

Interest Rate Risk and Bank Common Stock Returns: Evidence from the Greek Banking Sector

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Abstract

The paper explores the effect of changes in the long-term interest rate on the common stock returns of banks listed in the Athens Stock Exchange. Two alternative econometric strategies are followed. First, in a single equation framework the interest rate sensitivity of stock returns is tested, allowing for time-varying conditional volatility. Then, 'pooling' information across stocks, a system-theoretic approach is employed where explicitly interdependence of stocks is exploited. The findings from both methods were consistent providing evidence for significant sensitivity of bank stock returns to interest rate movements. Working capital was found as the variable that may account for the cross-sectional variation of the interest-rate sensitivities providing evidence for the nominal contracting hypothesis.

Keywords: *APT, Bank Common Stock Returns, GARCH-modelling, Seemingly Unrelated Regressions (SURE)*

JEL classification: *C22, C32, E43, G12*

1. Introduction

Stock returns sensitivity to interest rates was theoretically advocated by Merton (1973), Long (1974) and Stone (1974). Essentially, risk averse investors demand higher compensation for exposure to factors, other than the market portfolio, that are correlated with intertemporal changes in the investment opportunity set. Merton suggested that the level of market interest rates might provide a proxy for shifts in the investment opportunity set (Flannery et. al, 1997).

Therefore, if a risk averse investor is choosing between two assets giving the same distribution of future wealth but exhibiting differential sensitivity to interest rates (in terms of covariance), then she will select the portfolio that provides better hedging services against unfavourable movements in interest rates (Yourougou, 1990).

Empirical investigation of stock returns interest rate sensitivity has produced evidence in favour of the existence of such sensitivity. For instance Fama and Schwert (1977) and Fogler et al. (1981) have shown that the inclusion of an interest rate factor adds substantially to the explanatory power of the single-factor model. Also, Sweeny and Warga (1986), Yourougou (1990) report that for a subset of securities interest rate risk is present.

The issue of interest rate sensitivity of bank common stock returns is of major interest for regulators, banks and academics for that reason a voluminous literature has explored the issue. Empirical studies have provided substantial evidence for bank stock returns exhibiting statistically significant inverse relationship with interest rate changes (Flannery and James, 1984; Brewer and

Lee, 1985; Scott and Peterson, 1986; Kane and Unal, 1988; Saunders and Yourougou, 1990; Kwan, 1991; Akella and Greenbaum, 1992; Choi et al., 1992).

The research interest on the issue has been recently revived, attracting more attention in the empirical literature producing a new wave of further evidence for a significant negative relationship between bank stock returns and interest rate changes (Choi et al., 1996; Allen and Jagtiani, 1997; Flannery et al., 1997; Elyasiani and Mansur, 1998; Benink and Wolff, 2000; Jianping and Zheng Wang, 2000). However, Choi et al. (1996), Allen and Jagtiani, (1997) and Benink and Wolff, (2000) conclude that interest rate sensitivity has decreased in the late 1980's and early 1990's due to the availability of interest rate derivatives contracts that can be used for hedging purposes.

The bulk of the research has almost exclusively focused on the US banking sector. The present study will investigate the interest rate sensitivity of the Greek banking sector.

The paper makes two main contributions. First, in methodological terms a robust way is used in order to test for interest rate sensitivity of bank common stock returns, both within a single equation framework model (allowing for time-varying conditional volatility) and also in a systems framework. The second contribution of the paper is that it tests whether bank sensitivity to interest rates is uniform across banks. Additionally, it investigates the possible determinants of the apparent cross-sectional variability in the interest rate sensitivity parameters.

The importance of the study stems from the fact that financial intermediaries play a crucial role in economic growth. In the case of emerging markets, like the Greek, financial intermediaries play an even more significant role in the development process (Bencivenga and Bruce, 1991; King and Levine,

1993; Levine and Zervos, 1998). Therefore, studying the effects of interest rate movements on bank stock returns is of great significance for policy design. Additionally, knowing the nature of this relationship can also provide valuable information for portfolio management purposes both domestically, as well as, internationally. Given the increased comovement of mature financial markets, diversification gains could be exploited by turning investment attention to emerging markets like the Greek.

