to A-	BBB+ to BBB-	BB+ to B-	Below B-	Unrated
Sovereigns		0	20	50	100	150	100
Banks	Option 1	20	50	100	100	150	100
	Option 2	risk weights are based on external credit assessment					
	Up to 3 months	20	20	20	50	150	20
	Over 3 months	20	50	50	100	150	50

Credit Assessment / Claims on	AAA to AA-	A+ to A-	BBB+ to BB -	Below BB-	Unrated
Corporates	20	50	100	150	100

1) The risk weight for retail portfolios (individual person or persons or small businesses) which meet certain criteria (product, diversification of retail portfolio, low value of individual exposure) is 75% (in Basel I the risk weight was 100%).
2) The risk weight for lending secured by mortgages on residential property is 35% (in Basel I the risk weight was 50%).

B. The formula for calculating the capital requirement under the IRB approach:

The formula for calculating the capital requirements *(K)* as a percentage of the bank's Exposure at Default *(EAD)*, which is based on a model assuming portfolio invariance (Gordy 2003)[20] and the normal distribution function to measure the borrower's PD (Vasicek 2002) is[21]:

$$K = \left[LGD \times N\left(\frac{N^{-1}(PD) + \rho^{\frac{1}{2}} N^{-1}(0.999)}{\sqrt{1-\rho}} \right) - [PD \times LGD] \right] \times A^{*} \qquad \text{(A1)}$$

Alternatively to equation (A1), the unexpected loss *(UL)* or the required capital as a percent of *EAD* can be written as follows:

$$\frac{UL}{EAD} = K = \left[\frac{VaR}{EAD} - [PD \times LGD] \right]$$

where,

PD = probability of default, per rating grade, which gives the average percentage of borrowers that default in this rating (normally in the course of one year).

LGD = loss given default, which is the percentage of exposure which the bank might lose if the borrower defaults i.e., (1- Recovery rate).

EAD = exposure at default, which is an estimate of the amount of credit outstanding if the borrower defaults.

N (x) = the cumulative distribution function for a standard normal random variable (i.e. the probability that a normal random variable with mean zero and variance of one is less or equal to *x*).

$N^{-1}(x)$ = the inverse cumulative distribution function for a standard normal random variable.

As the equation shows, the Basel Committee chose 99.9% percentile confidence interval, where, $N^{-1}(0.999) \approx 3.09$.

ρ = the weighted (by λ) correlation between the different exposures (different credits), determined by the Basel committee which shows how the asset value of one borrower (exposure) depends on the asset value of another borrower (exposure)[22].

[20] Portfolio invariance means that the capital required for any given loan should only depend on the risk (*PD*, *LGD* and *EAD*) of that loan and must not depend on the risk of the portfolio it is part of. This characteristic is essential for calculating and applying the *IRB* framework, as presented in equation (4). Otherwise, one has to recognize the diversification effect of the loan portfolio in calculating the capital charges (*K*).

[21] For further explanation for formula (A1) and the meanings of its components see BIS (2005).

[22] The equation of ρ is: $\rho(PD)=0.12\lambda+0.24(1-\lambda) - 0.04[1-(S-5)/45]$ where, $\lambda = \left[\frac{1-e^{(-50\times PD)}}{1-e^{(-50)}} \right]$ and S = the size (determined by the extent of sales) of the corporate.

A^* = a component used to adjust capital requirements to the effective time to maturity *(M)* and to the probability of default *(PD)* [23].

Accordingly, the unexpected losses *(UL)* in monetary terms, K^*, can be written as:

$$K^* = K \times EAD.$$

It can be shown that *PD*, *LGD* and *EAD* are positively related to *K*[24]:

$$\frac{\partial K}{\partial PD} > 0; \frac{\partial K}{\partial LGD} > 0 \text{ and } \frac{\partial K}{\partial EAD} > 0$$

[23] The A^* component is specified as follows: $A^*(M, PD) = \left\{(1-1.5b(PD))^{-1} \times (1+(M-2.5)\times b(PD))\right\}$

where, the coefficient *b* is determined by the Basel Committee as $b = \left[(0.11852) - 0.05478 \times ln(PD)\right]^2$

The formula for the effective time to maturity is: $M = \sum_t t \times CF_t \Big/ \sum_t CF_t$

where, CF_t = The cash flows (principal, interest payments and fees) of the loan in period *t*.