As discussed above recent studies for the US banking sector have concluded that interest rate sensitivity has decreased in the late 1980's and early 1990's due to the availability of interest rate derivatives contracts for hedging purposes (Choi et al., 1996; Allen and Jagtiani, 1997; Benink and Wolff, 2000). However, Greek banks did not have access to a local derivatives market in order to use such contracts for hedging purposes. The Athens Derivatives Exchange (ADEX) was only established in April 1998 offering a restricted set of contracts. So interest rate exposure could not be explicitly hedged until recently.

In particular the present study will address the following research questions:

- Do bank common stock returns exhibit significant sensitivity to changes in the long-term interest rate?
- Then, if indeed the sensitivity is significant, is there a negative relationship between stock returns and interest rate changes?
- Is interest rate sensitivity uniform across banks?
- If uniformity is rejected, in favour of heterogeneity, which are its determinants?

Addressing these questions will assist in understanding the interest rate risk exposure of the Greek banking sector and will also provide evidence for an emerging market. The latter will allow for a comparison between capital markets of different depth and maturity.

The paper will be organised as follows. Section 2 will provide a brief literature review. Section 3 will summarise the data employed. Section 4 will outline the econometric methodology. Section 5 will discuss the empirical findings and finally, Section 6 will conclude.

2. Literature Review

There are two strands of the literature. The first one explores interest rate sensitivity of bank stock returns by assuming and explicitly testing a two-factor model based on the Arbitrage Pricing Theory (APT, hereafter) developed by Ross (1976). The two factors 'driving' stock returns are typically identified as the market portfolio (M) and changes in the long-term interest rate (I). The general form of the APT model assumes the following return generating process:

$$R_{i,t} = E(R_{i,t}) + \sum_{j=1}^k \beta_{ij} [F_{j,t} - E(F_j)] + \varepsilon_{i,t} \quad (1)$$

where $R_{i,t}$ is the observed return on security i at time t , $E(R_{i,t})$ is the expected (unobserved) return on security i at time t , $F_{j,t}$ is the level of market factor j at time t and $[F_{j,t} - E(F_{j,t})]$ measures the unexpected change in factor j at time t , β_{ij} is the sensitivity of stock i to factor j . Finally, $\varepsilon_{i,t}$ is the specific error for security i at time t . It is assumed that the specific errors are serially uncorrelated and orthogonal to unexpected change in the factor j . Assuming no arbitrage opportunities one can

show that the expected return on a security is linearly related to the risk premia on the above mentioned factors:

$$E(R_i) = \alpha_0 + \sum_{j=1}^k \alpha_j \beta_{ij} \quad (2)$$

where α_0 is the risk-free rate or the return on the zero-beta portfolio and α_j is the risk premium associated with the risk factor j . Substituting (2) in (1) and rearranging, gives:

$$R_{i,t} = \alpha_0 + \sum_{j=1}^k [(\alpha_j - E(F_j))] \beta_{ij} + \sum_{j=1}^k \beta_{ij} F_{jt} + \varepsilon_{i,t} \quad (3)$$

If a two-factor APT model is assumed where the factors are identified as the market portfolio and long-term interest rate changes, then (3) can be written as:

$$R_{i,t} = \alpha_0 + [\alpha_1 - E(R_m)] \beta_{i,M} + [\alpha_2 - E(I)] \beta_{i,I} + \beta_{i,M} R_{M,t} + \beta_{i,I} I_t + \varepsilon_{i,t} \quad (4)$$

where $R_{M,t}$ is the return on the market portfolio and I_t the long-term bond yield.

Estimation of model (4) requires full information maximum likelihood (FIML) in order to estimate in one step the factor loadings (betas) and the risk premia (alphas). In this context one is testing whether stock returns are sensitive to interest rate changes (significance of β_I) and also whether interest rate risk is priced in equilibrium (significance of α_2). The empirical findings are mixed suggesting that bank stock returns are sensitive to interest rate changes. However, explicit pricing of interest rate risk is not undoubtedly established.

The second strand of the literature does not test the restrictions imposed by an explicit two-factor APT model, although such a return generating process is implicitly assumed in the background. In this framework a more flexible testing

approach is followed where interest rate sensitivity is of main concern. The model is assumed to take the following general form:

$$R_t = \phi_0 + \sum_{i=1}^n \phi_i X_{i,t} + \theta \Delta I_t + \varepsilon_t \quad (5)$$

where variation of stock returns is assumed to depend on a set of variables X_i , which could well include past returns on the stock, and changes on the long-term interest rate (ΔI). This unconstrained set up can also accommodate time-varying conditional volatilities.

Estimating models in the form of (4) has the advantage of providing a robust statistical framework where sensitivity and equilibrium pricing of interest rate exposure are simultaneously tested. Its main disadvantage is the inability, due to computational complexity, to capture the stylised fact of time-varying conditional volatility in stock returns. On the other hand, models of the form of (5) lack in terms of theoretical foundation but have the attractive feature of potentially incorporating stochastic volatility effects.

The present study will attempt to 'merge' in a way the two approaches by testing a hybrid model that is a combination of models (4) and (5). An elaborate discussion on this will be given in section 4.

3. Data Issues and Summary Statistics

The dataset consists of the daily closing of nine bank common stock prices listed in the Athens Stock Exchange (ASE) from 14/11/1997 to 16/11/2000 providing 785 observations for each stock. The banks included in the sample are (in alphabetical order)¹: ALPHA BANK, ATTICA BANK, COMMERCIAL BANK OF GREECE, EGNATIA BANK, EUROBANK, GENERAL

HELLENIC BANK, NATIONAL BANK OF GREECE, NIBID, PIREAUS BANK.

Additionally, the closing price of the General Bank Index was sampled for the same period. The long-term interest rate chosen was the 10-year swap rate. As a proxy for the risk-free rate (in order to calculate excess returns) the One-week Interbank rate was chosen. Finally, a set of financial variables from the banks' balance sheets² was used including the following: Market Value, Total Debt, Equity, Working Capital, Market-to-Book Ratio and Total Assets. All data series were obtained from the *DataStream's* database.

As background information it is interesting to mention that 5 out of the 9 bank stocks included in the sample appear in the 12 most actively traded stocks in the ASE³. Furthermore, the banking sector accounted on average for about 28% of the market capitalisation during the sample period.

Weekly excess returns for each of the nine bank stocks were calculated as follows:

$$R_{i,t} = \left(\frac{P_{i,t+m} - P_{i,t}}{P_{i,t}} \right) * 100 \quad (6)$$

$$XR_{i,t} = R_{i,t} - R_{f,t} \quad (7)$$

where $m = 5$ (weekly returns), $R_{i,t}$ and $XR_{i,t}$ stand for the return and excess return respectively for stock i at time t , and $R_{f,t}$ stands for the risk-free rate at time t calculated as the holding period return of a One-week bond⁴. All returns were annualised. Table 1 reports the summary statistics for all stocks as well as the unit root tests (Dickey and Fuller, 1979, 1981).

[Table 1]

As expected the null of non-stationarity was rejected for all excess returns implying that standard asymptotic theory can be applied.

At this point it should be noted that typically in the literature the analysis considers portfolios of banks stocks rather than individual stocks as it is done in the present study. It is expected that the formation of portfolios would have the advantage of smoothing out the noise in the data due to transitory shocks to individual banks. An apparent disadvantage of such an approach, however, is that it masks the dissimilarities in the micro level (Elyasiani and Mansur, 1998).

In the present study, however, the small number of stocks does not allow the construction of financially meaningful portfolios. In other words, the analysis on the one hand has the drawback that noise is not 'averaged out', but on the other hand allows the evaluation of interest rate risk on the micro level (across banks).

4. Econometric Methodology

4.1 Single Equation framework

In order to test the interest rate sensitivity of bank common stock returns a number of alternative models will be estimated. First, within a single equation framework a variant of model (5) will be employed. In particular, the model to be estimated has the form:

$$XR_{i,t} = \phi_0 + \sum_{j=1}^k \phi_j XR_{t-j} + \theta \Delta I_{t-1} + \varepsilon_{i,t} \quad (8)$$

$$\varepsilon_{i,t} | \Omega_{t-1} \sim (0, h_{i,t}) \quad (8a)$$

$$h_{i,t} = \alpha_0 + \beta \varepsilon_{i,t-1}^2 + \gamma h_{i,t-1} \quad (8b)$$

where h_t is the conditional variance of ε_t , Ω is the information set and $\phi_0, \phi_j, \theta, \alpha_0, \beta, \gamma$ are parameters to be estimated.