Both, theoretical and empirical evidence suggest that long-term credits are riskier than short-term credits. As a consequence, the capital requirement *(K)* should increase with maturity *(M)*; $\frac{\partial K}{\partial M} > 0.$

[24] It can also be shown, that in the relevant range, $\frac{\partial K}{\partial \rho} > 0.$ An intuitive explanation to the positive relation between ρ and *K* is the fact that as the correlation between the components of the loan portfolio (borrowers or sectors) is lower, loan portfolio is more dispersed or less risky, and less capital is therefore required to cover the unexpected losses in the loan portfolio. The opposite will happen when the correlation between the components of the loan portfolio is higher.

References

Bank of Israel, Banking Supervision Department, *Israel's Banking System,Annual Survey, 2005.*

Barnea A., Y. Landskroner, Y. Paroush and D. Ruthenberg, 1999, "An Econometric Model of Israel's Banking System", *Bank of Israel Banking Review* 7.

Basel Committee on Banking Supervision, 2006 "International Convergence of Capital Measurement and Capital Standards" BIS, June.

Basel Committee on Banking Supervision, 2006a "Result of the Fifth Quantitative Iimpact Study (QIS 5)" BIS, June.

Basel Committee on Banking Supervision, 2005 "An Explanatory Note on the Basel II *IRB* Risk Weight Functions" BIS, July.

Berg S.A. and M.Kim, 1998, "Banks as Multioutput Oligopolies: An Empirical Evaluation of the Retail and Corporate Banking Markets", *Journal of Money, Credit and Banking* 30(2) pp 135-153.

Cave J., J. Feid, G. French and W. Stark, 2003, "Risk-Based Capital Requirements for Commercial Lending: The Impact of Basel II" FDIC.

Claessens S. and L. Laeven, 2004, "What Drives Bank Competition? Some International Evidence", *Journal of Money, Credit and Banking*, 36(3) part 2.

French G., 2004, "Estimating the Capital Impact of Basel II in the United States" FDIC.
Gordy M.B., 2003, "A Risk-Factor Model Foundation for Rating-Based Bank Capital Rules", *Journal of Financial Intermediation* 12, pp 199-232.

Gordy M.B and B. Howells 2006, "Procyclicality in Basel II: Can we treat the disease without killing the patient?", *Journal of Financial Intermediation* 15, pp 395-417.

Hasan I. and C. Zazzara, 2006, "Pricing Risky Bank Loans in the New Basel II Environment", Journal of Bank Regulation, 7, 243-269.

Klein M.A.,1971, "A Theory of the Banking Firm ", *Journal of Money, Credit and Banking,* 3 (May), pp. 205-218.

Landskroner Y, D. Ruthenberg and D. Zaken, 2005, " Diversification and Performance in Banking The Israeli Case"", *Journal of Financial Service Research 27:1. pp. 27-49.*

Liebig T., D. Porath, B.W. di Mavro, M. Wedow, 2004, "How will Basel II affect Bank Lending to Emerging Markets? An Analysis based on German Bank Level Data", Deutsche Bundesbank, Banking and Financial Supervision, Discussion Paper No 05/2004.

Paroush J. and David Ruthenberg, 2003, "The Risk Premium and Market Power in Israeli Banking", *Bank of Israel Banking Review* 8, pp. 55-66.

Repullo R. and J. Suarez, 2004, "Loan Pricing under Basel Capital Requirements", *Journal of Financial Intermediation*, 13(4), pp. 496-521.

Sealey C.W., 1980, "Deposit Rate Setting, Risk Aversion and the Theory of Depository Financial Intermediaries", *Journal of Finance* 35 (December), pp. 1139-1154.

Vasicek O.A., 2002, “Loan Portfolio Value”, *Risk*, December, pp 160-162.