In this model the excess return on the bank common stock is assumed to depend on each history and conditional volatility is allowed to be time-varying generated by a Generalised (potentially Integrated) Autoregressive Conditional Heteroscedasticity (IGARCH) model (Bollerslev et al. 1986). Within this context, interest rate (non-) sensitivity is tested by essentially testing the null hypothesis that the parameter θ is insignificantly different from zero.

The use of the first difference of the long-term interest rate follows Sweeny and Warga (1986) and Elyasiani and Mansun (1998) whom employ this measure as a proxy for innovations in the interest rate⁵. The change in the interest rate is introduced with a lag following Elyasiani and Masun (1998), in order to escape any potential contemporaneous correlation of the shocks to the capital market (error term) and the innovations in the interest rate that would result in estimator inconsistency.

4.2 Systems framework

By recognising that bank stock returns are probably interrelated (either because they are generated from the same data generation process or simply there are shocks that affect the banking industry as a whole) resulting in statistical interdependence of disturbances across stocks, then there must be efficiency gains that can be exploited by estimating equation (8) as a system (across i s). Thus, the equations in (8) are stacked to form a system of nine equations, which are simultaneously estimated by using the 'seemingly unrelated regressions' method (SURE) (Zellner, 1962). The model to be estimated takes the following form:

$$\mathbf{XR}_{i,t} = \boldsymbol{\varphi}_0 + \sum_{j=1}^k \boldsymbol{\varphi}_{i,j} \mathbf{XR}_{i,t-j} + \boldsymbol{\theta}_i \Delta I_{t-1} + \boldsymbol{\varepsilon}_{i,t} \quad (9)$$

where⁶ $i = 1, 2, \dots, 9$ (the number of banks in the sample) and $\mathbf{XR}_{i,t}$ is an $T \times 1$ vector of observations, and the vector of autoregressive coefficients takes the form $\boldsymbol{\varphi}_{i,j} = [\phi_{i,1}, \phi_{i,2}]'$, with $\boldsymbol{\theta}_i = [\theta_i, \dots, \theta_9]'$, and finally $\boldsymbol{\varepsilon}_i$ is a vector of disturbances that may be potentially correlated across equations such that:

$$E(\boldsymbol{\varepsilon}_i \boldsymbol{\varepsilon}_p') = \sigma_{i,p} \mathbf{I}_n \neq \mathbf{0} \quad (10)$$

where $\sigma_{i,p}$ is the covariance between i and p disturbance terms.

Ideally, one would prefer to incorporate the GARCH effect in a multivariate context, however computational difficulties preclude the estimation of such a 'master' model that would essentially nest both (8) and a variant of (4). In other words, allowing for interdependence across stocks comes at the cost of dropping the assumption of time-varying conditional volatility.

However, treating stock returns as a system allows one to conduct two joint tests. First, that stocks' sensitivity parameters to interest rate changes are jointly significant and second, that they are of equal magnitude (stocks exhibiting uniform interest rate sensitivity).

5. Empirical Results

5.1 Single equation models

Starting with the single equation framework, as a prelude, model (8)-8(c) was estimated for the General Bank Index in order to explore whether the aggregate measure of banks exhibits any interest rate sensitivity. Then the models

were estimated for each of the nine bank stocks individually. Table 2 reports the estimation results for weekly returns.

[Table 2]

Starting with the estimation results for the General Bank Index, interest-rate sensitivity is present and also affecting negatively returns. Thus, this is informal evidence suggesting the banks are jointly sensitive to interest rate innovations. Also, the model captures the GARCH effect adequately. Moving now to the micro-level, where bank stock returns' are viewed individually.

First the model exhibits sufficient explanatory power. In particular, the coefficient of determination attains values between 73% and 77% approximately. As far as the volatility equations are concerned, all parameters are highly significant justifying the use of a GARCH model. The sum of $(\beta + \gamma)$ is a measure of volatility persistence, the closer to unity the higher the persistence in volatility. In case the sum is equal to unity then the process is non-stationary and the so-called Integrated GARCH (IGARCH) describes its behaviour. Moving to the mean equations, the autoregressive parameters are highly significant implying that excess returns are characterised by second-order dependence.

The weekly excess returns' sensitivity to interest rate changes, as measured by the coefficient θ , is always negative as theory requires and is significant in 7 out of 9 cases. Therefore, there is substantial evidence that for weekly excess returns when controlling for their past history and also allowing for time-varying conditional volatility, one cannot reject that interest rate changes exert a significant negative impact.

All in all, the single equation analysis has provided evidence for significant negative interest rate sensitivity of bank common stock returns. These findings for the Greek banking sector are in line with those reported for the US market.

As discussed in section 4.2 one would expect that excess returns are interdependent and therefore estimating equation (8) as a system should be a superior strategy since it would exploit the apparent efficiency gain. The next section reports the results for the system estimation.

5.2 Systems framework

Treating model (8) as a system (across banks) produces nine equations whose parameters are simultaneously estimated by the SURE method. Table 3 summarises the results for the weekly returns.

[Table 3]

The fit of the model is satisfactory ranging from 72% to 80%. What is encouraging is that the results are qualitatively similar to those obtained from estimating the equations separately. The coefficients measuring interest rate sensitivity are all negative and 6 out of 9 are significant. A test of their joint insignificance (all stock returns exhibiting zero interest rate sensitivity) was comfortably rejected (see panel B of table 3). Also the hypothesis of uniform interest rate sensitivity, where the null tested was that all interest rate coefficients are equal in magnitude, was again rejected (see panel B of table 3).

Thus, the estimation of the SURE model in conjunction with the two hypotheses tests provided strong evidence in favour of a significant sensitivity of bank stock returns to interest rate movements. Furthermore, the sensitivity is far from uniform implying that each stock exhibits idiosyncratic interest rate

sensitivity. The next section attempts to shed more light on the determinants of this differential interest rate sensitivity.

5.3 The determinants of cross-sectional variation of interest-rate sensitivity

Given the rejection of the uniformity hypothesis an interesting exercise would be to investigate the determinants of interest rate risk heterogeneity. In other words, one would like to know what might account for the cross-sectional variation in the interest-rate sensitivity parameters (θ 's). A number of possible explanations have been proposed in the literature as to why banks (or firms in general) may exhibit heterogeneity in terms of their sensitivity to interest rate movements. According to Flannery and James (1984), the cross-sectional differences in bank stock interest rate sensitivities' are related to their balance sheet maturity composition. Flannery and James' analysis was based on the concept of nominal contracting hypothesis (Kessel, 1956; Bach and Ando, 1957; French et al., 1983). The nominal contracting hypothesis (NCH, hereafter) postulates that a firm's holdings of nominal assets and nominal liabilities can affect common stock returns through the wealth redistribution effects caused by unexpected inflation. Unexpected inflation redistributes wealth from creditors to debtors. Hence stockholders of firms with higher level of nominal liabilities than nominal assets should benefit from unexpected inflation, while the opposite should be true for the equity value of firms with the reverse position. This effect will vary directly with the relative duration of the nominal contract. As duration of the firm's nominal assets increases relatively to its nominal liabilities, so will do the effect of unanticipated changes in inflation on the value of the equity (Kwan, 1991).

The link between bank stock returns and unexpected inflation is given by interest rates. If movements in interest rates result primarily from changes in inflationary expectations as Fama (1975, 1976) and Fama and Gibbons (1982) have argued, then the NCH implies a relationship between interest rate movements and common stock returns. Finally, according to Flannery and James (1984), as interest rates change the common stock returns of a firm financed entirely by equity and holding only nominal assets should behave like a bond with a maturity equal to the average maturity of the firm's assets.

However, exploring the cross-sectional variation in interest-rate sensitivity established in section 5.2 in the light of the NCH detailed balance sheet information concerning the proportion of net nominal assets and the maturity composition of nominal contract holdings. Unfortunately, such detailed information is not available. The only reliable and consistent balance sheet information for the banks in the sample that was available comes in the form of values for the following financial variables: total debt (D), market-to-book value (MB), equity (EQ), working capital (WORK), and leverage (LV). Obviously these variables are not what ideally one would like to use, however they can be used as a proxy. In particular, important information is conveyed by the equity, the working capital, and leverage measures. The latter two are defined as:

$$\textit{Working Capital} = [\textit{Current Assets} - \textit{Current Liabilities}]$$

$$\textit{Leverage} = [\textit{Debt} / \textit{Equity}]$$

The analysis will focus on uncovering the determinants of interest rate sensitivity. In particular, the following questions will be addressed:

- Can differences in the working capital account for differences in interest rate sensitivity?
- Is equity a significant determinant of interest rate sensitivity?
- Do difference in leverage explain interest rate sensitivity?
- Do differences in debt explain interest rate sensitivity heterogeneity?
- Is market-to-book ratio an important determinant?

By adopting a rather pragmatic approach the ability of any given variable to account for the cross-sectional variation will be evaluated by running a regression of the interest rate sensitivity measures (θ 's) on alternative balance sheet variables in the following form:

$$\theta_i = \alpha_i + \gamma_i BS_i + u_i \quad (11)$$

where $i = 1, \dots, 9$ (across banks) and $BS = (D, WORK, EQ, LV, MV)$.

The analysis is aiming at uncovering the balance sheet variable(s) that explain the highest proportion of the interest-rate sensitivity's variability. Table 4 reports the results from the estimation of the above-mentioned regressions⁷.

[Table 4]

Inspection of the results (see table 4) shows that market-to-book ratio and leverage have no explanatory power over the interest rate sensitivity measure. In contrast, market value, working capital, equity, and debt explain a significant proportion of the variation in interest-rate sensitivity across banks. Market value has the lowest explanatory power (40%), followed by debt (57%) whereas working capital exhibited the highest (80%), with equity attaining an intermediate value (78%).

Clearly, there is evidence that 'growth' of the stock (as measured by market-to-book ratio) does not play a significant role in interest rate sensitivity.

The same is true for financial leverage, which is at odds with what one would expect. Furthermore, when the components of leverage are considered individually (equity, debt) they do exhibit significant explanatory power. Thus, although the absolute level of equity and debt matter for each bank's interest rate sensitivity, their ratio (the composition of bank financing strategy) does not matter. One could interpret⁸ this in the light of the Modigliani-Miller irrelevance theorem (Modigliani and Miller, 1958). In other words, what seems to matter is the absolute level of financing that determines interest rate risk exposure rather than its composition.

Finally, working capital is the statistically preferred determinant (highest coefficient of determination, lowest SIC). The important question now is why is it the case that working capital explains differences in interest-rate sensitivities. This can be explained by employing the nominal contracting hypothesis. Recall that by the NCH unexpected increases in interest rates (as a result of unexpected increases in inflation) redistribute wealth from creditors to debtors. Hence, the greater the working capital (higher level of assets relatively to liabilities) the greater the potential loss from unexpected increases in inflation and thus the greater the bank's sensitivity. Flannery and James (1984) and Kwan (1991) reported similar results by using slightly different variables than those employed in the present study.

6. Conclusion

The present study focused on the interest-rate sensitivity of Greek banks' common stock returns. The issue of interest rate sensitivity was explored through two alternative econometric methodologies. First, within a

single equation framework where allowing for time-varying volatility of banks' excess returns the null of zero interest rate sensitivity was rejected in 7 out of 9 cases suggesting that bank stock returns exhibit significant sensitivity to interest rate movements.

Second, by recognising the interdependent nature of banks' excess returns, a SURE model was employed where cross-equation (that is across banks) dependencies were allowed (and hopefully statistically exploited). Having the advantage of simultaneous estimation of the interest-rate sensitivities, a joint test for their insignificance was rejected implying that banks as a group exhibit significant sensitivity to interest rate innovations. The hypothesis that the interest-rate sensitivity is uniform across banks was also rejected suggesting that the interest rate effect is bank specific.

Given the rejection of the uniformity hypothesis an empirical investigation as to which are the possible determinants of the cross-sectional variation of the interest-rate sensitivity coefficients was pursued. In particular, the ability of balance sheet information to account for the cross-sectional variation was tested. The findings suggested that although a number of variables were correlated with interest rate sensitivity coefficients, working capital was the statistically preferred determinant, finding which was compatible with the nominal contracting hypothesis.

Therefore, significant interest-rate sensitivity of bank common stock returns seems to be a robust empirical finding. Greek banks have been facing interest rate exposure since a derivatives market that would provide hedging services did not exist until recently.

Future research could move towards the estimation and testing of an explicit APT model with the long-term interest rate as one of the factors. Also, following the recent establishment of the Athens Derivatives Exchange (ADEX), as data become available one could directly test the effect of hedging instruments on the bank interest-rate sensitivity.

Endnotes

1. This is not a complete list of the bank stocks currently trading in the ASE. A number of other bank stocks were dropped from the sample either because reliable data were unavailable or because of an insufficient number of observations.
2. Data are based on the 1998 balance sheets, which was the only year for which data were available for all banks.
3. These correspond to October 2000. Information obtained from the ASE's website (<http://www.ase.gr>).
4. That was done to ensure comparability of the bond return with the stocks.
5. An alternative way of doing that would be to estimate an ARMA model and use the residuals as a proxy for the innovation. This was also considered but the results were very similar.
6. Bold face symbols are used to denote vectors.
7. One should interpret the results cautiously given the small size of the sample (8 obs, data for EUROBANK were not available), which also precludes inclusion of more than one possible determinant at a time.
8. Again this interpretation should be viewed with caution.

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Tables

Table 1 Summary Statistics and Unit Root Tests

Excess Return (Bank)	Mean	Standard Deviation	Sharpe Ratio	ADF
Alpha	1.09 (4.11 [*])	7.4	0.14	-11.6 [*]
Attica	1.37 (3.71 [*])	10.3	0.13	-10.8 [*]
Commercial	1.79 (5.75 [*])	8.63	0.20	-11.7 [*]
Egnatia	1.17 (2.98 [*])	10.8	0.10	-10.9 [*]
Eurobank	2.16 (5.35 [*])	11.2	0.19	-8.80 [*]
General	1.22 (3.65 [*])	9.32	0.13	-12.6 [*]
National	1.39 (4.77 [*])	8.11	0.17	-11.5 [*]
NIBID	1.67 (5.56 [*])	8.35	0.20	-10.5 [*]
Piraeus	1.75 (5.44 [*])	8.94	0.19	-10.9 [*]
Index	1.14 (4.72 [*])	6.72	0.19	-11.7 [*]

* The mean and standard deviation correspond to the sample values. The numbers in the parentheses stand for the t-ratios. The Sharpe ratio is calculated by dividing the sample mean by the sample standard deviation. ADF stands for the Augmented Dickey-Fuller test (Dickey and Fuller, 1979, 1981). The asterisk denotes significance at the 5% level.

Table 2 Single equation results

$$XR_{i,t} = \phi_0 + \sum_{j=1}^2 \phi_j XR_{t-j} + \theta \Delta I_{t-1} + \varepsilon_{i,t}$$

$$\varepsilon_{i,t} | \mathcal{Q}_{t-1} \sim (0, h_{i,t})$$

$$h_{i,t} = \alpha_0 + \beta \varepsilon_{i,t-1}^2 + \gamma h_{i,t-1}$$

Excess Return (Bank)	Mean Equation			Volatility equation			Adj. R ²	DW
	ϕ_1	ϕ_2	θ	β	γ	$\beta + \gamma$		
Index	1.04 (25.5)	-0.26 (-6.1)	-2.25 (-4.1)	0.17 (3.7)	0.77 (15.8)	0.94	0.74	2.09
Alpha	1.02 (28.4)	-0.24 (-6.9)	-2.19 (-3.7)	0.19 (3.7)	0.73 (12.9)	0.92	0.72	2.06
Attica	1.02 (27.9)	-0.24 (-6.7)	-1.57 (-1.8)	0.2 (4.4)	0.66 (9.2)	0.86	0.73	1.88
Commercial	1.08 (29.5)	-0.29 (-7.7)	-2.66 (-4.2)	0.17 (3.9)	0.73 (13.1)	0.90	0.75	2.06
Egnatia	1.00 (26.1)	-0.25 (-6.1)	-1.88 (-2.2)	0.24 (4.2)	0.6 (8.6)	0.84	0.74	1.82
Eurobank	1.02 (25.3)	-0.23 (-5.3)	-0.89 (-1.5)	0.22 (4.8)	0.76 (17.3)	0.98	0.79	1.76
General	1.05 (29.8)	-0.26 (-7.5)	-1.44 (-2.5)	0.21 (4.8)	0.75 (16.3)	0.96	0.71	2.08
National	1.11 (27.8)	-0.32 (-8.1)	-2.25 (-3.5)	0.17 (4.4)	0.76 (15.6)	0.93	0.77	2.1
NIBID	1.09 (29.7)	-0.3 (-8.5)	-2.11 (-3.4)	0.24 (5.3)	0.71 (15.5)	0.95	0.74	2.06
Piraeus	1.05 (27.6)	-0.28 (-7.4)	-2.51 (-3.1)	0.2 (5.2)	0.75 (16.6)	0.95	0.74	1.99

* DW stands for the Durbin-Watson statistic (Durbin and Watson, 1966). The numbers in the parentheses below the point estimates stand for the t-ratios Bollerslev and Wooldrige (1992) heteroscedasticity covariance matrix. The Bernt et al (1974) algorithm (BHHH) is used to maximise the likelihood function. Adj. R² stands for the adjusted coefficient of determination.

Table 3 SURE estimation

$$XR_{i,t} = \phi_0 + \sum_{j=1}^2 \phi_j XR_{t-j} + \theta \Delta I_{t-1} + \varepsilon_{i,t} \quad i=1,\dots,9 \quad (\text{across banks})$$

Panel A. Estimation Results						
Excess Return (Bank)	ϕ_0	ϕ_1	ϕ_2	θ	Adj. R ²	DW
Alpha	0.19 (1.3)	1.02 (44.1)	-0.28 (-12.4)	-3.09 (-4.86)	0.72	2.11
Attica	0.24 (1.2)	1.09 (44.4)	-0.29 (-12.1)	-1.2 (-1.45)	0.74	2.05
Commercial	0.26 (1.7)	1.1 (48.2)	-0.3 (-13.5)	-2.93 (-4.3)	0.75	2.09
Egnatia	0.18 (0.9)	1.1 (42.2)	-0.3 (-11.9)	-1.78 (-2.1)	0.75	2.07
Eurobank	0.31 (1.6)	1.14 (38.2)	-0.3 (-10.1)	-1.46 (-1.8)	0.8	2.06
General	0.21 (1.1)	1.1 (41.0)	-0.3 (-11.4)	-1.12 (-1.4)	0.72	2.22
National	0.22 (1.5)	1.08 (48.2)	-0.32 (-14.8)	-3.93 (-6.2)	0.77	2.08
NIBID	0.28 (1.8)	1.09 (43.2)	-0.3 (-12.2)	-2.18 (-3.2)	0.74	2.08
Piraeus	0.3 (0.16)	1.09 (42.8)	-0.3 (-12.1)	-2.28 (-3.1)	0.75	2.09
Panel B. Hypothesis testing						
H₀: $\theta_i = 0, \forall i$	50.9 (p-value 0.00) (zero interest sensitivity)					
H₀: $\theta_1 = \dots = \theta_i$	26.07 (p-value 0.00) (uniformity hypothesis)					
H₀: $\theta_1 = \dots = \theta_i$	13.38 (p-value 0.02) (uniformity based only on significant parameters)					

* DW stands for the Durbin-Watson statistic. The numbers in the parentheses below the point estimates stand for the t-ratios. Adj. R² stands for the adjusted coefficient of determination. The hypotheses tests were based on the Wald test and as result are distributed as a chi-square with degrees of freedom equal to the number of restrictions under the null hypothesis.

Table 4 Cross-sectional variation

$$\theta_i = \alpha_i + \gamma_i BS_i + u_i \quad (\text{across banks}) \text{ and } BS = (\text{TD, WORK, EQ, LV, MB})$$

Determinant	α	γ	Adj. R²	F-stat	SIC
Working Capital	-9.1 (-4.18)	0.62 (5.45)	0.8	29.13	1.37
Equity	-10.5 (-4.36)	0.71 (5.41)	0.78	26.5	1.47
Market-to-Book ratio	2.23 (4.7)	0.014 (0.25)	-0.16	0.01	3.15
Leverage	1.81 (3.48)	0.21 (1.11)	-0.04	3.04	0.7
Debt	-5.8 (-1.83)	0.43 (2.64)	0.57	10.5	2.14
Market Value	-4.75 (-1.41)	0.36 (2.14)	0.4	5.83	2.48

* The absolute value of the interest rate sensitivities was used since the sign was identical across banks. The working capital, equity and debt were used in logarithmic form to enable comparability of the estimated coefficients. SIC stands for the Schwartz Information Criterion (Schwartz, 1978). The numbers in the parentheses below the point estimates report the heteroscedasticity-adjusted t-ratios based on White's method (White, 1980).